SECTION II.

ENGINEERING AND ARCHITECTURE.

ADDRESS,

By JAMES LEMON, M.Inst.C.E., F.R.I.B.A., F.S.I., F.G.S., &c., Mayor of Southampton.

PRESIDENT OF THE SECTION.

This Section includes a great many subjects; my predecessors in this chair, in most cases, have selected *one* subject, and made it the basis of their address. I propose to adopt a somewhat different course, and to take a general view of the aspects of sanitary engineering, leaving it to the writers of the various papers to deal with the various subjects in detail.

Sanitary engineering may be called a modern science, as it is only since the passing of the Towns Improvement Act of 1847, and the Public Health Act of 1848, that serious attention has been given to it. Investigations were made into the causes of zymotic diseases in towns, and it was found that want of efficient sewerage, defective house drainage, pollution of drinking wells, badly constructed dwellings, and want of ventilation were amongst the main causes of the high death rate.

The medical profession have always been pioneers in sanitary reform, and when they proved that certain diseases were preventable, public opinion called loudly for the removal of the causes referred to, the sanitary engineer may then be said to have been created. His sanitary knowledge, forty years ago, was extremely limited, he was a civil engineer, or an architect and surveyor, and in some cases a surveyor of highways, and he was suddenly called upon to sewer a town. Is it a matter of surprise that so many mistakes were made? ought we not to congratulate ourselves that there were not more? But it is a peculiar feature in the character of an Englishman that he rises to the occasion. The demand for sanitary knowledge

created the supply. Men of superior professional attainments took up the work, and to-day England stands in the front rank, America being her only competitor of importance. The sewerage of towns necessarily occupied an important position amongst the questions to be dealt with by the sanitary reformer, and a great controversy was commenced between the advocates of sewers, sufficiently large for men to enter for the purpose of cleansing, and the advocates of small pipe sewers—called by their opponents "the quart into a pint school," or the pot pipe party—but the sturdy common sense of our professional advisers, who looked at the question as scientists only, and not as party advocates, prevailed, and the drainage engineer of to-day designs his sewers according to the work they have to do. Small pipe sewers have, in the main, won the victory, because with proper gradients they are self cleansing, and the brick sewers of former times were ridiculously out of proportion to the quantity of sewage flowing through them. This leads me to the consideration of the principles to be kept in view as regards town sewerage.

I would give the fall the first place. All sewers should, if practicable, have a self-cleansing velocity. This fall will, of course, vary according to the size of the sewer, large sewers not requiring so much fall as small ones. It is a common error amongst inexperienced engineers to increase the size of a pipe sewer when the gradient is bad, in order to show that a self-cleansing velocity is gained; but if they would take the trouble to ascertain the wetted perimeter, this fallacy would be at once exploded.

The quantity to be dealt with is another important factor, as it necessarily influences the gradient of the proposed sewers. This will depend upon the water supply, and the rainfall to be provided for. I am glad to say there is a tendency to make a more liberal provision for the water supply per head per diem than was thought necessary a few years ago. Water closets are becoming more general, and baths in small houses are common.

In Southampton houses letting at only £26 per annum are provided with baths, and in some cases workmen's dwellings of only £16 rent are similarly provided; sewers are better flushed, roads are more frequently watered, urinals, courts, channels and gulleys flushed down; this all means more water, and with it a higher state of cleanliness and improved health. In small towns 20 to 25 gallons per head is sufficient, but in towns of 50,000 and upwards, 30 gallons per head should be provided.

I now come to a vexed question, viz., the rainfall. What is to be done with it? As it is not usual to discuss a Presidential

Address, I do not desire to deal with controversial matters, but still there are many questions of vital importance to sanitary progress which should be referred to and also discussed in this section, and if I point them out I may induce others to write or speak upon them. Amongst these questions I put the disposal of the rainfall. I am afraid the rainfall is dealt with in rather a perfunctory manner, even by drainage experts. Leave the rainfall alone says the drainage engineer, it got away before, why meddle with it? We don't want it in our sewers. I confess I have said the same thing myself, but there is a limit to this kind of doctrine. A damp subsoil has a detrimentral influence upon the public health, and if a town is to be properly drained, the water level must be permanently lowered. I am quite aware that the sewerage of a district lowers the water level. I remember when the main sewer was carried through Nunhead by the Metropolitan Board of Works, the water level in the private wells was lowered, and in some cases the wells run dry, but this was due to the fact that we cut through the clay basin. This result is not, however, always obtained, it depends entirely upon geological causes, and the relative level of the district.

I wish to drive this question well home, because it applies very strongly to Portsmouth, and the very least we can do in return for the generous hospitality of the Corporation, the officers and citizens, is to try and deal with questions in which they are interested. A discussion of the pollution of rivers by the refuse from factories, would be useful to this Congress, but it does not interest the people of Portsmouth very much. Sir Frederick Bramwell stated in this hall at the meeting of mechanical engineers held in July last, in answer to a question from myself, that he had allowed for a quarter of an inch of rainfall in 24 hours in the calculations he made for the sewerage of the borough lately carried out by him. Now this is the Metropolitan scale, exactly the same as that adopted by the late Sir Joseph Bazalgette. It has failed in London and it has failed in Portsmouth, and it will fail everywhere where it is adopted under similar conditions.

It was all very well in those parts of the Metropolis north of the river Thames, where the old sewers, utilized as storm overflows, are above the level of high water, but in the south of London, where I formerly lived, and in other low-lying parts, there is no free outfall, and the heavy rains must either saturate the subsoil or flood the surface of the district and the basements of the buildings.

In London special supplementary surface drainage outfalls have been constructed, to remedy the defects that arose from the defective design of the Metropolitan main sewerage, previously referred to, and in other towns where this scale has been followed the Local Authorities will have to adopt similar remedial measures. But what I wish to impress upon this Section in particular, and the Congress generally, is the importance of dealing with rainfall according to local circumstances, having regard to the rainfall in the district, the relative level of the district and the river or sea, and the geological conditions. It must not be left to take care of itself; it must be calculated and dealt with with as much care as the water supply. In low-lying districts it should be provided for by a duplicate system of sewers, and lifted by steam or other power above the level of high water.

In the foregoing remarks I have not specially referred to the separation of the rainfall from the sewers, although it might easily be inferred that my views ran in that direction. There are, no doubt, great advantages attending the separate system, more especially where it is necessary to treat the sewage chemically, or to dispose of it on land. In the first place, the quantity to be dealt with can be more easily ascertained, and consequently the sizes of the sewers and tanks, and the area of the land, more correctly determined. But what is meant by the separate system? If a duplicate system of drains to every house be meant, then I say at once it is not in my judgment either practicable or desirable, but if on the other hand it is only intended to exclude the rainfall from the roofs of houses draining to the front, and the surface of the streets, then my preceding remarks will apply.

Sea Outfalls.

As the Congress is assembled at a seaport town it may not be out of place if I say a few words as to sea outfalls. The Corporation of Portsmouth are very fortunate in having a large harbour, and rapid tidal currents which carry away the sewage from the town, the natural advantages referred to have been utilized to their fullest extent in the construction of the sewage storage tanks and outfall, and I have every reason to believe there is no return of sewage on the foreshore, and no nuisance; but the young engineer must not take Portsmouth as an example and adopt the principle somewhere else, where the local conditions may be altogether different.

Sea outfalls require the greatest care as to their placement and construction, and if the currents are not favourable crude sewage should not on any account be discharged from them. In cases of this kind precipitation must be resorted to, and the effluent only discharged into the sea.

Amongst the questions which are agitating the public mind is that of the ventilation of sewers. Inquiries are continually being made by local authorities, patents taken out, and experiments made by experts, but we are practically to-day where we were 30 years ago. The prevailing system is that of open gratings over the manholes in the centre of the streets, but this has the disadvantage in some cases of causing a nuisance to passers by and to the occupiers of adjacent dwellings. To remedy this defect, connections have been made between the manholes and existing chimneys, the result has been satisfactory, but the area ventilated has been so small that it is only a partial remedy; another mode is the erection of pipes against the walls of buildings, as outlets from the manholes or Sewers.

The use of charcoal trays in manholes was at one time strongly advocated, but that mode seems to have died a natural death. The trays were found to obstruct the ventilation, and after a short time, the charcoal was of doubtful utility. I was never in favour of this mode, but I have used charcoal trays, as I found them useful as a remedy against sentimental objections. I remember a rather amusing incident in reference to them: a gentleman in Southampton, who resided opposite a manhole, asked me to put in some charcoal trays, as he was confident they would remove the smell of which he complained, I ordered the trays to be put in, which was done, but, unfortunately, the man forgot to put in the charcoal, my friend saw the manhole opened and the trays put in from his window, and after the man was gone he went down on his hands and knees to try if there were any smell, he was so convinced of the efficacy of the charcoal that he wrote to me and reported that the smell was entirely removed; when I told him that the charcoal was non-existent, he was, of course, very much astonished. This is a sample of some of the sentimental objections which are sometimes raised to ventilators. Another mode of ventilation which has lately come to the front is the invention of Mr. Holman Keeling, which he calls a destructor, it consists of a vertical cast iron lamp standard, with the ordinary street lantern, and fitted with a gas furnace for the burning of the gases from the sewer.

I do not think I can do better than allow Mr. Walker, the well-known Borough Engineer of Croydon, to give his experience in his own words. He says: "We have allowed all comers to try anything that any inventive age could suggest, most of them not worth a moment's consideration."

"One of Keeling's Destructors has been well tried, with results far better than any other. It was placed on high ground on the apex of a 9-inch sewer, and in the 6-inch pipe connected with it, an anemometer was placed for many weeks,

registering the speed of air passing from the sewer to the Destructor. The average was 1507 cubic feet per hour, with 8 cubic feet of gas consumed in the burner, and the temperature of the air inside the column, four inches above the burner, was 190° Fahr. This was tested last April (1891), the Destructor having all the recent patented improvements in it. At the same time, I found, by placing similar anemometers in the ventilating pipes in various parts of the Borough, that the average was 1852 cubic feet per hour. The patentee expressed his satisfaction with the result of the test of the destructor, and I am sure the Association of Municipal and County Engineers will agree with me that the average amount of sewer air passing up the ventilation pipes was eminently satisfactory."

"A special anemometer has been used that does not unregister, if the current is reversed. If the anemometer was reversed, it would register the down current only."

"We have about 250 pipe ventilators in use, chiefly up houses, and almost every week others are put up: where a sewer-ventilator smells, or is supposed to do so, there is very little difficulty in getting permission to erect a ventilation pipe. This is done on the understanding that it is taken down in 24 hours if the owner or occupier requests it."

I think it is unnecessary for me to express any opinion upon these experiments. They are so clear, they speak for themselves, and the members of this Section will draw their own conclusions; I will say, however, that Mr. Walker has been more successful than most engineers in obtaining the consent of the owners and occupiers to the erection of ventilating tubes against the houses. I have invariably found that a very small percentage will give their consent.

In my own practice I place the manholes about 100 yards apart, with gratings thereto to open or shut, and also put as many shafts and tubes as I can. The manholes will in most cases act as inlets for fresh air, and the tubes as outlets, but if the current be reversed no harm is done, as there is a continual change of air in the sewer.

I consider you cannot have too many inlets and outlets to a sewer, and after 40 years' experience I have come to the conclusion that an open sewer down the centre of a street, with a good fall, would be the best form of construction; that is, however, impracticable. I therefore say, get as near to it as you can. When a deputation waited on Sir Robert Rawlinson and complained of the smell from the ventilators in their town, He replied, "Put in some more." When a ventilator smells the local authority generally orders it to be closed; greater folly cannot be committed, you cannot bottle up a stink. If you will not have it in your streets, you will most probably get it in your houses. It is evident that the sewer is badly constructed or that it wants flushing.

This leads me to repeat an opinion I have so many times expressed, that if we had properly designed and constructed sewers we should hear very few complaints of the want of sewer ventilation. Noxious gases (of which we hear so much) cannot generate in a sewer with a self-cleansing velocity. Happily, we are making rapid progress, the sanitary engineer of to-day is very different to what he was 30 years ago. He is now a gentleman of education, and properly trained for the work he has to do; and as sewerage works are properly designed, so will the present sanitary defects disappear.

I have dealt with some of the main points of the sewerage of towns without attempting to discuss the details, in the hope that they will form the subject of a paper before this Section, and be fully discussed. The disposal of the sewage of towns is too large a subject for me to refer to in a brief address, but I desire to refer to the question as it presents itself up to date. We have lately seen the system of precipitation growing more into favour. This is due to several causes: first, the improved means of disposing of the sludge: secondly, the failure of so-called sewage farms; and thirdly, the growing tendency to combine precipitation with land filtration. As regards sewage irrigation and intermittent filtration, I believe the failure is due to the adoption of unsuitable land to save pumping, and to the letting of the land by the Local Authorities to tenants who naturally look to making a profit and care little for the successful disposal of the sewage.

Healthy Dwellings.

Although the successful sewerage of a town is a most important consideration, we must not overlook the health of our dwellings. We are now face to face with a cholera epidemic, and every Englishman should put his house in order, and every Local Authority should strictly enforce the most improved regulations for the preservation of the public health.

I had considerable experience during the cholera epidemic of 1866, and I know the disease took a firm hold of those parts of the town which were in an insanitary condition. If you wish to resist an attack of cholera, you must have good sewerage, good house drainage, a pure water supply, and plenty of air space.

The towns of Hamburg and Havre are illustrations of this want of those essentials to public health. A physician of Hamburg says, "Unfortunately Hamburg is built contrary to all rules of sanitation. The houses have no yards, and close behind are other houses—old, many-cornered, dark, and airless —the overcrowded habitations of the poor, filled with dirt, and ill-smelling. In addition, the Elbe is partly dried up, and on its banks is deposited all manner of refuse."

On the other side of the channel we have the large and important seaport of Havre, the normal death rate of which is more than double that of Portsmouth. In the year 1884, I prepared a Report on the sewerage of this town, the authorities appointed a committee of experts to sit upon it, but nothing has been done from that day to this. These two towns Hamburg and Havre, are in communication with this country, and they are sending forth a pestilential army to invade our shores, we may by constant vigilance, keep them out, but it is a scandal in these days of International Congresses, that such sanitary neglect in Germany and France is allowed to exist.

Fortunately for England, the local authorities are better prepared than they were in 1866; these Sanitary Congresses have educated the people, and the average Englishman now recognises the advantages which sanitary legislation has conferred upon him. But it is to the safety of the poor we have still to look, our towns are still overcrowded. Much has, however, been done in the last year under the Houses of the Working Classes Act, 1890. Houses unfit for habitation have been closed, but a danger still remains, and local authorities must face it, however reluctant they may be to do so. The occupiers of insanitary dwellings are removing to other houses in the locality, and so the overcrowding is still continued. What is wanted is the erection of suitable dwellings to take the place of those condemned, notwithstanding the fact the owners in many cases put the houses in a proper sanitary condition, and they are allowed to be reoccupied. Here is a splendid opportunity for the architect: to design a good healthy dwelling for the poorer working class, at a reasonable cost, so that local authorities may be induced to erect them. A good model working man's home is wanted in our crowded towns, where there is a large dining-room, and reading-room common to all, and a separate bedroom for each lodger; such a place for single men would be much sought after, and would always command good tenants.

Before closing this Address, I should like to say a few words as to the construction of houses for the middle and upper classes. It is assumed, and not unnaturally, that the well-to-do classes, as distinct from the poor, enjoy greater immunity from zymotic diseases, but that is not always so. The poor are more hardy, they have to rough it, they are less likely to take cold from exposure to inclement weather, and although they run far greater risks from bad drainage, and from the wretchedly-constructed dwellings in which so many live, they to a certain extent become disease-proof, and escape from the dangers which would be fatal to the more delicately nurtured children and the more carefully housed, well-to-do-classes.

A man in moderate circumstances takes a house in the suburbs of one of our towns, or he may be induced to buy it. He does not consider it necessary to consult an expert, or he will not incur the expense; what is the result? He finds after a brief residence that some member of his family does not enjoy his or her usual health: the doctor is called in, and an opinion is expressed that there is "something wrong with the drains," or in other cases the water is found to be impure, or the house is damp or draughty from the shrinkage of the green material with which it is built. This is the common experience of every day life.

What is the remedy?

No man should take a house unless he has satisfied himself that it is in a proper sanitary condition. But, you say, who is to pay for this examination? My answer to that is, the owner, if he wish to secure a good tenant, should in his own interest do so. If the owner refuse, it is evidence that he is not prepared to put his building to a proper test; but he may say the house has been built under the supervision of Mr. A. B., a well-known and competent architect; in that case the tenant might be disposed to run the risk, but in the interest of his family and himself I should advise him to pay the small cost of an examination, he would then feel that he had done his duty as a father and a citizen.

While saying this much, I am quite willing to admit, that this want of confidence is due to the fact that we are too much in the hands of the jerry builder, and that on the part of some of our architects and builders there is not that knowledge of the Sanitary details of our houses there ought to be. Our dwellings should be above suspicion, and with attention to a few principles of sanitation and proper supervision of their construction they would be.

The Sanitary Architect (I have coined a new term), should insist upon the following points, viz.:—

1. A dry subsoil. If it be not naturally dry, he should make it so by land drainage. If there are no means of effecting this, do not build the house.

2. A damp proof course, either of asphalte or two thickness of slate in cement.

3. Walls built of hard kiln burnt bricks, which will keep out heavy rains, and in the Southern parts of England, hollow walls.

4. A good pitch to the roof and *outside* gutters, eaves' gutters if practicable.

5. Good ventilation under the floors, and to the rooms, by separate ventilating flues next the smoke flues as exits and proper inlets.

6. Drainage in stoneware pipes, outside the house, disconnected with the main sewer and ventilated. If compulsory to go under the house, then the drains should be laid in cast iron pipes, with lead joints like a water main.

7. Water closets should have flush-down basins, with the soil pipes *outside* the house, carried up the full size and ventilated.

8. Sinks of all kinds and baths should be disconnected with the sewers and discharge over open gratings.

These are eight of the principal requirements for a healthy dwelling, and if they be observed, we should hear very little of typhoid fever and other kindred diseases.

In conclusion, allow me to say, I congratulate the thriving borough of Portsmouth in receiving The Sanitary Institute. I am certain these Congresses have a tendency to raise the standard of knowledge and of thoroughness of work amongst my professional brethren. I do not wish to underrate in any way the labours of medical men, no man has a higher opinion of that noble profession than myself, but I would say to the engineer and architect of to-day, that as you do your work in the future and keep abreast of the progress of Sanitary Science, so will the onerous duties of the medical officer and the sanitary inspector decrease: you are the creator, upon you falls the labour and constant study necessary to design good sanitary works, upon you also rests the heavy and serious responsibility of proper supervision of your works in many cases performed by others under your charge.

Failure has resulted in some cases, but in the overwhelming majority, the engineer and architect performs the duties entrusted to him with fidelity and zeal, and he is fairly entitled to the confidence of the community at large.

Sir Charles Cameron (Dublin) said he had much pleasure in moving a vote of thanks to the President of the Section for his interesting and practical address. It was far more usual for Presidents to deal in platitudes and to bring forward abstract ideas, and very often abstruse ones, than to reason so much from the abstract to the concrete as their worthy President had done. His address had been practical and most suggestive, and they had all listened to it with pleasure and profit. He had been particularly interested in the remarks Mr. Lemon had made with regard to the disposal of sewage in towns like Portsmouth, which were situated upon the sea-coast, for at the present moment they were engaged in Dublin in carrying out a main drainage scheme under the direction of a very experienced Sanitary Engineer, Mr. Chatterton, a Dublin man, though practising chiefly in England. The question of the disposal of sewage in towns upon the sea-coast had not yet, he thought, been completely studied, and there must be a great difference in the precipitation required in these towns, and in towns situated a long way from the sea, in which cases the effluent must necessarily be discharged into a river. In that case they had to deal with the perplexing question of the soluble organic matter, and to get rid of this was somewhat difficult, for though they might discharge an effluent, apparently pure, before it reached the sea, the matter separated and assumed a very objectionable form. From some experiments he had made, he had found that within twenty-four hours an effluent which had no odour whatever, became extremely offensive, particularly in warm weather. In Dublin it was not necessary to do anything more than to use the smallest amount of precipitating material to purify the sewage, for after discharging the effluent into the ocean they would never again see the dissolved matter contained in it. He had been much interested in the visit they had paid to Portsmouth Sewage Works, but they could hardly take the case of Portsmouth as an example of the way the sewage of other towns could be dealt with. At Dublin, experiments with corks and other devices had shown that a great portion of the crude sewage came back upon the shores, and, therefore, it was necessary to clarify the sewage to a certain extent. He had also made some experiments with regard to the ventilation of sewers in Dublin; at the present time in that city they had ventilating openings in all the sewers at comparatively short distances from each other. These were practically open sewers, and so far as emanations from sewers were concerned, it would be better to have open conduits through the streets were it practicable. Very unpleasant vapours at times came out of these openings, and the question had been raised whether it was any advantage to have so many of them. He had made a number of experiments on this subject in all parts of Dublin, at high and low levels, in poor localities and rich districts, and as a rule he found that the air was going into them and not coming out. He had tried it with delicate anemometers, and early in the day he found that the air went in like a whirl-wind, due, no doubt, to the currents created by fires being lighted in houses where the traps were defective, allowing the air to be drawn up. He thought there was not much pressure in sewers, and if proper precautions were taken to make properly trapped communications between the house drains and street sewers, he believed a very slight pressure would be insufficient to force the traps. But of course they would have to consider whether the sewage was always running or not. In Dublin the sewage was often impounded for eight or ten hours in the day, but even then the pressure was very slight indeed, from half an ounce to an ounce and often none at all.

In Dublin all the sewage went into the Liffey, the mouths of the sewer valves opening and closing as the tide rose and fell. These, however, would be done away with by the new sewage works, which would have a continuous flow.

Sir Thomas Crawford, K.C.B. (London), as Chairman of the Council of The Sanitary Institute, seconded the vote of thanks to Mr. Lemon for his address. He said that to Sanitary Engineers they owed much of their success in their efforts to educate the public upon these great questions of health. In his last paragraph their President was very complimentary to medical men, and speaking with the experience of from 40 to 50 years, he did not think the compliment was altogether undeserved. But as Director General of the Medical Department of the Forces he had always laid down and impressed upon his Officers, the point at which a line should be drawn between the good work to be done by Medical Officers and Sanitary Engineers. That line was distinct, and the Medical Officer's duty was to search out the cause of the disease, and if it was to be removed by Engineering skill to leave the remedy in the hands of the Engineer. Medical Officers could suggest remedies, but, as a rule, they did not know anything about engineering.

On "Apparatus for Softening Water," by Henry Law, M.Inst.C.E., F.R.M.S.

The quality known as *hardness* in water is caused by the presence in solution of certain salts, and the process of *softening* consists in the more or less perfect removal of these salts.

Water may be softened in a greater or less degree by boiling, by distillation, by exposure, by freezing, by filtration, and by chemical re-action; and it is of this last process that it is proposed to treat in the present paper. The rationale of the process consists in adding to the water certain substances which re-act upon the foreign substances already contained in the water, forming new compounds, which, being no longer soluble, may be removed either by filtration or by precipitation.

The substances and the proportions in which those substances should be added to any particular water depend upon the chemical composition of the substances already contained therein. In the present paper it is not proposed to deal with the chemical question, but only with the conditions which insure the most perfect result, and the mechanical means by which those conditions are most perfectly fulfilled.

The process which has been most extensively adopted is that which was patented by Dr. Thomas Clark in 1841, and consists in the addition of a certain quantity of *lime* to the water to be softened. To explain the mode in which the lime so acts, it is necessary to state that the hardness in the water upon which lime will act is caused by the presence of bi-carbonate of lime, consisting of 9 parts by weight of lime, combined with 14 parts by weight of carbonic acid, forming a salt readily soluble in water. If now 9 parts by weight of lime be added to the water, it takes from the bi-carbonate half its dose of carbonic acid, combining with the same and forming 32 parts by weight of carbonate of lime, composed of 18 parts by weight of lime and 14 parts by weight of carbonic acid, a salt which is not soluble in water, and which is consequently precipitated, leaving the water free from the presence of the bi-carbonate of lime which it originally contained, the quantity of carbonate of lime precipitated containing double the quantity of lime previously existing in the water.

As in most waters bi-carbonate of lime is the chief cause of hardness, only lime is used for the purpose of softening the water; but other substances in addition to lime are sometimes used to re-act upon other salts of which lime and magnesia form the base. The action, however, is in all cases similar to that above described, namely, by the addition of certain substances the *soluble* salts originally contained in the water are decomposed and fresh compounds are formed which, being *no longer soluble*, are precipitated from the water.

Now, in order that this process may be carried out in the most perfect manner, the following conditions should be observed, namely:—

1. The substances to be added should be perfectly dissolved before being mixed with the water to be softened so that they may be presented to the substances to be re-acted upon in the most finely divided state possible, as this is necessary to insure perfect chemical action.

2. The substances so added should be neither in excess of, nor wanting in the due proportion required to re-act upon the substances contained in the water to be softened.

3. It is important (as was pointed out by Dr. Clark) that the lime, or lime water, that is the softening ingredient, be put into the vessel first, and the hard water gradually added, because there is thus an excess of lime present up to the very close of the process, and this circumstance is found to render the precipitation of the carbonate of lime produced in the process more easy.

4. Means must be employed to remove from the water the

insoluble compounds resulting from the chemical re-action; and this may be effected in one of two ways; namely—

(*a*) By subsidence or precipitation, or

(*b*) By filtration.

The most perfect means of fulfilling the first condition is to form a *saturated* solution of the softening ingredient which will then contain a certain definite quantity in any particular measure, and can be added to the water to be softened in the exact proportion required to react upon the salts contained in the same, and leave no excess of the softening ingredient in solution in the water at the conclusion of the process.

In order to obtain a *saturated* solution an excess of the softening ingredient should be mixed with water already softened in a separate tank or vessel; various methods have been adopted to insure a thorough mixture. At Luton Hoo there are two tanks into each of which an excess of milk of lime is poured, and they are afterwards filled with softened water to a certain fixed height. The contents are then agitated for about a quarter of an hour by a two-bladed screw, revolving in a short tube by which the water in the tank is kept in constant circulation. The screw is then lifted out of the tank and the excess of lime subsides to the bottom, leaving a perfectly clear saturated solution of lime.

The composition of the water to be softened being known it is easy to calculate what depth of water in the lime water tank will be required to soften a given quantity of the hard water, and this quantity is run off into the bottom of a larger tank into which the given quantity of hard water is subsequently poured.

By this method the first three conditions are fulfilled in the most perfect manner, the lime being first thoroughly dissolved and then mixed with the hard water in exactly the right proportion, and the water to be softened being added gradually to the lime water.

The contents of the tank are then left for some hours in a state of quiescence, during which the insoluble matter resulting from the chemical reaction gradually falls to the bottom of the tank, leaving the supernatant water perfectly clear. The precipitate thus deposited is not removed at each operation, but is allowed to accumulate for some time. When the hard water is poured into the tank this deposit is stirred up and mixes with the water, and assists in carrying down more rapidly the fresh insoluble matter resulting from the chemical action. At intervals varying from one to three months this deposit is run out of the tank. It is usual to have three softening tanks, one in process of filling, one in which the water after being treated is in a quiescent state the deposit subsiding, and one from which the clear softened water is being drawn for use. This is the process as originally proposed by Dr. Clark, and is that which most perfectly effects the object desired and fulfils the conditions already laid down.

In practice, however, where the quantity of water required to be softened is considerable, a very large space would be necessary for the tanks, and to meet this difficulty various methods have been devised for carrying on the process continuously, the substance resulting from the chemical action being removed by *filtration* instead of by *subsidence.*

One great difficulty in the continuous process is to cause the water to be softened and the softening ingredient to be mixed continuously and uniformly in due proportions. Where the water is to be used for dietetic purposes this is essential, as an excess of lime or other re-agent would render the water unwholesome.

It has been sought to effect this object by supplying the hard water and the softening ingredient through two separate pipes, which are of such relative discharging capacities as will cause each to discharge the quantity required; but this is very difficult if not impossible to accomplish. For, however accurately they may be adjusted in the first instance, the smaller pipe which supplies the softening ingredient is liable to become partially choked by deposit.

Assuming that lime alone is to be used to soften the water, then each 700 gallons of water will require 1 oz. of lime to be added for each degree of hardness; so that if the water has $18\frac{1}{2}$ degrees of hardness, $18\frac{1}{2}$ ozs. of lime will be required to soften 700 gallons; then as 750 parts by weight of water is necessary to hold in solution 1 part of lime 751 times $18\frac{1}{2}$ ozs. or 866 lbs. of lime water must be added to 7,000 lbs. of the hard water; that is to say the water to be softened must equal 8 times the quantity of lime water which it is necessary to add to it.

Where the softening process is carried on in open vessels it is comparatively easy to detect any want of proportion in the water and the lime, as the quantities being respectively delivered by the two supply pipes can be measured from time to time. It is, however, obviously frequently of importance that where hard water is supplied under pressure, it should be capable of being softened in close vessels under pressure. Under these circumstances it becomes extremely difficult to regulate the quantity of lime added, or to detect any want of due proportion in the same.

A great number of patents have been taken out having for

their object the removal of these difficulties; but as far as the author knows there are not any which have been entirely successful. When the water is thus confined in vessels under pressure, it is obvious that the process cannot be continuous, but must really be intermittent. For unless water is being drawn from the vessels, neither hard water or lime water will be flowing, the whole of the contents of the closed vessels being stagnant. When water is drawn a current will be produced causing a quantity equal to that withdrawn to enter the vessels, but it is difficult to conceive any arrangement which will ensure one-ninth of the required quantity always entering by the smaller pipe and eight-ninths by the larger pipe, as so many varying conditions will tend to cause a greater or less discharge from either of these supply pipes.

The largest installation as far as the author knows to soften water for domestic supply is that which has been carried out by Mr. William Matthews, at Southampton. The process here adopted is to deliver the hard water from the pumps into the head of a trough with baffle plates, the lime water being allowed to flow into the same by gravity in a regulated quantity, the agitation of the water and the action of the baffle plates being relied on to insure proper mixture of lime water with the water to be softened. The mixed water thence flows into a tank 76 ft. long, 42 ft. 2 in. wide, and 6 ft. deep at one side, sloping to 7 ft. at the other. The water is about one hour in passing through this tank, escaping at the further end over a cross wall 4 ft. 9 in. in height, so that the surface water only passes over the same, and a certain quantity of deposit is thus arrested in the tank.

In order to remove the remaining deposit, the softened water is passed through filters, which are described as follows by Mr. Matthews in the Paper* supplied by him to the Institute of Civil Engineers:—

"Water is admitted to the filters through horizontal 6-inch pipes, terminating, in the softening tank and supply tank, with bell-mouthed bends, in which heavy leather-faced valves are fitted, actuated from the front of the filters by levers and chains. Each filter consists of an open tank, cast in one piece, $\frac{3}{4}$-inch thick, $7\frac{1}{2}$-feet long, and 3-feet $7\frac{1}{2}$-inches wide; the ends are vertical, 6-feet deep on the centre line; while the bottom falls 3-inches each way towards the centre. The tank is V shaped in cross section, having a radius of half the width. The inlet enters through the back plate, $9\frac{3}{4}$-inches above the bottom, where a socket is cast in the plate, and the joint made with lead.

* Minutes of proceedings of the Institution of Civil Engineers, Vol. CVIII.

A 6-inch bend is bolted to an opening in the bottom of each tank, and discharges the waste through a pipe and valve fixed under the floor, into a line of 12-inch pipes running the whole length of the house, and communicating with the drains outside. The valve is worked by a lever from above the floor-level. A cast-iron cross bearer is fixed across the back of the tank, and carries a brass-lined bearing fixed on the centre line, 4-feet $2\frac{1}{4}$-inches below the top; while a corresponding trunnion bearing is formed in the front plate of the tank. These serve to support the cast-iron disc shaft, which is $5\frac{1}{2}$-inches in diameter, and is hollow, closed at the back end, and has grooves and openings in it, so that the water from the discs which it carries may be admitted to the central portion. Near the front end a spur-wheel is keyed on, and is driven by a pinion and short shaft, which works through a stuffing-box formed in the front plate of the tank, and is actuated on the outside by bevel gearing and shafting arranged along the front of the filters, and driven through belting from a line of shafting supported on the walls above them.

"Each hollow shaft carries twenty galvanized cast-iron discs of light open work pattern; they are 3-feet in diameter, and $\frac{7}{8}$-inch wide, and are covered on either side with perforated zinc sheeting, over which is stretched stout twilled cotton cloth, which acts as the filtering medium, the cloth being held in position by clip-rings and studs, which secure it at the periphery of the disc. Galvanized cast-iron distance pieces are placed between the discs on the shaft to keep them the requisite distance apart of $3\frac{1}{2}$-inches from centre to centre.

"The turbid softened water, being admitted to the filters, percolates through the cloth into the discs, whence it passes to the hollow shaft, and through the trunnion to a valve fixed on the front of the filter, which regulates the flow into the softened-water tank formed under the filter-house floor. The water is now in a perfectly clear state, the precipitated bi-carbonate of lime having been arrested on the face of the filter cloth, whence its removal is effected by means of water jets. Between the discs, $\frac{3}{4}$-inch spray pipes are placed, capped at their outer ends, and pierced on either side with small holes or slots. These pipes are connected by T-pieces to a $2\frac{1}{2}$-inch pipe, fixed along one side in each filter, closed at the back end, and mounted on a pivot; while the front end passes into a trunnion formed in the tank plate, and communicates with pipes and a regulating valve supplied from the high-pressure service main outside the building. The outer ends of the small spray pipes are fixed to a bar; and the whole set can thus be raised or lowered between the discs, the $2\frac{1}{2}$-inch pipe being free to

revolve in its bearings. The pipes are raised by a chain wound on a small drum, to which motion is given by worm gearing and a hand wheel placed conveniently on the front of the filter.

"The operation of cleansing a filter is as follows:—the inlet valve being closed, the water filters away, leaving the tank nearly empty; the outlet valve from the disc shaft is then closed, and the waste valve opened; next the disc shafts and discs are set revolving, and at the same time the spray valve is opened, and jets at high pressure are discharged from the spray pipes. These being raised and lowered between the revolving discs, the whole surface of the cloth is swept by the spray, and deposit washed off and carried away through the waste pipes, leaving the filter again fit for use. With the thirteen filters working, the operation of cleansing, which occupies under two minutes, has to be repeated every seven or eight hours, when the plant is passing water at the rate of $2\frac{1}{4}$ million gallons in twenty-four hours."

The filters above described were invented and patented by Messrs. Atkins, and it is stated that the cloths have a life of over eight months, filtering day and night continuously.

As an example of water softening on a large scale by the continuous process in closed vessels under pressure, on the system invented and patented by Mr. H. Porter, and generally known as the Porter-Clark system, the apparatus at the Penarth Dock Station of the Taff Vale Railway near Cardiff may be referred to.

The hard water and lime water in the proper proportions are admitted into a closed cylindrical vessel, 4 ft. 9 in. in diameter and 20 ft. in height, the contents of which are kept in constant agitation by revolving T-shaped vanes. From the top of this vessel the softened water is carried by a pipe to the bottom of a second cylindrical vessel, 7 ft. in diameter and 20 ft. in height, in the lower part of which are shelves so arranged as to baffle the water in its passage to the top of the vessel, from whence it is carried by a pipe to a third cylinder similar in construction and size; and from the top of this last vessel it is conveyed to the filter presses, which are of the usual construction employed to press sewage sludge. It is stated that a square foot of filtering surface will supply filtered water at the rate of 30 gallons per hour, the amount varying according to the pressure under which the filtration takes place. On an average the cloths are changed after being used about twelve hours, and after being cleansed in a power-washing machine are ready for further use. A full description with drawings of this apparatus will be found in a Paper by Mr. W. W. F.

Pullen in Vol. XCVII. of the Minutes of Proceedings of the Institution of Civil Engineers.

It is found with these filters, in which cloth is the filtering material, that the carbonate of lime which is deposited upon the cloth in very fine crystals becomes itself a very perfect filtering medium.

Sir Charles Cameron (Dublin) asked what would be the estimate cost per million gallons. He also enquired whether the operation, explained by Mr. Law, was applicable to water, which having been filtered at a distance from the town where it was used, was received into a service reservoir. Very often solid matter made its appearance in such water, especially small crustaceans and even eels. The water works at Dublin were from twenty-five to twenty-six miles from the city, and the water was brought within five or six miles, and then stored there about three weeks. But they found that small crustaceans and eels and organic matter subsequently made their appearance in the pipes. He had advocated filtration from the service reservoir, and that the water should be used as soon as possible after filtration.

Mr. Rogers Field, M.Inst.C.E. (London), said there could be no doubt that the process described by Mr. Law was a very valuable one, and it would be a good thing from a sanitary point of view if it were adopted more largely. For softening large quantities of water for public supply the process could be carried out with the greatest advantage, and with increased knowledge by the public on this matter he had no doubt that pressure would be brought to bear on Water Companies and Corporations who owned Waterworks, to soften the water they supplied when it was hard. That could be done effectually, and there was no very great difficulty in it as long as it was done on a large scale. Where, however, the water was not softened on a large scale difficulties did arise, and especially when it was a question of a domestic process applicable to small houses, as the smaller the houses the less inclined their occupants were to have trouble and to provide a series of tanks. To overcome this objection various arrangements of taps had been invented for supplying the lime water and the hard water together, and at first sight these looked very simple and nice. Some years ago, however, he made a careful investigation into the different processes there were for softening water on a small scale, and took trouble to find places where they had been in action for a considerable time. Then he discovered the difficulty there was in practice, viz., that the taps which had to supply the lime water were very liable to choke up, with the result that they failed to give the right proportions between the lime water and the hard water, so that the softening process was not properly carried out. He was afraid that the apparatus had yet to be invented which would enable them to soften water satisfactorily on a domestic scale in small houses. With regard to the softening of public water supplies, however, there was not a shadow of doubt that it could be done, and done cheaply. The expenses would be exceedingly small, and he thought the Water Companies and Corporations which owned Waterworks, would be well advised in adopting it. To take only one item of saving, the money people paid for having their hot water pipes cleaned was more, he had no doubt, than the small extra charge they would have to pay in consequence of the public water supply being softened.

Mr. William Whitaker, F.G.S. (Southampton), said that Mr. Law had pointed out a difficulty in getting the proper mixture of the lime water and the water it softened. That, however, in his opinion was to a large extent a theoretical difficulty, for in all large softening operations you did not want to thoroughly soften the water; so that there need be no excess of lime water used. In the Southampton Waterworks the original hardness of the water came to about 18°, and Mr. Matthews, the Engineer, softened it down to about 8°; below which was too soft. As far as the Sanitary advantages went, he did not think there was much difference between hard and soft water; but it made a great difference to boilers, and it was really an Engineering and not a sanitary matter. There was a difficulty in getting rid of the residual deposit, and he believed there was an opening to make a profit out of this waste product. "Make Whitening out of it" might be said, but unfortunately this residuum was not a mechanical but a chemical precipitate, and whitening could not be made of it, for it would go off almost at a breath. The question was asked by Sir Charles Cameron as to the cost per million gallons. At Southampton, roughly speaking, the cost was ¼d. per thousand gallons, and this would make the cost per million something between a pound and a guinea; in deference to Sir Charles' professional feelings he would put it at a guinea. At Bedford, a town of about half the size of Southampton, the cost was estimated at about ½d. a thousand gallons. It was a curious point about Water Companies that while they pooh poohed the idea of softening water for the public use, they sometimes took care to soften it for their own boilers.

Dr. Axford (Portsmouth) said that as a medical man he must take exception to a remark which had fallen from the last speaker, viz., that from a sanitary point of view the matter was of little consequence. He contended it was a matter of the greatest importance. The water of Portsmouth was hard, and as a consequence he had cases of disease come under his notice entirely due to the hard water. The hard water we used no doubt produced skin diseases, and in some localities it had been known to produce stone in the bladder and kidneys.

Mr. Frank R. Chappell (Portsmouth) contended that the important factor in this discussion was the question of cost. It was a pity that no comparative statement had been made, showing on one side the cost of softening the water, and on the other an approximate estimate of the loss to the community, by the use of hard water, through the great waste of soap and the destruction of hot water pipes and boilers. It must also be considered that soft water was not wanted for many purposes such as flushing sewers, &c. Generally speaking he did not think that water containing from ten to twelve grains of hardness per gallon required softening.

The PRESIDENT of the Section (Mr. James Lemon) said that with regard to what has been said the Corporation of Southampton were fully alive to the importance of not using too much soft water, and they had used water from other sources for watering the streets. That system would be extended to save the cost of softening, and it did seem absurd to use the beautiful clear softened water for watering streets and flushing drains.

Mr. H. LAW, M.Inst.C.E. (London), in replying on the discussion, said that Mr. Whitaker had sufficiently answered Sir Charles Cameron's question with regard to the cost. In works like those at Southampton, where they had machinery, the cost was greater than where they had settling tanks. In the latter case the cost amounted to little more than the lime and the pay of one or two workmen to carry out the work. Undoubtedly filtration might lessen the hardness, but in answer to Sir Charles Cameron's second question he should reply that the softening process was applicable for all the hard ingredients of water, which would be removed by boiling it. He desired to emphasize all Mr. Field had said upon the subject, for that gentleman had had a very large experience in observing the working of small softening apparatus for domestic supply. With regard to getting rid of the sludge, it was found to be a very valuable top dressing for land, and in some works, as at Luton Hoo, the sludge was taken from the bottom of the tanks and put upon the land. It also made very valuable tooth powder.

On "The Cause and Prevention of Typhoid Fever," by W. R. MAGUIRE.

THE limited amount of time allowed for the consideration of the subjects brought before this Congress compels an abrupt brevity not always undesirable.

The prevention of typhoid fever is a subject worthy of close attention, even when briefly considered.

To prevent any occurrence of disease we must know something of its nature, its causes, and its antidote.

Sir Charles Cameron, the President of this Congress, has clearly described typhoid fever as "distinctly a germ disease, caused by specific germs which exist in the infected soil, and ascend into the atmosphere at some seasons in greater numbers than in others."

Dr. J. W. Moore, of Dublin, states in his recent work on eruptive and continued fevers, that "since the discovery of Eberth's Bacillus Typhosus, and the establishment of its causal relation to enteric fever, the doctrine of the *de novo*, or spontaneous origin of the disease, whether without or within the body, has become untenable. Enteric fever arises only when the spores of these specific microbes enter the body, especially the intestinal canal, of a susceptible individual."

But the state of health which accompanies habitual constipation, with fœcal decomposition in the intestines, the result of that constipation, enormously increases the susceptibility of an individual, and in fact acts so powerfully as a *predisposing cause*, as almost to appear to be the exciting cause of an attack of the disease. Under such circumstances a very minute dose of the specific poison will suffice to kindle an attack of enteric fever.

Enteric Fever probably arises in the following way: the specific bacilli, or rods, form spores inside the organs of one sick of the disease, especially in the mucous membrane of the small intestine. The micro organisms are then discharged with the motions in their most resistant condition, *i.e.* as resting spores, and thus pass into leaky or faulty drains or cesspools, or into the ground. In these situations they may remain quiescent and harmless for a long time, for want of suitable nourishment or temperature. At last these spores arrive by chance in a body capable of being affected, and there they develop into bacilli, to begin anew their cycle of existence.

These germs of typhoid may be transported on currents of air. If they are inhaled and drawn into the lungs pythogenic pneumonia may be caused. If they come into contact with pure water, milk, or food they may be conveyed thus to the human intestine, there to breed and develop typhoid fever, and the period of recovery may extend from four to twelve weeks. The incubatory period is uncertain, but is some time under twenty-one days.

The stools of typhoid patients cannot when fresh, communicate the disease, but within twelve hours the infectious properties may be developed. All typhoid dejections should therefore be destroyed by some powerful disinfectant. Certain peculiarities of constitution seem to favour an attack of typhoid fever, and others seem to give protection. Through constant exposure to the poison the human system apparently becomes habituated or inured to its evil effects; enteric fever has thus some resemblance to dysentery, ague, and malarious fevers. Removal from a healthy locality into an infected one is a powerful predisposant to typhoid. One severe attack generally protects the individual from liability to a second; but well-authenticated cases have occurred of typhoid fever contracted a second time. Typhoid is most prevalent in autumn, and it attacks rich and poor alike; overcrowding, on which typhus fever thrives, cannot be said to cause typhoid. Enteric fever may be communicated to others from the decomposition of infected excreta —outbreaks of typhoid can usually be traced to direct infection or poisoning of air, water, milk, or food, with decomposing infected excrement. The coming and going of epidemic diseases such as typhoid fever depend upon a combination of conditions. Upon season, temperature, rainfall, atmospheric pressure; upon rising, falling and flowing of underground waters: upon water supply, drainage and other sanitary conditions. The effects of these can best be studied as they occur within towns or districts which have been for long years occupied by man and subjected to continued accessions of pollution.

In old cities, where the old sewers and drains originally intended for rain and surface waters, roughly built of masonry or formed defectively of unjointed pipes, having flat gradients, tide locked at the outfalls, have been employed to carry or to receive yearly increasing volumes of excreta, it is plain that the subsoil and the underground water must become saturated with sewage matters. It is in such districts where fœcal impurity accumulates in the subsoil that typhoid is disseminated by the introduction of contaminated underground air into dwellings, and that cholera and typhoid are spread where the drinking water is drawn from wells; these results occurring markedly in certain conditions of the atmosphere, and influenced by the movements of the underground waters. During a dry warm summer the ground-water level falls and draws volumes of air into the ground to replace it; the subsoil impurities pollute this air in some years more than in others, the extent of pollution depending on the condition of the ground, on the length of time the air remains in stagnant contact within it, and on the meteorological conditions of the pressure, moisture, and temperature of the atmosphere. When at the end of a dry hot season the rain falls on the surface of ground thus impregnated with foul air, it seals up the surface pores of roads, streets, and yards through which the air had previously been drawn down, but the underground pores remain laterally open right and left, affording

free passage to the polluted air pent between the falling and rising waters, above and below, whence it is forced through dry foundation walls and basement floors of dwellings, whose pores are open and unsealed by rain water. And as it is an almost universal practice for householders to allocate basement rooms for use as larders, pantries, dairies and kitchens, to say nothing of servants' bedrooms, the persons there living, and the food and drink therein stored, receive the first concentrated impact of the incoming flow of polluted underground air and absorb the infinitesimally minute impurities so conveyed to them.

As a general rule, to which there are also exceptions, it has been observed in populous districts that when the ground-water has remained sometime very low and is beginning to rise, driving out the ground-air, disease becomes prevalent. When ground-water is falling and drawing in the air diseases abate in virulence. The first flow of rain or percolation through the ground, from any cause, after a long dry season is favourable to the spread of typhoid. The fluctuations in ground-water level vary greatly according to the locality, from 100 ft. in some inland places to a very few feet close to the sea shore, the smallest amount of rise and fall giving the best sanitary results. Low water years are usually unhealthy periods, and high water years are healthy; but high water rapidly following low water gives rise to epidemics of typhoid. Pettenkofer showed by his investigations at Munich a close connection between typhoid and low water level, owing to the fact that drinking water was chiefly derived from wells into which the polluted subsoil waters had drained. The American records bear out these observations. In these countries in towns where pure water supply is provided, typhoid fever tends to prevail in Autumn when ground-waters reach their lowest level and then commence to rise.

The typhoid death-rate during the outbreak in Paris, 1882, clearly followed the lines of the rainfall there. Mr. Durand Claye published official records showing that the fever first appeared after a rise of ground-water, and the outbreaks investigated in this country also confirm that observation.

Outbreaks of typhoid have been traced repeatedly to special dates of heavy rainfall following low ground-water periods.

Old cities and towns in addition to other insanitary conditions, are usually honeycombed with old wells, and these receive contamination from defects in drains and yard surfaces; the polluted waters flow on percolating unceasingly underground towards the river and the sea, and carry the impurities a certain distance through the soil, distributing the pollution thus to an extent little understood or realized. The impurities accumulate in the subsoil while the waters pass on purified as by filtration, and if among these impurities the bacilli of typhoid be existent, we can understand how that disease is spread. Strange as it may appear, the introduction of improved water supply to such cities, by causing the old wells to be disused and to overflow, seems to increase rather than to diminish the prevalence of typhoid fever. Sanitarians become responsible, knowing these facts, to use their influence in warnings, advice, and practise to preserve the ground on which dwellings are erected in town or country from all such contamination, whether from polluted rivers, or foreshores of the sea, from defective main sewers, from leaking house drains, surface soakage from stables or farm yards, streets and roads, or from pollution by any cause of the underground waters.

Experience and reason thus point to the free underground waters in polluted malarial condition as one of the chief cultivators and carriers of typhoid fever. The best way to preserve a city from epidemics of typhoid fever is to render the subsoil underground waters pure by means of perfect drainage and pavements. In cities built on tidal rivers intercepting sewers carried along the river banks will cut off that main artery from sewage contamination. The citizens are thus relieved from the twice daily back flow of foul waters through the sewers and subsoil, a certain cause of typhoid. The foul sewage will be more rapidly removed, but all the street sewers and house drains should be rendered self-cleansing, impervious, and otherwise perfect, so as to prevent the escape of dangerous sewage matters into the surrounding subsoil and to preserve the purity of the underground waters.

Nothing will deliver our cities from the curse of typhoid until something is done by law or otherwise sufficient to ensure that every public sewer and every house drain, and every branch drain and every junction, is sound and efficient to fulfil its intended purpose, to convey every drop of foul liquid and every particle of solid matter which enters them to a safe outfall; until every yard surface is paved with impervious pavement, over which every drop of water that falls on it shall be carried direct to its proper gulley-trap; until every street is so paved and graded that all its surface-waters shall be caught and conveyed to its special conduit, and nothing suffered to pass into the subsoil; until every sewer under every street is rendered air-tight on its inner surfaces, and quickly self-cleansing by proper falls or proper flushing; until the products of human and animal combustion are carried away within the twenty-four hours and disposed of in some harmless manner.

The pollution of the air we breathe, and of the air which surrounds our food and drink, follows this pollution of the earth, and of the waters under the earth, as surely as the night follows the day.

This communication of the disease is effected most frequently by drinking-water which has been infected by the specific germ. Professor Brouardel tells us that the proportion of 80 per cent. of typhoid cases investigated by him, and traced to their sources, was due to infected drinking-water; and in this country the disease has occasionally been traced to the milk supply, which had evidently been infected by abnormal contact with impure waters.

What, then, constitutes impure waters?

Strangely enough, the purest water most greedily absorbs infection when exposed to polluted air. Hard waters, whether stored in private wells, in public reservoirs, or in distributing house-cisterns, when impregnated with carbonate of lime or magnesia, will resist pollutions from the surrounding atmosphere, while pure soft waters will absorb them rapidly. Hard waters are unsuitable for domestic purposes, yet they are said to be the most healthful waters for drinking; but I belive that pure soft water, such as that supplied from Loch Katrine to Glasgow, and from the river Vartry, in Wicklow, to Dublin, while pre-eminently suitable for domestic use, should be also the most wholesome for drinking, except where such water is exposed to impure air rising through and from an infected subsoil, which attacks and dangerously pollutes that class of water in such circumstances.

Milk, meat, food of all kinds stored in basement rooms and larders, or in meat safes in yards and confined spaces, are liable to this infection from polluted air, and may thus become vehicles for conveying the infection to susceptible persons. Enteric fever or typhoid is an ubiquitous disease found in all countries and in all climates,—in Iceland, as in the tropics—and it is endemic, dwelling, unfortunately, among the people of the Continent and of the United Kingdom and Ireland, and wherever human beings hold intercourse.

The period of the maximum activity of the typhoid germs when the disease assumes epidemic proportions is determined by meteorological conditions, and perhaps by the annual autumnal debility and decay manifested by nature in the change and fall of the leaves, and in the miasmatic autumnal vapours which we observe hanging close above the ground, and in the autumnal failure of health-giving sunshine and daylight. We find at this same period of the year hundreds and thousands of dwelling-houses, especially those belonging to the wealthy class, unoccupied during the long summer days, and whose probably defective insanitary arrangements, disused, neglected, untrapped, and unventilated, are suddenly at this coincident period brought into use, the houses occupied by returning families with children and servants who had been residing during the summer months away in purer air at the seaside, or enjoying continued out-of-door life in the brighter sunshine of other countries.

We find the autumnal change of temperature also affecting the question; for while the summer air outside the dwelling-houses is warmer than that within, no fires are burning under the chimney flues, all windows and doors are opened day and night admitting the outer air direct, instead of, as in winter, drawing it up through the ground; and all this healthful process going on during June and July, making them our two healthiest months; then comes a change, soon followed by the rise of typhoid fever, sick and death-rates. Families return, autumnal chills set in with copious rainfalls following dry seasons in these islands. Doors and windows are tightly closed, fires begin to glow, and heated chimney shafts to draw in air which must rise through the ground polluted from subsoils infected by leakages from defective drains and sewers and subsoil waters; this underground-air, gathering pollution as it passes, rises through foundations, walls, and floors, into basements, where it silently contaminates the food and drink stored in cool basement, cellars, and pantries.

And moreover, in cities these underground pollutions are carried by the flow of subsoil waters from house to house and from well to well; so that although one house may possess perfect drainage arrangements, it may unfortunately suffer from underground pollution communicated from defective drainage of the surrounding houses.

The movement of pure ground-waters under pure ground, rising and falling and flowing onwards, would cause health and salubrity, it is the pollution of ground-water which renders it a source of danger. Stagnation of every kind is allied to death, whether of the contents of the veins, the intestines, the house drains, public sewers or underground waters.

In country houses the same dangers may arise if underground waters are allowed to become contaminated from cesspools, defective drains, stable and farmyard surface soakage.

But in towns and suburbs we find many sewers (and we have no choice but to connect our drains into them) loaded with foul deposits from two to twelve inches deep, giving off foul gases which are both offensive and dangerous. These deposits are caused by the insufficient fall or by the needlessly large dimensions or improper sections of the sewers, which defects prevent sufficient

cleansing scour. Other sewers are subject to tidal back-waters, which cause deposit, or are built so close to front walls of houses as to be a constant danger to the residents.

It is a common practice in town houses to carry the house drains crossing the house out under the scullery, which is usually placed under the hall steps, and thence out under the communicating coal vault direct to the public sewer, which often happens to pass close by the coal vault wall; this practice I have condemned for the last 15 years as dangerous. The proper course for the house drain is across the open front area, in order to secure an effectual open-air break between the public sewer and the house wall.

This technical point, which is one of the most important details of town house sanitation, needs to be insisted upon strongly, for the public, and, indeed, many sanitary contractors seem unable to appreciate its importance.

To prevent the entrance of typhoid and other germs all house drains should be cut off or intercepted from the main sewers. Otherwise the main sewer, which carries or contains, as the case may be, the excreta of all the infectious diseases of the city—poured into it from fever hospitals and from infected houses—sends its polluted air up the house drains and pipes, whence it is infallibly drawn into the warm houses through every defect and through imperfect traps, especially when at night the doors and windows are closed. Physicians have frequently given testimony to the nocturnal retrogression of their patients suffering from typhoid fever from this cause.

Intercepting traps on drains are generally much too large; 6, 9, and even 12-inch traps have been removed by the writer from drains of houses and replaced by 4-inch traps, with the result that although the large traps caused frequent stoppage of the drains and all attendant dangers, the smaller traps have never given any trouble, because every flush of water is sufficient to cleanse them fully. The drains themselves are also too large, but it has been clearly demonstrated that where 6, 9, and 12-inch drains were formerly used, 4, 5, and 6-inch drains are more efficient, cheaper and safer.

It is understood now that interception means much more than trapping a drain. It is of equal importance that, in addition to the trap, an ample open-air space shall be provided between the trap and the house drain—this space may be covered by a grating or remain quite open, to act as a fresh air inlet for the ventilation of the drain. If this grating becomes choked by leaves or dirt, so that fresh air has no longer free purifying access to the drain and trap, then the interception is nullified, and the drain is placed in single-trapped connection with the sewer. Care must be taken, therefore, to prevent this danger of the closing-up of gratings.

When placing intercepting chambers or intercepting traps on drains in areas, which is the proper position for them in town houses, it should be remembered that the area is a confined space, and that the basement windows, and generally a scullery or kitchen door open upon it; therefore, that air in the area is drawn direct into the house at these doors and windows. Therefore, the open grating on the drain should be safely arranged, so that in the event of any return of drain-air back through the grating intended as an inlet for fresh air, this foul air shall not be drawn into the house.

It is a good plan to extend the open-air inlet by means of a tube right up out of the area and to carry it through the foot-path parapet wall to the street, fitted with a vertical grating where the air will pass freely in, and where a chance return of drain air shall not enter the house. These return whiffs of drain-air will not occur if the vent shaft arrangements are properly formed and extended above the highest roofs in front or rear. Extract shafts should be treated just as the flue of a stove—the exit carried to a high point above windows and roofs, where foul air may pass away as freely as if it were smoke from a flue. And then the draught on this flue or vent shaft must not be spoiled by carrying other and lower rain pipes or vent shafts into it from lower return roofs. This error is the cause of many of the odorous back whiffs observed from openings intended to act as fresh air inlets.

There is danger in building access or intercepting chambers too close to house walls, and in not cementing them absolutely air-tight. The fact that houses, especially when warmed in autumn and winter, draw or suck in the underground air through walls and basement floors in large volumes, should always be present to the mind of the sanitary engineer. It is often very difficult to convince practical men that this action takes place. There are many other technical defects which are dangerous.

The inspection and cleansing arrangements for the drain outlets are often left unsealed, and are dangerous; therefore, these openings should not be led into manhole chambers but to open air.

The inspection and interception chambers are often unskilfully formed, so that they become very filthy and eventually dangerous. The interception traps are used much too large, and, therefore, are not self-cleansing; ordinary water-flushes pass through and leave a residuum, they choke in time, and the drain fills up with solid filth behind them, so that drains leaking

in any of the joints or through defects in the pipes foul the sub-soil under the basement. Access eyes of open traps and of drains are often placed in position and not rendered air-tight, where the drain-air may be drawn into windows or may pollute food stored in meat safes in areas.

Grease traps of large dimensions are attached to scullery trough wastes and are not cleaned out for months at a time until the grease has decomposed.

Ventilating and soil pipes are fixed of such light material that no proper and safe joints can be made on them; they leak, therefore, at all points, and passing windows the foul air enters the rooms; they are also allowed to discharge at dangerous points. Traps are attached to fittings, such as lavatory basins, baths, troughs, slop sinks, &c., at such distance below the fittings that quite a long length of foul waste pipe is left open between the trap and the fitting, and the air is contaminated. Other traps are so ill arranged, without proper outgo ventilation, that they unseal themselves or are unsealed by other fittings every time they are used. Sometimes one trap is made to do duty for several waste pipes. Nearly always the outgo gratings of basins, baths, and troughs present less area than the waste-pipe, which is, therefore, never fully flushed.

Disconnection of house fittings may be carried too far, every fitting may be trapped off from the drain, and no ventilating shafts provided to clear the drain of foul air. W.C's. with porcelain traps need very great care in connecting with the soil pipes. Frequently these over-floor traps are not connected securely to the soil pipes and allow foul air to pass into the house from the soil pipes.

Clay is still sometimes used for jointing drains, and light rain-water pipes are still used for vent shafts to soil pipes. Dry areas round house-wall foundations are often connected direct to foul drains and sewers, and the traps which might afford partial protection soon run dry, leaving the house in direct connection with the drains and sewers.

Field drains are used to drain the subsoil of houses and round the foundations. Great danger arises from these if they are in any way connected direct to the sewers, as often happens, or if a leakage occurs at any joint or point in a line of house drain, beside which these subsoil field drains are often laid, and so the foul air is drawn for long distances through the field drain into the basements.

In all works of construction the great importance of close attention to apparent trifles is known and acknowledged by engineers; the writer therefore hopes he may be justified in asking the patient attention of the members of this Congress to the comparatively simple subject of this paper, for it concerns the welfare of the community more than many greater problems, and it is hoped that good practical results may follow a discussion of the subject.

The commendatory words, "modern sanitary arrangements," and "sanitation perfect," commonly inserted in advertisements by agents for the disposal of houses are so frequently untrue or misleading as to constitute a practical danger to the public health. Sanitarians are especially bound to warn and to protect the public against such dangers. We leave a fair margin when we assert that 90 per cent. of the houses daily advertised for disposal are more or less dangerous as residences.

Let us consider this point. Owners wishing to dispose of houses place them upon an agent's books for the purpose; they almost invariably state that the sanitation is perfect; if illness had occurred in the house it is not mentioned. The house agent, an ordinary mortal enough, proceeds, as in duty bound, to dispose of the houses at their highest value without delay. He, being neither architect nor engineer, finds no professional duty incumbent upon him to investigate the sanitary condition of houses, he therefore properly accepts his client's assurances, and retails them to enquirers with possibly a *crescendo* movement. If the agent conveys any doubt, by word or manner, as to the perfect sanitary condition of any house, the enquirer takes prompt alarm and forms a strong opinion that such house must be bad indeed. The house remains on the agent's hands unlet or unsold.

The writer has suggested to house agents the idea of keeping two distinct lists of first and of second-class houses. The first-class list reserved for houses examined, tested, and certified by competent sanitary engineers responsible for their certificates, all other houses being relegated to the second list, for which the agent should accept no responsibility. Experienced house agents regarded the idea as Utopian, and said that they might as well give up their business as attempt to carry out such a scheme.

Standing thus in the forefront of this question is the fact that the house agents are employed by owners solely for the purpose of disposing of their houses, and that in order to ascertain the condition of any house some independent authority must be employed on behalf of the intending purchaser or tenant. It is unreasonable to expect any house agent voluntarily to advise or suggest the employment of expert sanitary surveyors to examine and report on the condition of their houses so long as it remains true that ninety per cent. should be condemned by such examination. This, then, is a practical subject for consideration, and it is necessary to impress the public with the great importance of clearly understanding the nature of the danger.

The sanitary condition of any house may be ascertained, if the owner consents to the investigation, by any qualified engineer, architect, or sanitary surveyor known to possess the necessary special sanitary knowledge, the necessary practical sanitary experience as an expert in house sanitation, and the necessary firmness, truth, and thoroughness of character which are essential to secure an effective sanitary examination. Such an engineer will make a systematic, thorough inspection of any house, he will rigidly test the drains and fittings by the searching methods now known to sanitary experts, and he will give an honest and carefully written report on the facts ascertained and on the sanitary requirements. It is a most important point for every person about taking or buying a house to refuse to sign any document until the full facts concerning the sanitation of the house have been definitely ascertained. After a binding agreement is signed it becomes difficult to secure satisfaction in the event of the arrangements of the drains and fittings proving insanitary. Instances come to our knowledge every week of worry, trouble, and loss thus occasioned by signing agreements in haste and repenting at leisure without means of redress. If it is essential that some agreement shall be signed before the owner will permit the opening of ground necessary for a thorough sanitary examination then the agreement should be framed so that the person to be employed to inspect and certify shall be such a one as described, and his name should be inserted in the agreement; great care should be given to this selection, for under such an agreement the future health of the tenant and his family will depend upon the engineer doing his whole duty. The agreement should bind the proposing tenant only in the event of the house being certified as perfect, or on its being rendered perfect within a stated period, and upon the production of the engineer's written certificate.

Then again, danger often exists in carrying out such works from the want of skill, the careless spirit, and the negligent habits, too often characteristic of artizans—much of this must be attributed to the lack of proper instruction and education, but whatever the cause may be, we find the danger confronting us, which calls for constant vigilance and much experience on the part of the engineer—no doubt the need of proper technical education and practical craft instruction is fairly acknowledged now by thoughtful men, and efforts are being made to supply the deficiency, but many years must elapse before the artizans themselves will really learn the value of proper trade-craft education, and before the public will gather the harvest from the seed now being sown—here a little and there a little, line upon line, precept upon precept, practice upon practice.

In the plumbing craft there is an awakening to be seen, perhaps for the reason that no craft needed it more, and every encouragement should be given to such efforts after improvement.

An employer who knows his business in theory and practice will appreciate good workmen and employ none other, but he often meets a negligent workman, and with such persons who can deal? Such a man's knowledge of his craft serves only to enable him to scamp his work and hide the knavery; this is one of the greatest of the dangers we have to face in sanitary work.

A competent engineer designs a perfect system of main drainage, or of house sanitation, he selects a competent contractor, but the difficulty of ensuring absolute soundness in the work still exists. Care is now always taken, by those who know their business, to test every part of the work by rigid means; too often these tests reveal defects, and the work has to be done over again. That means, in many cases, the removal of the defective work and the complete renewal of it; but it sometimes means, when work is needed in urgent haste, that no time for such renewal remains, and that the engineer is compelled, much against his own will, to allow the defects to be cut out and the work made sound in some undesirable fashion, *faut de mieux*.

For these reasons cheap work and cheap contractors seldom prove satisfactory. If employers who surround themselves with the best artizans they can train, find difficulty in always securing sound work, how can we expect that unskilled artizans at low wages can ever turn out good work under any circumstances. As a body of practical sanitarians this Institution knows well the anxiety and worry entailed in the supervision of all works where human life is at stake when we are dependent on the care and competence of workmen; there is no branch of the engineering profession requiring closer personal observation of details than that of drainage and house sanitation.

These dangers will only cease, and the prevention of typhoid fever epidemics be secured, when the law with a strong hand will provide for the enforcement of a perfect sanitary system equally upon all—individuals and corporations will never do all that is necessary. If the Legislature will not fulfil this duty the loss of human life will continue and increase every year that the world grows older.

This radical reform could be effected in the most complete way (indeed I see no other way to hope for it) by the appointment of a Minister of Health invested with ample powers to

compel individuals and corporations to do whatever is essential for the health of the community. Scientists and specialists are now sufficiently well agreed on the proper sanitary methods to prevent serious mistakes in sanitation, but power is required for their uniform enforcement. In this age of ceaseless progress in sanitary reform we may well complain of any carelessness or ignorance which still holds back so many responsible persons from intelligently adopting and promptly acting upon the clear answers now authoritatively issued in response to what, a few years ago, were but so many sanitary questions. Questions imply doubts, but we have now definite statements of ascertained sanitary facts established beyond doubt concerning typhoid fever and other diseases. If we act faithfully upon the basis of the knowledge already attained, typhoid fever shall be banished as effectually as we have succeeded in banishing small-pox, so that no case shall occur within the community unless actually imported from some infected district. It is the aim of this Sanitary Institute and of this Sanitary Congress to hasten the arrival of that good time.

On "The Smoke Clauses of the Public Health Act, 1875," *by* HUBERT L. TERRY, F.I.C.

THE state of the atmosphere in our large cities is a subject that is fraught with interest to the sanitary reformers of this country, consequently I have little hesitation in bringing forward the smoke question, although I am not sanguine that the views I hold will commend themselves to the majority of my hearers. It seems to be generally agreed that smoke is a nuisance, and that black smoke in particular is the incarnation of evil. Now, from a hygienic point of view, I do not feel at all sure that the case against black smoke has been made out. The legislature certainly concerns itself only with black smoke as evolved from factories and workshops, but there is a growing conviction amongst those who have gone into the matter that the grey smoke, of the household grate, is really a more deleterious product. Without going deep into the chemistry of the subject, it may be stated that while the high temperature of the boiler fire causes the hydro-carbons of the coal to dissociate producing hydrogen and free carbon, the lower temperature prevailing in the household grate, especially where the fire is made up to last a long time, produces a smoke consisting largely of oily hydro-carbons. These latter are naturally more injurious to organisms than is free carbon, which is recognised as a most powerful deodorant and disinfectant; in fact it is quite probable that black smoke plays an important part in the economy of town life in this respect. Apart, however, from its blackness, all smoke contains sulphurous acid, and it is to this body that the destructive action of town smoke on vegetation is really due. Considering the present state of our knowledge on the subject, the legislature very wisely omits any reference to this sulphurous acid, the agent which has destroyed the vegetation in such large districts in Lancashire and Southern Spain. Figures have frequently been given by writers on the smoke question shewing the amount of oil of vitriol poured into the air of our isles from burning coal. The yearly production of coal in the United Kingdom, allowing for exports and gas-making, would on the basis of 1 per cent. of sulphur, a low estimate, on combustion yield over 4,000,000 tons of sulphuric acid. Although such figures are liable to give the general reader an exaggerated idea of the evil owing to the extreme dilution in which most of this acid is formed, yet they serve to show that the evil is of some magnitude. I have gone into these details about smoke to show that any legislation which only deals with black smoke can have but very small results. And now for the point I wish to draw special attention to. Supposing for the sake of argument that black smoke is a great evil and worthy of suppression by Urban and Sanitary Authorities, I submit that these latter should be careful how in their zeal to purify the atmosphere they so harass manufacturers in their localities as to cause them to take wings and fly away to countries where such restrictions are not enforced. To take the case of chemical manufacturers, a class of men who are generally credited by the public as the source of all atmospheric pollution in the vicinity of their works. Without going into details as to names or places, I may say that the authorities of a certain town have recently seen fit to institute proceedings against various chemical manufacturers under the Smoke Clauses of the Public Health Act, 1875. In their defence the chemical manufacturers claim exemption under the saving clause which reads as follows. . . . . "The Court shall hold that no nuisance is created within the meaning of this Act, if it is satisfied that such fire-place or furnace is constructed in such manner as to consume as far as practicable, having regard to the nature of the manufacture or trade, all smoke arising therefrom, and that such fire-place or furnace has been carefully attended to by the person having charge thereof."

They feel assured that it was for such cases as theirs that the legislature admitted the saving clause. This, however, has been ruled against them on appeal. Now to my mind this clause would apply specially to chemical works where operations involving intermittent firing, the gradual heating-up of retorts and kilns, &c., &c., are necessarily productive of black smoke. It is one thing to fire a boiler for the supply of steam to a steady running engine, and another to fire it when steam is required for chemical purposes, and when the boiler pressure may fall 20 pounds in a minute or two. It would therefore seem that cotton mills and chemical works should not be classed in the same category. Supposing, however, that the spirit of the saving clause were admitted as being applicable to chemical works, this would necessitate the supplanting of the smoke inspector as found at the present time by a chemical engineer, or other person competent to express an opinion on the terms, "as far as is practicable," or "having regard to the nature of the process." The inspector of to-day is certainly not so qualified, and some dissatisfaction has been expressed by manufacturers who have come under his notice, as in such cases as the colour of smoke "personal error," is an important factor. In the case of a smoke prosecution, attention should be paid to the state of the weather. Were I an inspector and had a grudge against a certain chimney—I do not for one moment suggest that such cases really occur—I know what sort of a day I should choose for my inspection. The state of the weather will no doubt be considered by the qualified inspector of the future. In the foregoing I do not wish to be understood as approving at all of the emission of black smoke where such can be easily prevented. The smoke problem, as the direct cause of the injurious fogs in London, is one worthy the attention of our foremost scientific men, although contributions to the literature of the subject from the pens of practical men should be invited. The recent reference to the matter in the House of Lords, the trial of anthracite for house purposes, and the trials of smoke consuming appliances by Mr. A. E. Fletcher's committee, are all indications of the attention the subject is receiving. Smoke consuming appliances arise like the flies in summer, but the appliance is not yet on the market that will prevent a careless fireman from making smoke. To conclude, our local authorities —presuming that the prosecutions are instituted entirely from a Benthamite point of view—should be lenient in respect to chemical and allied works, especially when these form the means of livelihood to the working classes in their vicinity. We must not forget that our large towns in many cases owe their pre-eminence to their manufactures, and it would be impolitic to impose vexatious restrictions, especially when the benefit to be obtained is so problematical. No doubt it would be much pleasanter if our town atmospheres could equal the air of Grindelwald, but it is more than possible that we may have to decide between commercial supremacy and salubrity. Can we support our increasing population on pure air?

Without moving any formal resolution, I would submit that—

(1.) Local authorities should acknowledge the special applicability of the saving clause to section 91, sub-section 7, Public Health Act 1875, to chemical works.

(2.) That where the smoke clauses are enforced the inspector should be a chemical engineer or other person competent to carry out the spirit of the Act.

Dr. W. G. Black (Edinburgh) expressed the hope that the discussion would be extended to greater length than the paper, for the subject was one he regarded as of the greatest importance. The greatest sinners were the law makers themselves, who thus became the law breakers. Out of the chimney of the humble working man's cottage one might see thin blue smoke curling, but let them only go to the large manufactory in the neighbourhood, and from it came a large column of dense black smoke as from the summit of Vesuvius; striking anomalies like these ought to be mitigated by reasonable supervision. Staying at the marine and residential town of Scarborough he had once noticed dense columns of smoke issuing from the chimneys of the large hotels there, hotels which had been built on scientific principles for the use of health resorters. From the windows of the Queen's Hotel at Manchester his attention had also been particularly called to the density of the smoke issuing from the chimney of the Royal Infirmary, which was presumed to be under scientific management. The nuisance was so great to the streets that he communicated with the Medical Officer of Health there. The other day in Edinburgh he had especially noticed the dense smoke which issued from the newly and expensively built University Building, and from the "George Watson" School, polluting the atmosphere of the neighbourhood. In these two cases also he reported the nuisance to the Medical Officer of Health for Edinburgh. The evil in many cases arose from the inferiority of the fuel used, the want of smoke-consuming grates, and in the absence of efficient supervision of the lighting and management of the furnaces.

Mr. J. Oldfield (London) said the paper had been a most interesting one from many points of view, and one for which they must all thank the reader. The question of smoke was, he contended, distinctly one of degree. With regard to black smoke he felt that the blackness was not seriously the great cause of the fault, and the removal of the blackness would not remove the fault. That the carbon contained in black smoke was essentially injurious was proved by the fact that it affected the lungs of men who had to endure it, such as sweeps, colliers, &c., and when they remembered what serious injury had been caused in the North country by hydrochloric acid diffused by smoke, and how it had been removed by legislation to the ultimate benefit, even of the manufacturers, it was sufficient answer to the difficulty raised by the reader of the paper that legislation must not harass the manufacturers. The great thing they had to look at was the health of the community, and if necessary we must harass the manufacturers and send them from one place to another until they find a way to utilise these waste products that they sent out into the air and bring them to some useful purpose, as was done with the hydrochloric acid, owing to the legislation. It was done in the case of hydrochloric acid, and it could be done with smoke. If the legislature prevented them discharging the black smoke, then ingenuity would soon set to work to utilise this waste product in some useful manner. Near Ealing his attention had been called to a smoke pollution in the air arising from brick-fields, the air was absolutely pure in appearance but to breathe it caused a deathly feeling, and therefore he said the blackness of smoke was not the essential evil. It was, as he said at first, a question of degree, and when they had discovered the limit beyond which it was harmful to the community, then pollutions beyond that limit must be prevented.

Dr. J. Groves (Carisbroke) said he hoped to get some light in reference to a smoke poisoning which had harassed him for some years. It was a nuisance arising from cement works, and if anyone could help him to a solution of this nuisance it would be a great help to him and many other people, and would relieve a very great lady of what had been an annoyance to her at various periods. The sanitary authority of the locality were unable to do anything, and Local Government Board Inspectors under the Alkali Acts said they were doing all they could. So objectionable was the pollution that when the wind was blowing from the works the inhabitants had to close their windows a mile off. There was no black smoke but a smell, like the smell from brick-works—something very irritating—which caused people to cough a mile off and to sneeze. The smoke had been analysed again and again, but the most they could arrive at was that there was a certain amount of chlorine in it, though not sufficient to produce the effects of which he had spoken. It seemed curious indeed that in this advanced age they could not get that gross nuisance stopped.

The President of the Section (Mr. James Lemon) said that some years ago the cement works at Southampton were a very great nuisance indeed. He was one of the deputation which travelled through

England to get information about it, and they harassed the manufacturers until they at last induced them to do something, and the result was, that at Southampton they had no longer any nuisance from these works. They had a kind of cremator at the cement works and the fumes passing over this were practically consumed. During the last few years they had had no complaint to make of any annoyance or nuisance from these cement works.

Mr. H. L. Terry (Manchester), replying to various suggestions which had been made, said that at Manchester, as had been mentioned, the hotels and Infirmary were a source of nuisance, and they escaped without punishment. If a manufacturer had created as much nuisance for three minutes in the hour he would have been fined £5, and he contended that what was wanted was, that the law should be administered equally in all cases. There ought also to be a proper inspector to decide if the nuisance could be prevented. Wherever black smoke could be prevented it must be done, but with regard to utilising the waste products of smoke, he did not think they could see any way to do that at present. He had had no personal experience of the fumes from cement works, but he had been told they were strongly fertilising in their properties.

On "*Drain and Soil-pipe Ventilation*"—(*with a suggestion*)—*by* H. R. Kenwood, M.B., D.P.H., F.C.S.

I feel that it is unnecessary for me to insist upon the importance of this subject; indeed, it is admitted in the attempt now generally made to bring about a satisfactory Drain and Soil-pipe Ventilation; nor is it necessary to dilate upon the fact that danger results from inefficiency—danger, that is, against which it is our duty and our province to cope!

The Model Bye-laws enact, as you will remember, that for efficient ventilation it is essential to provide at least two untrapped openings in the drains. These openings are required to be respectively as near the upper and lower extremities of the drain as practicable. Paragraphs (a) and (b), section 65, of the Bye-laws, with respect to new streets and buildings, prescribe that one of the two requisite openings is to be at or near the ground level, and is to consist of a suitable pipe or shaft, or a disconnecting

chamber or manhole, placed as near as practicable to, but on the house side of the trap; and the second opening is to be by a vertical pipe or shaft (which may be the soil-pipe) carried up as far distant from the other opening as practicable, to a height of at least 10 ft., but so as to avoid risk of discharging drain air into any building. Such provision is made, of course, so as to procure a current of fresh air through the entire length of house drain (and soil pipe where such exists), and thus to exclude the possibility of the entrance of drain air, as such, into the house.

Now what are the conditions which may be held to insure that air will enter an opening in the base of a pipe say 40 feet high and escape at its upper end? There is no natural law with which I am acquainted which will insure this, and some provision must be made to rarefy the air in the pipe, and thus considerably diminish its pressure: as by warming it and causing it to expand.

With regard to the aspirating effect of the wind blowing over the top of a 4-inch ventilator, with its outlet protected by a small wire cap, its action must be at any time very small indeed, and its effect is probably not felt very low down the pipe; and cowls do not add to this effect. Moreover, the only factors which need seriously concern us in such an important matter as drain and soil-pipe ventilation, are those upon which we may count upon, and the wind not only "bloweth *where* it listeth," but also *when* it listeth.

The most recent and improved method is, as you are aware, to carry up the fresh air inlet to the drain and soil-pipe a few feet above the ground level, and to guard the opening by a talc valve flap; and it is the examination into the efficiency of such provisions that I have more especially concerned myself, for it represents the most recent and advanced sanitation in respect of this subject, and it is the one which is now confidently recommended, and which is becoming generally adopted.

My tests, then, have been especially directed to those houses in which the best provisions for such ventilation obtain!

The talc valve affords a capital means of ascertaining when an incurrent or otherwise is taking place, and in those cases where it is lightly hung, kept clean, and has perfect freedom to move within the valve-box, it is a delicate indicator of such currents. When there are none of these upon the inlet, I have had, of course, to resort to the test of the smoke from smouldering brown paper, or to note the effect produced upon small captive hydrogen balloons. I have examined 100 of these valve-guarded inlets in the front gardens or areas of houses, chiefly in the district of Chelsea.

At the commencement of my investigations I found pretty generally that the valve opened and shut intermittently, and that the extent to which it opened also varied, and I naturally asked myself the question, why this intermittency, and why this difference in degree of the air-current? It was obvious that if in the soil-pipe itself conditions obtained which were sufficient to cause the air to ascend it, such air must enter the inlet by virtue of a "vis-a-fronte" or aspirating effect. Why then should this aspirating effect vary every moment as it does in its intensity, and become a negative quantity with almost equal frequency? There is no altering condition of the soil-pipe and drain, except when a water-closet is being used for any purpose, and how often is this? certainly for not much more than twenty minutes altogether in every day!

It was not, therefore, difficult to see that if there was anything to induce soil-pipe ventilation at all within the drain and soil-pipe, that something must be a constant factor upon which we could reckon, except for, say 20 minutes every day, when it was disturbed; and that the valve should be ALWAYS opened, if not always motionless. The true cause of the intermittent and varying extent of movement in the valves, was clearly demonstrated to be due to external air currents (arising from external causes) which impinge on the valve, and not to any causes acting within the drain and soil-pipes themselves; and the effect of such external air currents in drain and soil-pipe ventilation must be practically nil, and cannot do much more than effect a movement of the valve. Valves which many would call "acting" were seen not to act when external influences were shut off as completely as possible by a card-board box, arranged so as to admit of plenty of air to meet any aspiration (suction) requirements, but so as to prevent the impact of an external and independent air current. And in this connection I would point out that it is not sufficient if the wind is blowing—say down a street—to guard the opening from the wind solely in the direction from which it blows, for, of course, it is deflected by steps, porches, etc., the current breaks up and eddies, and approaches the valve-box from almost any direction.

On several occasions I had the top sashes of the windows pulled down, and the inlets being close to, and on about the same level as the part of the window opened, the movements of the blind and those of the talc valve could be compared, and these were always found to be perfectly synchronous and to correspond in degree; and this again clearly demonstrates the true cause of the valve movements in the majority of cases.

To further convince myself however of the fact that external and independent air-currents were responsible for the movements of the valve in the great majority of cases, I then procured a detached valve-box and placed it alongside that attached to the drain inlet, and found that the movements in the two cases absolutely synchronized with each other. Lastly, gentlemen, where on the same day different valves have been working—I prefer to put it that way—in different degrees, I have frequently found a solution to the conundrum by finding that some are more protected from external air-currents by steps, etc., than others.

I would also warn you that, in conducting such investigations, the fact that a valve is seen to be open must *not* be taken as conclusive evidence of its "working." There are tricksters in every trade, and I have met with some cases where the valve boxes and valves are so fixed and fashioned, that the valve hanging plumb never closes the inlet, except when a back current is taking place, and sometimes not even then.

Drain and soil-pipe ventilation to be *thoroughly* efficient *should* be constant!—I think no sound sanitarian will dispute that fact—far less do I fear dissent when I contend that an air-inlet when provided should take *in* air and not send it *out*. I am convinced, from many carefully applied tests, that it is comparatively seldom that an air-current is induced to ascend the soil-pipe and ventilator; and in every case, where there is anything at all taking place, the current is of an extremely ephemeral nature, and is apt at short intervals to take a diametrically opposite course, to descend the soil-pipe and drain and to escape at the point at which the merest tyro in physics could tell that it should enter, if anything at all is taking place. This, however, would not be claimed to be of much importance where valves are provided (and hence the value of this addition) save that it shows that the principle is defective.

But what shall we say of those cases—numerous as they are—where the inlet is not guarded, and foul air escapes near sitting-rooms and pantrys to enter by the open windows? Here is a real source of danger! and to accentuate this fact I may point out, that once while examining such unprotected *inlets*, the back currents of air which frequently escaped here occasioned in me an acute attack of diarrhœa.

To further convince you of the occurrence of these down currents, I might add that in one or two cases I have placed a smoke-rocket well down inside the inlet pipe for fresh air, and noticed almost the whole of the smoke emerge from the inlet opening. In two cases which I had entered in my book as "acting intermittently," when I came to apply this smoke-rocket test I was able to get close to the exit opening (about

40 feet high), and not only in these two instances did I not detect the *slightest escape of smoke*, but on applying my nose close over the opening I could not even smell the faintest trace of it. Meanwhile a friend had been noting the escape of the *whole* of the smoke in heavy clouds, issuing in puffs *from the inlet.*

If there is any natural law, which might be expected to induce the air to constantly enter at the so-called inlet, by what controversion of that law can it be imagined that air shall escape, to almost the same degree as it enters, from the same opening? If this is the case—and I can show that it is—the fact reflects very seriously upon the efficiency of our latest provisions for drain and soil-pipe ventilation! One cannot watch one of these talc valves for two consecutive minutes, without noting that it is suddenly applied, under a slight pressure, against the window (or a cast shoulder in the face-plate) of the valve-box, and if the valve is *then* lifted, smoke is blown away from the inlet, and one's face commonly acquires a deposit of fine dust, and one's nose is assailed by odours which would not have been courted.

You will naturally be curious to hear, and you have the right to demand, some further information concerning the conditions under which I have tested such inlets. You will not consider that I have acted unfairly in selecting days upon which air movement was not too active, although on every occasion there has been a distinct though light breeze blowing; the shade temperature has varied upon the different days on which I have worked from 56 to 73, the Barometric pressure from 29·84 to 30·25. I have kept a list of the houses, the days upon which they were examined, together with the above-mentioned atmospheric conditions existing on these days, and the results of the 100 tests applied have been entered under three headings, *i.e.*—

(1.) "Not acting." These formed 58°/₀.

(2.) "Valve only very occasionally opened." These formed 23°/₀.

(3.) "Intermittently opened and shut with about equal frequency." These instances formed 19°/₀.

It must be understood that these results apply to inlets from which all external air currents have been shut off, and, in all alike, there were evidences of frequent back currents when the valves were removed, and the smoke test, and that of captive hydrogen balloons, were employed.

I have also noted the height (as judged by the number of stories of each house), and the course and point of termination of the soil-pipe and ventilator. I find that, very contrary to one's expectations, where talc valves are applied to the inlet, that the

movements of these do not appear to be influenced either by the height of the exit opening (I have not examined houses of more than four stories—*i.e.*, about 50 feet high), or by the number and nature of the bends in such pipes. Most of these have been carried up straight above the eaves, but in one remarkable instance—remarkable inasmuch as it was one of a very few instances in which I found any tendency to an aspiration effect induced—there were two rectangular bends, which are sufficient in themselves, by the resistance they offer to the flow of air to diminish the velocity of any current to one quarter the original! Sub-section 4, Section 65, of the Model Bye-laws with respect to New Streets and Buildings has been framed with an eye to this fact, though it would appear, on the evidence of this test to be of no great import, it runs as follows:—"no bend or angle shall (except where unavoidable) be formed in any pipe or shaft used in connection with either of the arrangements specified." In spite, however, of the great resistance offered, and *judging by the valve*, the inlet was acting with greater force than a neighbouring one in the same street which had the additional advantage of a straight soil-pipe and ventilator. One is acquainted with the fact that the unexpected is apt to happen with great persistency in this world, but when we find soil-pipe ventilation subverting all the laws of physics, it is logical to attack either the one or the other as being at fault. Gentlemen, it is the soil-pipe ventilation!

An idea which has occurred to me is so simple that I can lay no claims to ingenuity, indeed the principles of its application are so widely in vogue for other and different purposes, that I do not claim to have exercised any originality, and when I came to consider if there were any means of remedying the present unsatisfactory condition of drain and soil-pipe ventilation, it occurred to me so *spontaneously* that I could not believe for some time that it had not been already suggested—if not practised. I have failed however, strange to say, in finding any reference to it whatever!

I have always been struck with the persistence with which the bath room—and nowadays such is growing to be considered almost a necessity in every house—insists upon adjoining the water closet; why not therefore, where this is the case, take advantage of the hot-water circulation system to create the up-draught in the soil-pipe, which of course runs up the wall immediately outside the water closet? It occurred to me that all which was necessary was to connect a length of piping with the hot-water circulation system, it would only involve the removal of a brick in order to take this piping through the wall, two coils could then be conducted round the soil-pipe and ventilator, and the piping then returned into the hot-water circulation system again. The advantage to be gained by taking off this loop from the highest point to which the hot-water circulation system reaches is too obvious to need anything but mention!

Before the plan was put in operation I had some misgivings as to whether the increased resistance by friction which would thereby be offered to the flow of water, would affect its circulation, and accordingly I recommended that the curves should be made gradually spiral, rather than horizontal, so as to diminish friction. I also doubted whether the fact of thus conducting the hot water outside the house would affect the supply of hot water to the bath. Both these misgivings I find—a friend having kindly put the plan in operation—have not been justified!

The only other point which it occurs to me can be raised is, as to whether the part exposed may not be affected by frosts in the winter—of this I am assured by competent authorities, that if such exposed piping is incased in felt and boarded in, there is absolutely no risk whatever—no matter how severe the weather.

I must next speak of its efficiency! In the first place I would again adduce two points which we should aim at achieving, viz., that drain and soil-pipe ventilation should be made constant—and there can be no doubt that if this plan induces a current at all it must of necessity be a constant one—and also that the danger of the inlet allowing vitiated air to escape, where no valves are applied, must be guarded against. I would remind you that the hot water circulation is in action, as a rule, whenever the kitchen fire is alight, which in the majority of houses (especially in this age of late dinners) is all day long and late through the evening, through summer and winter alike; and that even through the night the pipes remain charged with warm water. Under ordinary circumstances no advantage is taken of this hot water circulation, save when the bath is used; but that when such a plan as I have indicated is adopted, it is always effecting some good in subserving drain and soil-pipe ventilation.

Does the plan ensure a constant entrance of fresh air into the inlet, and altogether do away with down drafts? I am in a position to say that in the case in which it has been applied that most assuredly it does, and that its effect has been uniformly satisfactory when tested under varying conditions of the atmosphere; that the opening of the ground level thus becomes invariably an inlet; and that the draft created is sufficient to draw in the smoke of burning paper from a distance of 6 inches from the opening, when the external atmosphere is quiescent and external air-currents are provided against.

If then the plan is efficient—and it appears to be so—it will provide a comparatively costless and a very simple means of effecting a greatly improved drain and soil-pipe ventilation, which will be welcome to those of us who consider that if such ventilation is a necessity at all, it should also be a necessity to effect it with the greatest possible degree of efficiency!

Dr. J. Groves (Carisbroke) said that people too often lost sight of the fact that there was a natural law which controlled ventilation everywhere—the law of the diffusion of gases. If Engineers would only keep this law always in view there would not be so many lamentable and ridiculous failures. Of course, if they made the air in the soil-pipe warmer than the sewer air the air would pass up, but if the air in the sewer was warmer than they made the air in the soil-pipe it would go down.

Mr. J. H. Ball (Portsmouth) said this matter was one in which even those of them who had been the least time at work had had some experience. Quite recently he came across an instance of the value of inlet ventilation at the foot of the soil-pipe. He had examined two adjacent ventilating-pipes, one of which smelt very bad, while the other was quite sweet. On examination he found that the air inlet near the foot of the one which was offensive had been closed, while in the other the current of air kept passing at all times, and the soil-pipe was free from smell. One more difficulty in the way of getting ventilation in house-drains as distinct from sewers was that the local authorities were so dreadfully handicapped in their insistance upon the right system, and the inspection of that system when it had been carried out. He thought it would be a matter of the greatest public service if they could get some one of undoubted experience to insist upon the advisability of bodies who had the health of a district entrusted to them having powers to see that proper sanitary arrangements in this respect were carried out in every house.

Mr. W. H. Axford, M.B. (Southsea), speaking as a medical man, said he regarded it as the duty of the profession to which he belonged to prevent rather than to cure disease. The difficulties they met with from obstinacy and ignorance were wonderful, and in this matter of insanitary arrangements in houses, as matters now stood they could only do away with the nuisance after the evil was done. He had come to the conclusion that house drainage ought to be done by the local authority, and not left to the owner or builder of the house. The authority should do the work and charge the cost to the owner. They had in Portsmouth a most elaborate system of drainage, satisfactory in the extreme, but the house connections were in many cases not so satisfactory as they ought to be. The difficulty was that people did not know how to do it, or would not go to the expense. Therefore he contended that the authority should do the work as it ought to be done, and charge it to the owner. That, he felt, would be the only way to insure a lower death-rate from infectious diseases.

Mr. Tom Nanson (London) said it is always well to strive after the ideal, but often there is a great distance betwixt the ideal and what is actually efficient. The ideal of drain ventilation is the passage of a constant current of fresh air through the drain. The scheme foreshadowed by the reader of the paper was not an impossible one, and should the necessities of a case require it he would be one of the first to adopt it. He thought that efficient ventilation could be obtained by fixing the ventilating-pipe on a wall having a south-east, south, or west aspect, so that it might be warmed by the sun in hot weather, and the ordinary current increased when putrefaction was most rapid; this would keep the house-drain sweet without going to the expense of Dr. Kenwood's scheme.

Mr. William Challoner (Blackpool) said that it had fallen to his lot to be one of the much abused individuals, a plumber, and Dr. Kenwood's paper dealt with that portion of sanitary work with which plumbers were most intimately concerned. The town of Blackpool, from which he came, was in an especially favoured position in this respect, for they had a sanitary inspector and staff of men who had nothing to do but inspect drains, on the house-to-house principle. He was rather afraid that the cure suggested by Dr. Kenwood would not act well in practice. There would be a difficulty in keeping the water at a sufficient heat, with an ordinary bath supply, to be of any avail when placed round the soil-pipe, and he did not think that one could be quite sure of preventing its freezing in winter unless it was covered with felting or some similar protection. He was also rather inclined to think, as Dr. Groves had suggested, the order of ventilation might at times be reversed. With regard to mica flaps, as the reader of the paper had said, he had found them break easily, and they required constant attention, which domestic servants did not give to them. One of the principal causes of their breakage was the pressure of air in the inlet-pipe, when the closet, probably a couple of stories higher, was discharged into the soil-pipe. The prevention of all the evils Dr. Kenwood describes can be effected without any of these contrivances; in a system of house-drains effectually trapped from the main sewer and the inside of the house, but open from inlet to outlet, if the inlet was carried up above the eaves and the outlet a little higher up the chimney stack, if convenient, and if not up the roof to the ridge, then the constant displacement of air in the soil-pipe and drains by the discharge of closet, bath, sink, and rain-water gullies would of itself, by natural means, prevent any danger or nuisance arising from stagnation of air in the drains, and any emanations that might arise would be delivered by either the intended inlet or outlet, and in either case high enough in the air to be practically harmless.

Mr. G. J. Symons, F.R.S. (London), said that the real question was that of the specific gravity of the two liquids. Cold air descended while warm went up, and in that they had the real explanation. With regard to this question of ventilation he desired to direct attention to the clear and able article by Mr. W. N. Shaw, F.R.S., on "Warming and Ventilation" in the "Treatise on Hygiene," which had just been issued by Mr. Shirley Murphy and Dr. Stevenson.

Mr. W. J. Fletcher, F.R.I.B.A. (Wimborne), said there was nothing in sanitary arrangements more important than the question they were now discussing. It was no use having house drainage carefully designed and executed unless the drains were ventilated properly, and he hoped nothing that had been said would prevent people maintaining the system at present laid down in the Model Bye-laws of having the two untrapped openings in every system of house drainage until something better was found out.

The President of the Section (Mr. James Lemon, F.R.I.B.A.) said he looked upon the ventilation of drains in the light of a safety valve, and he should be very sorry if any discussion they had should make the general public lose confidence in the ventilation which already existed. Though the system now adopted was inefficient, he should be very sorry to see the day come when the ventilation should be given up, for in some form it was essential. They might criticise more or less the model Bye-laws issued by the Local Government Board, but let them consider the conditions of towns which had no Bye-laws at all! A case had recently been brought to his notice in which it took about five years to get Bye-laws passed for a town, and the only remedy he could suggest to avoid such difficulties was that a Building Act should be passed to do away with Bye-laws altogether. They had a Building Act for the Metropolis, and he did not see why they should not have one for the whole of the country. Local surroundings could be dealt with by the local authority, but the strength of a wall was the same, and the laws of gases were the same all over the kingdom. And there would moreover be this advantage about it; there would be a certain amount of appeals, and the decisions which were given would be of use in guiding the community at large, the one law governing them all. The sooner they got legislation of that kind the better it would be for all the country.

Mr. H. R. Kenwood, M.B. (London), in replying to the discussion, said the question had been raised as to whether the suggestion which he had made would be satisfactory in practice; well, it had been put into practice and was found to work most efficiently. He was assured, in the case where it had been tried, that the provision was sufficient to create a continuous indraught; but he regretted the fact that hitherto he had not, himself, had the opportunity of witnessing the plan in operation. With regard to the accusation made that the aim of a constant up-current was too idealistic, he urged that they must go for ideals or they would cease to make progress. In aiming at an ideal the result was never more than an improvement in the original state of things; the ideal itself was never reached. He did not consider that any suggestion likely to effect good should be considered too idealistic when it had reference to the Public Health. As to the question of aspect, he thought it was going rather too far to suggest that aspect alone would insure a sufficient difference in the temperature all the year round, to effect much in the matter of drain and soil-pipe ventilation, though it was doubtless a factor which should be taken advantage of whenever possible, when planning the sanitary provisions of a house. He could assure the gentleman who feared the effects of frost that it would be found practicable to guard against this danger in the manner he had indicated in the Paper, *i.e.*, by the use of felt and a wooden casing. With regard to Drs. Stevenson and Murphy's "Treatise on Hygiene," mentioned by Mr. Symons, it could be read with the greatest advantage by all; and Prof. Shaw had contributed a most able article upon "Warming and Ventilation," in which the physics of the subject were treated of most exhaustively, and from which much valuable information might be gleaned. In conclusion he thanked those present for the kindly interest with which they had received the paper.

On "*The Pollution of Rivers and Canals by Manufacturing and Industrial operations: with special reference to recent processes for the prevention of such pollution*," by W. Hepworth Collins, F.C.S., F.G.S., F.R.M.S., &c., &c.

The recent action of many of our County Councils and Sanitary Authorities, together with trading-concerns and riparian owners possessing pecuniary interests in the preservation of water-rights and river and canal carriage, has undoubtedly wrought much good, and served a most useful purpose in calling public attention to the alleged danger to public health arising from the grave pollution of rivers and canals by matter other than sewage.

In speaking of this pollution, I purpose dividing the term "pollution" into two separate and distinct parts:—1st. The

pollution by manufacturing and industrial operations; and 2nd. The pollution by town's sewage; but I only purpose dealing with and considering the former of these in this paper.

"The difficult problem," as my late friend Dr. Angus Smith described the river pollution by manufacturing refuse question, would now appear to be no longer difficult; and it is a subject for more than surprise at the absolute apathy displayed by many of the local authorities, constituted to deal with the matter, in exercising the powers conferred upon them under the Local Government Board Acts, and the Rivers Pollution Prevention Acts.

The importance of the question cannot be over estimated, and this is evidenced by the fact that nearly every volume of the Transactions of this Institute contains valuable contributions on the subject by many of our most eminent sanitarians and chemists.

The extent also to which the matter has engaged the attention of the inventive mind is exhibited by the Official Journal of the Patent Office, which, at the same time, indicates the character of the outside attention which has been applied in endeavouring to secure the desired end by simple and economical means; and to effect this in such a manner as to thoroughly prevent any complaint or objection, at present in most cases only too well founded, of effluvium nuisance arising therefrom, and a consequent danger to public health thus created.

It is, somewhat unfortunately perhaps, a common practice when speaking of sewage to include in such a term the waste waters from manufacturing operations, which in many cases pass directly into the sewers, although we can hardly look upon sewage as composed solely of human excrement diluted with water, but as water polluted with a variety of other matters of an organic character in suspension and solution in varying quantities.

The refuse or waste waters from many of our manufacturing and industrial processes are passed, in multitudes of cases, direct into the sewers, with obviously dangerous results, which we shall consider later. In the case of large works, generally situated on or near a stream or canal, the river or water from other sources made use of in the works is afterwards passed directly into the river again but in a highly polluted condition through its admixture with the special matters made use of in the several technical processes carried on in such works.

These effluent waters, in most cases highly polluted with mineral and organic matter of a poisonous or dangerous nature, are then permitted to pass into the nearest watercourse and thus brought into intimate admixture with the sewage and organic matter contained in such stream and the adjacent river, and more or less chemical action is thus immediately set up.

The foulness of the river is thus increased as it flows along, and time, together with other peculiar facilities, is thus afforded to enable chemical reaction and decomposition of the complex organic matters contained in both sewage and manufacturing-refuse to progress.

These matters thus acting and re-acting on each other render the water not only most offensive to the sense, but also a prolific source of injury to health by its abundant nauseous gaseous emanations.

There can be no doubt that our rivers and streams in this state are absolutely injurious to health, and in a condition to readily encourage, foster, and propagate a typhoid or similar malignant outbreak.

In spite of the "Rivers Pollution Prevention Acts," of the enormous amount of money, public and otherwise, expended on works for the mitigation of river-pollution, and in litigation connected therewith, it is most unfortunately the case that the rivers and canals are, in general terms, more polluted and in a worse state of filthiness than they used to be, although they are probably less polluted by sewage matter in its gross condition. As an instance in point, the following results of my analyses show the state of the Irwell at Manchester in 1882, and during the present year:—

TABLE I.

Sample Marked.	May, 1882.	May, 1892.
1. Total Solids	122·93	160·64
2. Total Organic Matter	23·43	59·64
3. Total Mineral Salts	99·50	101·00
4. Total Solids in Suspension	17·26	29·63
5. Ammonia	0·963	0·9[illegible]0
6. Chlorine	6·390	11·946
7. Oxygen absorbed in one hour	2·909	4·900

In the case of an "industrial river," the clear bright water rising from the hillside comes to the first manufacturer who has works on the stream, and he takes for his purposes, whatever they may be, that which the people in the towns would be glad of for domestic use. If used simply for power, it leaves his works without receiving any injury; but because it is pure and clean it is immediately taken up by the dyer, calico-printer, bleacher, paper-maker, woollen manufacturer and dyer, each of whom requires such water. After they have done with it they

pass it from their works in a more or less highly polluted condition, as the following results of my analyses indicate:—

TABLE II.—*Effluent from Paper Manufacturing.*

Sample Marked.	Water before use.	Effluent No. 1 Mill	Effluent No. 2 Mill.	Effluent No. 3 Mill.
1. Total Solid Matter	10·6	815·73	1074·30	1445·53
2. Total Organic Matter	2·3	56·23	69·00	106·53
3. Total Mineral Matter	6·7	109·50	100·00	97·00
4. Total Solids in Suspension.	1·6	650·00	905·30	1240·00
5. Temporary Hardness	0·55	1·96	4·67	5·00
6. Permanent Hardness	4·50	11·00	12·90	13·63
7. Total Hardness	5·05	12·96	17·57	18·63

TABLE III.—*Strong Alkaline Effluent from Paper Works.*

Sample Marked.	Effluent from Straw Boiler.	Effluent from Esparto Boiler.	Effluent Wood Pulp.
1. Total Solids and Alkali	5·9	6·2	5·0
2. Total Organic Matter	7·3	9·0	6·2
3. Water	86·8	84·8	88·8

TABLE IV.—*Effluent from Bleach Works.*

Sample marked.	Water before use.	No. 1 Works Effluent.	No. 2 Works Effluent.
1. Total Solid Matter	16·1	1351·62	1491·30
2. Total Organic Matter	2·6	46·32	41·00
3. Total Mineral Matter	11·5	605·30	500·00
4. Total Solids in Suspension	2·0	700·00	950·30
5. Temporary Hardness	1·1	12·30	16·20
6. Permanent Hardness	5·3	21·00	25·30
7. Total Hardness	6·4	33·30	41·50

TABLE V.—*Effluent from Dye Works.*

Sample marked.	Water before use.	No. 1 Works Effluent.	No. 2 Works Effluent.
1. Total Solid Matter	21·12	378·60	368·40
2. Total Organic Matter	3·92	29·60	32·00
3. Total Mineral Matter	14·20	149·00	120·40
4. Total Solids in Suspension	3·00	200·00	216·00
5. Temporary Hardness	1·40	6·2	7·3
6. Permanent Hardness	5·50	10·9	15·0
7. Total Hardness	6·90	17·1	22·3

TABLE VI.—*Effluent from Calico Printing Works.*

Sample marked.	Water before use.	No. 1 Works Effluent.	No. 2 Works Effluent.
1. Total Solid Matter	20·50	385·13	306·70
2. Total Organic Matter	6·20	39·60	30·20
3. Total Mineral Matter	10·30	139·53	120·00
4. Total Solids in Suspension	4·00	206·00	156·50
5. Temporary Hardness	0·90	11·50	12·63
6. Permanent Hardness	3·65	17·00	19·00
7. Total Hardness	4·55	28·50	31·63

To all these industries, and others besides, pure *clean* water is a necessity, and it must be got from the spring, river, or well; or if from other sources it must undergo certain filtering and cleansing processes before being fit for use in any of the industries referred to. It is hardly, therefore, a matter of surprise to find works upon works engaged in such industries occupying sites on a stream up to within a few hundred yards of its source. The result of this is, of course, to absorb the whole, or nearly the whole, volume of the stream which is the outlet of the drainage of the adjacent country; a further result is to put on one side altogether the right of the dweller on the bank of the stream, and general riparian rights to, and interests in, the use of the water of the stream.

By this action it would appear to be sometimes assumed by the polluter that the extent of the evil, or the magnitude of the profits arising from the *abuse* of the water in various processes of manufacture is in itself a sufficient justification.

It is only in very rare instances that anything in the shape of serious efforts have been made by such manufacturers to deal with their effluent waters; and generally such attempts have taken the form of inadequate, clumsy, and badly designed settling tanks and filter-beds, or arrangements for straining the foul water through canvas or coarse cloth, followed by very imperfect filtration. But in a very great number of cases the foul waters are simply allowed to pass away as best they can, without any effort being made to effect any improvement or to remove the polluting and noxious matters with which the water has become so grossly contaminated.

These foul waters are thus rendered dangerous to animal and vegetable life; and thence by passing along into the rivers, and mixing with the sewage matter contained therein, a fresh danger arises.

The river is thus converted into a most noxious and offensive liquid, destructive to animal and vegetable life alike, and a

grave danger to the public at large. The whole volume of water is thus rendered not only useless, but absolutely dangerous, without previous purification, to those lower down the stream.

The black, filthy, fetid river, carrying with it every species of abomination thus proceeds on its course—a common sewer. The Municipal and other sanitary authorities complain, generally, that the rivers are polluted by sewage and manufacturing refuse of all kinds before the waters reach them; that such rivers are offensive to the sight and smell; that they are dangerous to health; that they are injurious to steam engines and machinery. But, in spite of all this, such authorities all continue to pour, and allow to be poured, all kinds of liquid filth into the streams, and thereby convert them into common sewers.

It would, therefore, appear to be a decided advantage, from every point of view, to prevent the waste polluted waters from industrial operations mixing with sewage matter at all. There does not appear to be any reasonable cause why every manufacturer should not be compelled to deal with his polluted waters on his own premises.

The prevention of pollution by liquid manufacturing refuse undoubtedly possesses very much more formidable difficulties than dealing with sewage alone; while the difficulty of dealing with the compound pollution—sewage *plus* manufacturing liquid refuse—is no doubt very much greater than either.

From my intimate knowledge of, and daily experience in, manufacturing operations necessitating the use of very large volumes of clean water, I have no hesitation in saying that every one of the polluting-liquids from the works referred to, and which at present damage the rivers to such an incalculable degree, can be kept out of the streams altogether. Such foul waters can *in every case* be sufficiently purified to admit of their passage into the river without the slightest prejudice to it.

This can be readily effected without interfering with existing manufacturing operations or interests in any way; and in most cases it would appear to be accompanied by a decided profit to the manufacturer. The waste-waters from the several industries mentioned appear to be among the chief sources of such pollution, as the tabulated results of my analyses show.

In the cases of the North and South Esk rivers, it has been amply demonstrated several years ago what the manufacturers on those rivers could do when compelled; and I have no doubt that if our Sanitary Authorities, who have already powers under the several Local Government Board, Public Health, and Rivers Pollution Prevention Acts, to deal with offences of the character indicated, would only exhibit a little more energy in applying and enforcing such powers, we should find a corresponding improvement in our rivers and canals, and consequently a lower death rate.

Possibly the most effective and economical method of dealing with the enormous volume of pollution from manufacturing sources is by concentration and evaporation, followed by condensation. This system presents the least difficulty, and certainly yields much more satisfactory results than any system of chemical treatment, settlement, or filtration. Enormous volumes of highly polluted and poisonous waters can be quickly and most cheaply dealt with by specially designed evaporators, the best type of which would appear to be the Theisen-Ashworth, which serves the purpose of "smoke-washer" as well.

The foulest effluent from manufacturing operations can thus be readily and cheaply disposed of by evaporation, and condensed, and consequently clean soft water returned to the river in its stead. This may therefore be looked upon as the latest, best, and most scientific and successful solution of the problem of economically dealing with manufacturing liquid refuse.

The President of the Section (Mr. James Lemon) said he could have wished that the paper they had just heard had been read in Manchester, for in the neighbourhood of the Irwell it must have lead to a discussion of great length. He contended that the polluted water from the manufactories should be kept clear of the sewage, for its presence enormously increased the difficulty of precipitating sewage. To put the matter plainly he asked, was the larger part of the community to have its difficulties increased and to incur a large amount of expense to favour a small minority? The amount of polluted water which found its way into the sewage was a small thing compared with the whole of the body of the sewage, but it largely increased the difficulty of dealing with it. The difficulty he felt might be remedied by collecting all the polluted water in an iron pipe, taking it to some common point and dealing with it by chemical or some other known means. He thought it would be fair to the manufacturers if the whole cost of this operation was levied upon them and he believed they would meet it readily.

Mr. H. P. Boulnois, M.Inst.C.E. (Liverpool) said the remarks the President had made had rather forestalled him, but coming from the North he could cordially agree with what had been said. The paper would have been a great benefit if it could have been read in the neighbourhood of Liverpool. No one who did not live in the North could imagine the extent to which rivers were polluted. There was

no occasion for analysis to be taken, the water was often as black as ink and worse than an open sewer, and this was mainly due to manufacturers' refuse. The difficulty of dealing with the question was however very great, and there was he believed a great field open for chemists to find out how some use might be made of manufacturers' refuse and waste. The suggestion made by the President of a special sewer was he thought a very good one. In Liverpool the waste water from chemical and other works had actually been found in some cases to destroy the sewers into which they flowed, and they had now had to put in special acid proof sewers to carry off these objectionable waste products, which were in addition often turned into the sewers at high temperatures.

Mr. J. Oldfield (London) said the writer of the paper spoke of the growing pollution of rivers. Speaking as a Barrister he admitted that a manufacturer might have the legal right to pollute a river to a certain extent. But, say a manufacturer had a right to throw in a hundred gallons of refuse a year, if they looked into it they would find that this amount was increased year by year, so that by imperceptible degrees more and more damage was done to the river. He thought that the section ought emphatically to express the opinion that it was inimical to the welfare of the community that these manufacturers, who had a title to pollute a river to a certain extent, should be allowed little by little to increase that pollution.

Major Lamorock Flower (London) said he cordially endorsed much that was contained in the paper and particularly with regard to the difficulty the polluted refuse from factories created in sewers. At Tottenham there was considerable difficulty in dealing with the refuse from an india-rubber manufactory, and the task of getting rid of the stinks from this had been insuperable. The London County Council had at last taken the whole of the sewage into its sewers and carried it away, to improve the condition of those eminently Sanitary places, Barking and Crossness.

Mr. J. Oldfield (London) asked if it was not within the power of the Section to pass some resolution upon the matter.

The President of the Section said he certainly thought they should do so, and moved: "That in order to prevent the increased pollution of rivers by manufacturers' refuse, enlarged powers should be given to local authorities to compel the manufacturers to purify the polluted water, and in default the local authorities should have power to carry out the necessary work at the cost of the offenders, and that The Sanitary Institute be recommended to take action accordingly."

Mr. J. Oldfield (London) seconded the resolution, which was carried unanimously.

"*Notes on Sewage Treatment*," by C. H. COOPER, Assoc. M.Inst.C.E.

As many papers and books have from time to time been written treating more or less fully of the various branches of the subject, it has appeared to the writer that a few notes setting forth points, although not new, might be viewed in a light which would add to their interest.

The writer proposes to divide sewage treatment into the three following classes:—

TREATMENT.	MEANS.	RESULT.
1. Natural ...	Irrigation and filtration.	Purification effected by nitrification.
2. Electrical.	Electrolyses, coupled with salts of iron from electrodes.	
3. Chemical ..	Addition of various chemicals.	Partial removal of organic matter in the form of a precipitate. Subsequent purification of effluent retarded.

NATURAL TREATMENT.

It is now generally admitted that the purification, or, as may be more correctly termed, the nitrification, of organic matter is effected by nitrifying organisms. Although there appears to be much doubt as to what particular organisms, when separated from their companions and placed apart from their natural home, will effect such beneficial results, still, nature has provided in rich moulds an abundant supply of these workers which can effectually reduce the most offensive organic matter to innocuous inorganic substances.

Similar supplies of micro-organisms can be cultivated in sand, even of considerable coarseness.

The writer has applied the term "natural treatment" to that effected by micro-organisms in the ground and filters. By taking advantage of the method of treatment afforded by nature, it would appear that the health of the surrounding district is rather benefited than otherwise; thus, on the sewage farms competing for the City of London's prize, offered in 1880, the death-rate was only 4 per 1,000.

Mr. Roechling, in his paper read in April last before the Institution of Civil Engineers, on the Berlin Sewage Farms, mentions that for the five years ending 1889 the total death-rate amongst a population of nearly 8,000 living on these farms (for the greater part misdemeanants), was only 9·75 per 1,000, and the zymotic death-rate 2·53 per 1,000; and he further states that "nearly every report mentions that in no recorded case of death was it possible to trace that it had any connection with sewage farming."

For many years past at certain sewage farms, of which Wimbledon is one, filtration through the ground to the subsoil drains has, as far as possible, been prevented, as it was found that a much better effluent could be obtained by allowing the sewage to run over the surface. This led the writer to believe that the work of nitrification took place at or near the surface; but it was not till the result of the Massachusetts State Board experiments on filtration of sewage was published that he saw it clearly demonstrated that such was the case. In this report the number of microbes found per gramme of sand and nitrogen per 100,000 parts at various depths is given in the case of filters Nos. 1, 2, 4, and 6. Taking the mean of the results for May and June, 1889, the microbes found in the 1st inch averaged 792,200 p.g., in the 2nd inch 473,120 p.g., in the remaining 58 inches 33,967 p.g.; and the nitrogen per 100,000 parts at similar depths was 64·71, 18·3, and 3·14.

The fact that the microbes near the surface perform the greater part of the work of purification leads us to the important question as to what soil provides the best home for these organisms to work in, and also whether more work is done where the soil is protected by a crop or left fallow.

The writer would impress the necessity for giving all irrigation ground even slopes without any places where water can lodge. The fall of such ground should be in excess of that usually given, not in any case less than 1 in 100, and may run to 1 in 20. The most perfect permanent irrigation meadows that the writer knows of are those laid out by the late Duke of Portland, which take the sewage of Mansfield. These meadows are supplied from a canal conveying the sewage in a rather dilute state; at one point the canal crosses a valley on an embankment; during heavy rains the reservoir formed by this embankment can be filled, and the water thus impounded used for irrigation during time of drought. For the most part the surface gradients of these meadows are considerable.

Mechanical Separation of Solids.

A considerable difficulty in dealing with sewage is occasioned by the organic matter being dispersed through some 2,000 times its weight of water. If we can mechanically separate part of such matter, in the great majority of cases it can be more readily dealt with, and the ultimate purification of the remaining water can be effected with less liability of nuisance or damage to certain crops. In the case of treatment by electricity or chemicals, mechanical separation forms an essential part of the process. Such separation may be effected by settling-tanks, filters, or to a small extent by screens.

So long as sewage has sufficient velocity, as it should have whilst flowing in a sewer, it can carry all faecal and other matters generally met with; this velocity is partly or entirely lost when the sewage reaches the settling-tank, and here matters in suspension are precipitated, more or less efficiently, according to the retardation of the current, and the time allowed for such precipitation to take place.

Tanks should therefore be designed with due regard to economy, so as to reduce as far as possible all currents.

The horizontal form of tank usually met with is particularly favourable to the formation of currents when used continuously, so much so that part of the sewage stands for hours without being changed, and thus throws the greater part of the tank out of action.

Herr Carl Kinebühler, Town Engineer of Dortmund, designed a vertical tank, somewhat in accordance with a tank patented in this country many years ago. This tank consists of a vertical cylinder 21 ft. 4 in. diameter by 29 ft. deep, having an inverted conical bottom. The sewage is admitted at the base of the cylinder, where it is distributed by horizontal arms; from these it rises in a vertical direction to a series of troughs placed at the surface, by which the effluent is drawn off, whilst the suspended matter that falls is collected in the conical bottom, from which it can be drawn off while the tank is in work. In this tank there is little or no dead water; the precipitate that falls passes through the sewage as it flows up, forms as it were a continuous shower, which tends to fetch down any precipitate that may be rising. A tank of the sizes given is said to be capable of treating 1,000,000 gallons of sewage a day, and could be constructed about London at a cost of say £500.

To still further effect purification a layer of filtering material may be introduced instead of the troughs.

Mr. Herbert Wollhein has patented what he calls "the radial system of sewage precipitation," which consists of two or more segmental tanks. The sewage is received in a round chamber at the centre, from which it can be admitted to one or all the segmental tanks radiating from the central chamber; the effluent is drawn off by a weir on the outer or circumferential wall. The tank bottoms face towards the centre when the sludge is drawn off. These tanks possess many advantages.

Filtration.

Filters for sewage may be divided into two classes—Roughing or simply mechanical filters, and Nitrifying filters.

A good example of small tanks with roughing filters may be seen where the High Level Sewer enters the Wimbledon Sewage Farm. These consist of two tanks 25 ft. by 25 ft. with a chamber between, into which the sewage flows, and from which it is admitted to the lowest level of the tanks by two valves; these act as outlet valves in cleansing the tanks. Near the surface the entire of these tanks are covered by eight inches of rough filtering material, and through this the effluent passes. For the purpose of treating the High Level sewage no chemical is admitted, and so great is the purification effected by this mechanical means that during the spring, summer, and autumn of 1889 the sewage of nearly 4,000 persons was continuously applied to two and a half acres, with the exception of a day or two's rest now and then.

These filters are roughly cleansed about once a week by allowing what water may be standing on the filter to flow down when the central chamber is emptied, and all sludge that has accumulated is allowed to flow to the sewage works where it can be pressed.

These filters act in no way as nitrifying filters, as the filtering material is not aerated. The writer has designed somewhat similar filters, which are now being constructed for Maybole, Ayrshire.

The best results obtained with nitrifying filters are those got by the International Purification Company, who remove the suspended matter from the sewage before it is admitted to the filter, and in addition take the precaution to keep the surface of the filters cleansed; by so doing a final cleansing to sewage is said to be given at the rate of 100,000 persons to the acre.

The sand filters experimented on by the Massachusetts State Board, where raw sewage of a dilute nature was admitted (without previous cleansing) on to a filter which received no cleansing, gave splendid results as to pure effluent, the amount treated being proportional to upwards of 5,000 persons per acre.

Chemical Treatment.

Although the prophecies of certain chemists as to the fortunes to be derived from chemical treatment have proved untrue, and further, it is now generally admitted that chemical treatment of itself cannot give a satisfactory effluent, still there is considerable misconception as to the amount of purification that may be effected by chemical means.

The following Table gives the results of thirty-four experiments made by the Massachusetts State Board of Health, which are borne out by a much larger number of experiments made by the same Board:—

Summary of Results of Barrel Experiments to Oct. 1, 1889.

	Cost of Chemicals per inhabitant annually.	Number of Experiments.	Per cent. loss on ignition removed.	Per cent. albuminoid ammonia removed
Sewage after settling	$ 0·00	10	30	26
Effluent with—				
700 lbs. of lime	·11	5	39	33
500 lbs. alum	·23	2	27	40
500 lbs. alum and 700 lbs. lime	·34	5	37	48
500 lbs. copperas	·09	1	36	21
500 lbs. copperas and 700 lbs. lime	·20	6	48	59
120 lbs. ferric oxide	·13	2	64	33
120 lbs. ferric oxide and 700 lbs. lime.	·24	3	57	51
Average for chemicals	·19	...	44	39·4

Taking the average of chemical treatment given in this Table it shows a removal of about fifty per cent. more albuminoid ammonia and about the same percentage of combustible matter at a cost of ·19 of a dollar over mean settling of sewage. This appears a poor return for the outlay, but on the other hand the chemicals act as deodorants, and by so doing retard decomposition, and it appears from observation that nitrification in the case of irrigation is also retarded.

Many persons believe that the greater the proportion of chemicals that is added to the sewage so much more is the purification effected increased.

When Dr. Dupré and Mr. Dibdin, about 1884, suggested, as the best known process, that four grains of lime and one of protosulphate of iron per gallon should be added to the sewage of London, the quantities were ridiculed as homœopathic. One of the principal reasons for this recommendation is to guard against dissolving matters in suspension by the addition of more lime, as Mr. Dibdin stated in a paper read before the Institution of Civil Engineers in 1887, "the point it is deemed expedient to guard against is that effecting the precipitation of the last few traces of solids. It is important that the putrescible matters in solution should not be increased tenfold for the fragmentary quantity it is endeavoured to remove in order to render the effluent perfectly bright."

The truth of this recommendation is clearly shown by Tables and diagrams given in the Report of the Massachusetts State Board of Health.

Screening Sewage.

The amount of work done by screens is small when compared with the other methods of removing solids, but in the case of pumping, and when it is intended to press the sludge, the use of screens cannot well be dispensed with.

[*For discussion on this paper see page* 217].

On "The Treatment and Disposal of Sewage and of Sewage Sludge," by Arthur Angell, Public Analyst, Southampton."

This Congress would in my opinion scarcely fulfil its functions in entirety were not the above really great and important question duly discussed.

It is not proposed on this occasion to travel over much beaten ground, yet, by way of preamble, it appears to be necessary to make a short reference to the more immediate past history of what has been termed the science of sewage treatment.

With the introduction of water closets and sewers there arose the difficult question of how best to deal with the accumulated sewage, and it behoves this Institute to disseminate information which shall keep the public up to date in the progress made towards the solution of the problem.

The most natural way to deal with sewage is to return to the soil that which has been taken therefrom, and so to enrich the earth and quickly to make use of materials which would otherwise lie idle for a time. This is the cry which continually goes up from the irrigationists.

If we existed in primæval times and were here and there one or two wandering specimens of natural man, we could carry out this programme most effectually no doubt, but as our lives of civilization are to a great extent lives of artificiality, our troubles which are the consequences of that civilization and artificiality must by art be governed and controlled.

That all excrementitious and waste matter shall be removed from the habitations of men, and treated in the best, the most rapid, and the most scientific manner, is now recognized as an imperative demand, it must not be shirked; its neglect by public bodies is nothing short of stupid, uneconomical, and wicked culpability.

Attention was at first wholly occupied in the endeavour to purify sewage by allowing it to flow upon agricultural land, and thus began what may be spoken of as the broad irrigation epoch, an epoch which is now fast passing away.

Broad irrigation with crude sewage has in most instances resulted in the production of nuisances; nuisances differing in degree from barely tolerable successes to miserable failures.

Serious complaints are being continuously made about the pollution of rivers and water-ways by effluents running away from sewage farms dotted about all over the country, and it appears upon the face almost needless to speak against sewage farming to members of this Institute; and yet, from time to time in print and in speech, one keeps hearing the proceeding lauded up to the skies, and that by those who ought to know better.

The apparent naturalness of the process as compared with all others, a pretty widely spread ignorance of the process of assimilation by plants, and, above all, strong local interests in the sale and purchase of land, cause broad irrigation to die hard.

Listen to the names of just a few cases complained of in the public press:

Cole Hall Farm, Birmingham, 1889. Official complaints of the pollution of the river Cole.

Lincoln, 1890. Sewage farm declared to be a nuisance.

Beddington, 1889. Great difference of opinion as to the degree of success attained.

Burton-on-Trent, 1892. Action threatened by Derbyshire County Council.

Coventry, 1889—Kenilworth Farm. Dr. Wilson, Medical Officer of Health: "the results of analysis of sewage farm effluents shew that they cause serious pollution of the brook."

Harrogate Irrigation Farm, 1890. The Knaresborough Improvements Commissioners call attention to the pollution of the Nidd.

Nuneaton, Hinckley Farm, 1892. Samples of effluent were found to contain a large quantity of suspended matter and to give off an offensive odour.

Leicester, 1892. Thurcaston Brook, which before the opening of the farm was pure, is now foul and smells badly at times.

Croydon, 1892. The Local Government Board are of opinion that the Wandle is seriously polluted by the Croydon Sewage Works.

Lichfield, 1889. Pollution of Carborough Brook.

Oxford. Leading citizens declare their sewage farm to be a perfect White Elephant.

These are a few instances, hastily collected together, where broad irrigation has turned out a failure from a sanitary point of view.

One of the most recent contributions to our information upon the question of sewage treatment, is given in a paper read by Mr. R. F. Grantham, M.Inst.C.E., F.G.S., who argues that the experiments of the Massachusetts State Board of Health, made at Lawrence, 1888 to 1890, shew that it is possible, by filtration, to treat the sewage of London successfully upon the Maplin and Foulness Sands, by simply permitting the sands to be converted, by the carefully applied sewage, into vast nitrifying beds.

That author states that the results obtained are remarkable for the "large quantities of sewage which can be purified upon small areas of land." It appears to me to be somewhat strange that any person, by reading the report, can arrive at any such very comfortable conclusion. It is difficult to understand how anyone, noting the rate of filtration adopted, can argue for the feasibility of such a method for the treatment of Metropolitan sewage.

In order to strengthen his case Mr. Grantham has selected and named certain places as illustrations of the good work that has been done in this country by passing sewage upon sandy soils.

Several places are named, amongst which I notice first comes Aldershot—that town is now resting under an injunction for the pollution of the Blackwater, time being granted for the adoption of a better method of disposal.

Berlin. A correspondent to the "Newcastle Chronicle" of October 6th, 1891, declares that the "effluent certainly has not lost its odoriferous properties, for the waters of the Spree are simply stinking."

Edinburgh. Here are the celebrated Craigentinny Marshes, which the late Dr. Tidy described as a vast stinking morass.

Kendal. The pollution of the Kent by the effluent from the Corporation farm is now forming the grounds of serious complaint.

Surely Mr. Grantham did not make sufficiently careful enquiries, or he would never have ventured to name these places as proving anything worth recording.

A very interesting question for debate is, whether the power of a filter bed is due to direct or chemical oxidation, or to nitrification caused by the vital action of organisms.

The first polarite sewage bed was laid down in 1888, and from that time to the present a considerable number of large filter beds has been established, both for the purification of sewage and of water. These beds have been operating successfully, and will I think continue so to do for an indefinite period.

The mode of management of these beds has been laid down and guided by the belief that the purification is produced mainly, if not entirely, by direct oxidation—oxidation brought about by the actual contact of dissolved organic matters (in the case of sewage previously partly dissociated by chemical treatment) with the possibly ozonized oxygen occluded within the pores of the polarite.

Nothing that appears in the report of the Massachusetts experiments should, in my opinion, alter this well established procedure. We demand intermittence as a *sine quâ non*, but not in order, as do they, to allow the nitrifying germs breathing time, but simply to permit the atmospheric oxygen again to fill up the pores of the material.

I quite see the immense importance of this most interesting question, because if we are to convert our filter beds into aërobian fermenting vats, a very different rate of filtration must be adopted, and the area now in pretty common use at sewage works, must be increased something like 50 fold.

Nitrification, caused by the vital action of certain forms of bacterial germs, cannot longer be a matter of dispute, it is settled; but I have found that newly made polarite, fresh from the retorts and therefore practically sterile, will oxidize dissolved sulphuretted hydrogen into sulphuric acid, and the albuminoid matters of sewage into ammonia and carbonic acid. That being so we must not get carried away into the biologists' dreamland by the results of the very admirable and very exhaustive, but at the same time very unpractical, Massachusetts experiments.

Dr. Dupré was, I believe, the first to suggest the possibility of treating sewage by innoculation with nitrifying germs. I well remember the guffaw of incredulous laughter with which this suggestion was received by a strong meeting of sewage experts, and yet the idea was pregnant with good sense. Since that time the Massachusetts reports have been published, and now several chemists and biologists are engaged in this branch of research, endeavouring to find out a means of selecting and controlling the fermentative changes which take place in sewage, so as to avoid putrefaction and to ensure the higher and less noxious changes which lead up to purity.

This forms a very interesting study, but it appears to me that the bacteriological treatment of sewage is not yet within a measurable distance of practical or applied science. As in a drinking water, so in a sewage effluent which is to flow into a river from which water may be taken, we are not warranted in pronouncing an opinion on their character by estimating the number of micro-organisms present. Chemical analysis, incomplete as it is, with a close observation of physical properties, is the only means of judging of the safety of an effluent.

The Massachusetts experiments shew that a high degree of nitrification by the aid of organisms does take place in sand beds when sewage is passed through them intermittently, and that the deposit upon the beds is burnt up by the organisms, so that the surface remains permeable to sewage and the filtration may be continued indefinitely without a renewal or cleansing of the top sand.

This is a most interesting scientific fact demonstrated to satisfaction, and would constitute an immensely valuable discovery if the rate of filtration performed in the least degree approached the lowest speed which is found to be practicable in treating a large flow of sewage; that however was not the case.

The speed of filtration was absurdly slow, namely, about 12 gallons per square yard of surface per 24 hours. A given portion of the sewage was stated to be slowly moving downward for a week over particles of sand intermingled with twice their volume of air.

In order to apply the sewage in a uniform manner all over the beds at one time, an ingenious sprinkling apparatus was devised.

These experiments undoubtedly prove that slow percolation through sand will purify sewage, and that the chief if not the only agents in producing nitrification were, what Pasteur entitled, aërobian germs. The process will be seen to be an admirable imitation of the way in which nature treats excremental matters which fall upon the land.

And yet on page 161, Part II. it is shewn that with a low number of bacteria and much oxygen the nitrates were high, and that with a high number of bacteria and limited oxygen the nitrates were low; this looks as though direct chemical oxidation in some instances was going on as well as, if not to a greater degree than, vital nitrification.

To filter Barking sewage at the rate and in the manner set forth in these experiments, about 1,666 acres of prepared filter beds furnished with revolving distributors would be required, and in order to establish and maintain the proper bacteriological equilibrium it appears that this great area must be covered in and protected from rain and snowfall.

The most exhaustive trials of the various processes for the purification of sewage which have come under my notice are those which have been proceeding at Salford, from the year 1889 up to the present time.

The chemists engaged to report upon these trials were Mr. Carter-Bell, F.I.C., A.R.S.M., Borough Analyst, and analyst for the County of Cheshire, and Dr. C. A. Burghardt, F.R.M.S.

In a general sense these gentlemen report favourably of both the International Purification Company's, or the Polarite process, and of Mr. Webster's Electrical process; placing these two far above any of the other methods tried, as far as purity of the effluents obtained is concerned.

Speaking of the effluents produced by these processes, Dr. Burghardt makes use of the words "The effluents were excellent, and have not up to the present time undergone any secondary decompositions."

The mean percentages of purification tabulated on page 8 of the Salford report are given as follows :—

	International, per cent.		Electrical, per cent.
Free ammonia......	83·47	...	26·75
Albuminoid ditto...	79·50	...	60·00

On page 46 Mr. Carter-Bell gives the result of the analysis of a sample of polarite effluent which he collected at Acton in August, 1890, after the filter beds had been in operation for more than three years.

Taking the reduction of albuminoid ammonia as the index, the purification was 95 per cent.

Acton sewage is a domestic sewage mixed with much laundry soap suds.

Salford sewage is very largely composed of manufacturers' refuse liquors.

I am at the present time engaged in the conduct of experiments, the object of which is to determine the cause of the action of porous filtering materials, especially polarite, upon chemically treated sewage.

The results obtained so far indicate that the porous body, when furnished with oxygen, possesses a selective, bacteriological power due to the action of the occluded oxygen upon the anaërobian or vibrionic forms of microbic life, allowing to pass uninjured those forms which produce nitrification.

These conclusions have been arrived at by noting the fact that albuminoid matters are changed by the action of new polarite into carbonic acid and ammonia, the saline ammonia of the effluent being in some instances much larger than in the original sewage.

An impure water has to pass through polarite in so finely divided a shower that it is in the state of a cloud or mist; by this means the impurities in solution are brought into immediate contact with dissolved and atmospheric oxygen, and direct oxidation of the carbon takes place, the nitrogen escaping in the effluent as carbonate of ammonia. At this stage no nitric acid has been formed, but nitrification speedily sets up in the filtrate, a few hours will produce a marked change in this direction; so that to judge where the nitrification takes place the analysis must be made immediately after filtration.

I do not find any statement as to whether or not this necessary precaution was taken in the Massachusetts experiments.

Brewery Refuse.

I have come to the conclusion that no practical method is known of treating a mixture of Brewery refuse and sewage when the former is present in anything like a large proportion. The living ferments which are washed from the barrels, and the high temperature of the waste liquors which escape from a Brewery, cannot fail to set up noxious fermentations in the sewers and at the works, and it is high time that all Brewers were compelled to impound these liquors in subsiding tanks until cool, and until the greater portion of the solids have separated by gravitation; this is being done successfully at one of the largest Breweries in England. It is not, therefore, too much to demand of the trade in general.

I will now conclude with a few words upon the disposal of sewage sludge.

Some years ago General Scott took out several patents for the making of Portland, or Hydraulic Cement, by burning sewage sludge with chalk or limestone, and there is no doubt he succeeded in making a useful cement from these materials.

The manufacture however did not succeed commercially in consequence of the immense quantity of water in the sludges at his disposal and the expense of obtaining chalk.

Now that sewage sludge is being pressed with lime into cakes containing about 50 per cent. of water, five tons of ordinary tank sludge being pressed into one ton of cake, the process is quite altered; it is simplified and cheapened, but there still remains the difficulty and cost of obtaining chalk or limestone at sewage works.

Protection has now been granted to a new process which promises to be a successful one, namely, the production of hydraulic cement from pressed sewage sludge cake, and waste gas lime from the purifiers as the two principal ingredients. The matter has been placed in my hands for experimental investigation. Some bushels of ground cement have been made by a well known cement manufacturer.

By this means two filthy bye-products, sewage cake and gas lime, both of which now await some useful means of disposal, can be converted into a material which is used in large quantities and purchased at high prices by Corporations and other public bodies. There is also much waste carbonate of lime accumulating at water works.

I am of opinion that much of the fish poisoning, which occurs from time to time in our rivers, is due to the use of poisonous gas lime as a manure upon adjacent land.

From a sanitary point of view this is a step in the right direction, and even if the cement produced should not vie with the best qualities in the market, the fact that the sludge now lying about in most sewage works in hundreds and thousands of tons, and accumulating at an alarming pace, and that useless stinking gas lime, can both be rendered innocuous by a process possibly remunerative, at all events economical, is a matter of the utmost importance, and in my opinion is well worthy of the special notice of the members of this Institute.

The samples of cement shewn were made under my supervision, and withstood a tensile strain of 293 lbs. to the square inch, or 659 lbs. to the $1\frac{1}{2}$ inch briquette.

NOTE.—A paper on "The Treatment of Sewage" was also read by E. SCRUBY.

[*This discussion applies to the papers by* C. H. COOPER, ARTHUR ANGELL, *and* E. SCRUBY.]

THE CHAIRMAN (Mr. H. PERCY BOULNOIS) said this was one of the vital questions of engineering. The papers had been most interesting, and he was glad to see that there were in the room champions of the various processes for the disposal of sewage. Taking Mr. Scruby's paper, it was certainly a novel process, but by the remarks in Mr. Angell's paper it appeared that oxygen was to play an important part in the purification of sewage. Of course, Mr. Scruby's experiment had only been made in the laboratory, and he regretted to say that when put into practical use many laboratory experiments had been found to fail. He should be pleased to hear when this one had been put to a practical test, and that it had succeeded. Sewage varied in almost every town, and it varied in amount and quality almost every hour of the day, so that any chemical process required a great deal of watching. Mr. Scruby had not said what he would do with the sludge that would be left. It must go somewhere, and what would he do with it? Then the cost for London would require £175,000 a year for oxygen alone, and that would make it most expensive. In his paper Mr. Cooper had laid before them valuable tables and very graphic diagrams, and to engineers these were most important. Those showing the effect of filtration were very interesting, as they could see that it was near the surface that the work was really done. He should ask Mr. Cooper, however, to explain this a little more fully, as it was a complicated matter. Mr. Angell's paper was especially valuable from a chemist's point of view, but the Chairman was certain that there were gentlemen present who would not agree with all he had said. The most important part, to his mind, was where Mr. Angell had stated that the results obtained by experiments made as to the cause of the action of porous filtering materials, especially polarite, on chemically-treated sewage, indicated "that a porous body, when furnished with oxygen, possesses a selective bacteriological power, due to the action of the occluded oxygen upon the anærobian or vibrionic forms of microbic life, allowing to pass uninjured those forms which produce nitrification." As to the making of cement, the invention Mr. Angell referred to was of enormous importance. If he succeeded in making cement from two such foul materials as sewage sludge and "blue billy," Mr. Angell would have solved one of the most baffling and difficult problems Sanitary Engineers had had to encounter.

Mr. SCRUBY (London) said that the Chairman, in making his remarks after the reading of the papers, made some reference as to the cost of oxygen gas required for the treatment of the sewage of London, based on my calculation. In reply to which he said, it would no doubt be accepted as a truth that a nation's health was a nation's wealth, and to those who accepted that statement it would necessarily follow that this subject must be dealt with in a generous spirit, especially when the importance of its bearing on the health of the community is realised. He illustrated his meaning of the above by saying that if he had a nuisance on his premises detrimental to the health of the neighbourhood, he was served with a notice by the Medical Officer to abate the same, not even being asked whether he could afford the necessary outlay, or whether it would cost him £5 or £50. He had to comply, and therefore Local Boards and Sanitary Authorities must take a little of their own physic.

Colonel JONES, V.C. (London), said he was in favour of applying the laws of nature in the best possible manner. He welcomed Mr. Angell's study of the subject, because he could see that that gentleman was tackling it with great ability as a chemist. And he expected great advantage from his discoveries both with regard to polarite, and as to the cement. With reference to the latter, Colonel Jones said that he took great interest in the late General Scott's patents, and he wished Mr. Angell more commercial success than the General obtained. He was pleased to hear Mr. Cooper's paper, because Mr. Cooper was doing admirable work at Wimbledon, but he suggested that in the tanks as shown on the drawings the circular outside channel should be taken off, and the effluent drawn away from a single conduit on one side. Coming as an old practised hand to the consideration of the subject of sewage disposal, Colonel Jones said it was satisfactory to find that irrigation still stood first and foremost. A very interesting paper was read last May by Mr. Roechling, at the Institution of Civil Engineers, as noticed by Mr. Cooper, and he (Colonel Jones) desired to point out, as he did on that occasion, the great lesson to be learned from the management of the Berlin Sewage Farms. In his reply the author of that paper quoted the remarks that he had made, and said, "It was perfectly correct as Colonel Jones had stated, that the most important lesson to be derived from the paper was, that the success of the Berlin experiment was due to the intelligent supervision of the administration, and to the careful distribution of the sewage over the land. This was doubtless a point on which great stress should be laid." The pay of the officials for administration of the Berlin Farms came to £2,116 per annum, and that of sewage men to £6,989, or at the rate of £233 per million gallons of sewage per diem. This was simply for the manual labour of distributing the sewage over the land. Now he did not know of any English Farm in which more than half of the latter rate of payment was made for the distribution of the sewage only, and yet the daily wages of a farm labourer in England must be higher than in Germany. Moreover it had been the usual practice in England to employ an Engineer to "lay out," as it was called, the lands for sewage, once for all, and then to leave the future management in the case of smaller sewage farms, to labourers under the control of a committee of town tradesmen. Under those circumstances it was remarkable that irrigation had held its own against chemical and electrical efforts at sewage purification, which were always carefully

tended by a trained staff from first to last. What was wanted in England was a staff of Engineer farmers, and in these days of technical education they would soon be found if sewage committees would learn to appreciate their services and offer sufficient pecuniary inducement. He was inclined to think that Mr. Cooper went a little too far in ascribing to the popular microbe of the present day, all the functions of purifying sewage. He held, too, that the purification of sewage by a given area of soil protected by a crop was much greater than on fallow land, and he concluded that the joint action of the nitrifying organism and plant rootlets produced the best results in sewage purification. At the same time it was certain that the work of purification was done within the first few inches of the surface, more or less, according to the porosity of the soil allowing the passage of oxygen to support the life of organisms. If the sewage passed too rapidly through the first few inches, it either flowed away by the drains unpurified, or remained in an inert stagnant state for an indefinite period untouched even by the deep roots of wheat, &c. Mr. Cooper's remarks as to settling tank construction were quite correct, and the Dortmund form was one of the most satisfactory, but the avoidance of currents which is so essential to success, could be secured in various ways. At last, in the Massachusetts experiments set forth in Mr. Cooper's paper, they found an attempt to discriminate between the results of simple natural subsidence, and those produced by chemical agents. He had often protested against the assumption hitherto universally put forward by precipitationists, that the total difference of analysis between raw sewage and effluent from any particular process, was due to the employment of one or more chemical agents in the precipitation tanks. Taking the average of the sewage experiments tabulated in Mr. Cooper's paper, it showed that only about 50 per cent. of the work done by natural deposition had been obtained by the employment of large quantities of chemicals, and at a cost of 10d. per head per annum of the population where the sewage had been thus treated. His own experience would have led him to have expected much less percentage of useful effect, and a higher cost for chemicals and labour. He would very much like the London County Council to give them the difference in volume of sludge, and analyses of raw sewage, and effluent *with and without* the employment of 3·7 grains of lime, and one of iron per gallon, from which their chemists now claimed to obtain important results with regard to the metropolitan sewage; nothing could be simpler than to compare the results on alternate days, and in conclusion, he suggested that as the point was of great scientific interest, the Council of the Sanitary Institute should memorialise the London County Council to carry out the experiment.

Alderman BOULTON (Burslem) said he should be glad to find that if tried there would be something of advantage to Sanitary Engineering in the new process. He was in favour of irrigation, and those who had gone in for the system were bold enough to say that it was not "fast passing away," as Mr. Angell had declared. No doubt Mr.

Angell had studied the subject thoroughly, and he (Mr. Boulton) congratulated him on the many points of great interest in his paper. Taking the sludge question, it was a great difficulty, and if it could be dealt with as Mr. Angell said, he for one would be pleased to advise Town Councils to adopt it. Some years ago a deputation (of which he was one) went to various places around London to investigate the various processes, but on getting back home, and considering the matter, they felt bound to come to the conclusion that irrigation was the system that was best suited for them, and the town adopted it. He was struck with a remark of Colonel Jones as to the way in which chemical processes were being carefully watched. He was quite astonished to find the number of places which had complained of irrigation, but he had come to the conclusion that because a thing was complained of that did not prove it to be useless. People often make complaints from various motives, some from interest and some from sentiment. It did not take a great deal to cause people to make complaints on the sewage question. However perfect it might be, they might consider that a sewage farm was scarcely the place to take their friends to for a pic-nic. It was not like a bed of roses. In Burslem, whenever complaints had been received the matter had been remedied. It was quite correct that the state of sewage matter differed at all hours of the day, and this might cause complaints at one time, and not at another. Taking all those things into consideration, he did not think that with all that had been done for the chemical process, it had been free from complaints. They had no fear as to their sewage farm, and they were not going to adopt another process from what he had heard at that Congress. They would wait and see the new processes tried, and in the meantime they were quite satisfied with irrigation.

Mr. C. H. Cooper (Wimbledon) said that if Mr. Angell had gone in for a list of complaints against chemical works, he would have had a much longer list than he had got against sewage farms. As to the River Cole, he was not aware of the existence of such a river near Birmingham. Mr. Angell mentioned Croydon, but he expected that he meant Croydon rural, which was quite another farm. As to Aldershot, that farm was troublesome, but that was because it was let to a farmer who mismanaged it. As to the Berlin farm, the River Spree was a stinking river, but that was not due only to the effluent, and it was unfair to say that it was. Mr. Angell said that fresh polarite would effect oxidation, but this was expensive, and what would be the cost of the purification of sewage if they had to continually get fresh polarite? Mr. Cooper questioned whether it was the polarite which effected oxidation. If it was, then why did not the International Purification Company place polarite at the surface in their filters, and not allow the sand to do the work before the sewage got down to where the polarite was placed! He believed that Mr. Angell was claiming a novel property for polarite in ascribing to it the functions of a policeman—arresting the baneful bacteria, while allowing the harmless ones to pass. As to filtration being slow, it had been proved by the Massachusetts State Board experiments that the sewage of a population of upwards of 5,000 could be dealt with on one acre of land, and these experiments were continued for some time.

Major Lamorock Flower (Lee Conservancy Board) said, Mr. Scruby's scheme had not been tested on a large scale; he would like to hear something more about the matter, and when Mr. Scruby could prove that he had treated one million gallons of sewage per day, for a period extending over six months, and show an effectively purified effluent he would be glad to hear from him again. Major Flower welcomed Mr. Cooper, as a good, honest worker in the cause of the disposal of sewage, and he was glad to hear such valuable opinions as he had given them that morning. He was also pleased to hear Mr. Angell, or anyone who would help them to solve this difficult problem. He agreed with Mr. Angell's remarks about the mixture of town sewage with manufacturers or brewers' refuse in the sewers. He also agreed with Colonel Jones that it would be quite as well to try the experiment of the effect of simple deposition, without applying chemicals. Sewage farms were very valuable, but care must be taken in the selection of the site and of the soil. He remembered one instance where the soil was yellow clay; in the wisdom of the day, the clay had been under drained, the result being that the clay cracked, and the sewage got down the cracks unpurified into the drains.

Mr. Rogers Field, M.Inst.C.E. (London), said he must protest against Mr. Angell using such a phrase as "it appears on the face almost needless to speak against sewage farming to members of this Institute." The members of The Sanitary Institute as a body have never expressed any opinion against sewage farming. On the other hand, many competent Engineers were of opinion that if sewage farms were carried on properly this was the best way of disposing of the sewage of a town. He did not think, therefore, the phrase ought to have been used. No doubt there were cases where chemical treatment was the best method, but it should not be advanced as a panacea. It so happened that he had to do with the first case where chemical treatment had been applied to sewage on a large scale, viz., at Leicester, some forty years ago. He was the pupil of the Engineer to the Works (Mr. Thos. Wicksteed), who, as well as the other people connected with them, thought they were going to make their fortunes, but on the contrary they lost their money. Then another scheme came up but this also failed. That made him watch very closely everything that happened of this kind, and every new chemical scheme that came up. The number of chemical sewage schemes which had come up in his time was very large. They were wonderful in the Laboratory, and the promises of their inventors were magnificent, but in four or five years little or nothing more was heard of them. Therefore he not unnaturally doubted this one until he had seen it in practical use for several years. He had also seen sewage farms which were failures, but in every case where this was so, it arose either from placing sewage on land that was altogether unfit for the purpose, or from improper management or neglect. Often they could see a farm which the Engineer had left in a beautiful condition allowed through neglect to get into a simply filthy state. If they spent anything like the money on the management of sewage farms which was spent on chemical schemes they would get results that would be very satisfactory.

Mr. A. ANGELL (Southampton) said that as to Mr. Cooper's point about the sand doing the work on the top of the polarite, it must be remembered that in his paper he quoted experiments made with new polarite, and the reason this was taken was because it was sterile. In polarite, as in all porous bodies, there was a selective power that would separate the lower forms of microbic life that caused nitrification. But he did not claim that for polarite alone; he claimed it for all porous bodies. Mr. Cooper therefore did not appear to have exactly recognised this point. With regard to the severe rebuke by Mr. Rogers Field, he did not think it was too severe. He had intended to say something that would bring a storm about his head, because there was nothing that so well brought a thing out as to have a storm over it, but he admitted that the expression was too strong. He had been asked for some particulars as to the quantities by which he had been governed in the production of the cement. In the early stages they could only get at the amounts approximately. The sludge he got at Salford, but it was the same all over the country. The weight of the sewage sludge of 1000 persons per diem was, say, 75 lbs. net, and this, with 225 lbs. of gas lime, would give 300 lbs. of cement. Multiplying that by 50 would give 15,000 lbs., or seven tons per diem—say five tons. A town of 50,000 inhabitants would require works of the following size: a mixer of 10 ft. diameter; a drying floor 20 ft. by 50 ft.; two ten-ton kilns, 15 ft. high with 15 ft. cupolas; grinding machinery, &c. The cost would be about £1000 and the labour about £6 per week. If they put the cement down as worth 30s. per ton, and allowed 15s. per ton for cost of production, that would leave 15s. profit, making a profit of £3 15s. per day. The cement manufactory for a town of 50,000 inhabitants would be a small affair. As he had stated, the specimens of cement before them were made under his supervision, and it had stood a test of 293 lbs. to the square inch. It was quite inodorous and not in the least objectionable, and he contended that it was better than that used on the Thames Embankment.

In reply to the discussion, Mr. SCRUBY said he did not deal with the solids. They would be left in the filter. In replying to a question from the Chairman as to what became of the solids in the oxidation chamber, he said none would be allowed to enter, as they would be left in the sand filter previously to the liquid being treated.

Mr. C. H. COOPER (Wimbledon), in reply, assured Colonel Jones

that his suggestion to do away with the troughs and draw off the effluent by a weir round the Dortmund would be impracticable, as it would leave a large body of fluid in the centre of the tank always unaffected, as the current naturally would follow the sides. Mr. Cooper was glad to find that Alderman Boulton was in favour of sewage farms. Where it was found absolutely necessary to separate the solids by some means, it could not be better done than by a proper system of tanks and roughing filters. Some speakers had alluded to certain land being unsuited for sewage, but he thought that if properly handled almost any land could be made suitable. Stiff clay land should not be drained, and by attempting to drain it the chance of a good effluent was generally lost.