Transactions of the Seventh International Congress of Hygiene & Demography.

INTERNATIONAL CONGRESS OF HYGIENE
1891

TRANSACTIONS

OF THE

Seventh International Congress of Hygiene and Demography.

LONDON, AUGUST 10TH–17TH, 1891.

Patron:—HER MAJESTY THE QUEEN.

President:—H.R.H. THE PRINCE OF WALES, K.G.

VOLUME VII.

SECTION VII.

ENGINEERING IN RELATION TO HYGIENE.

INTERNATIONAL CONGRESS OF HYGIENE · 1891 ·

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Assisted by the HONORARY SECRETARIES of the SECTION.

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SECTION VII.

ENGINEERING IN RELATION TO HYGIENE.

Tuesday, 11th August, 1891.

The Chair was occupied successively by
The President, Sir JOHN COODE, K.C.M.G., and
Professor HENRY ROBINSON, M.I.C.E.

PRESIDENTIAL ADDRESS

BY

Sir JOHN COODE, K.C.M.G., Past President of the Institution of Civil Engineers.

It is my first duty, and I esteem it at the same time to be my great privilege, to offer, as I now do, on behalf of the English members of the Engineering Section, a cordial welcome to those brethren of our profession who have come among us from afar in order to be present at this Seventh International Congress of Hygiene and Demography.

It has been, I can assure you, the anxious desire of the Organising Committee to provide such papers as will contribute to the advancement of the knowledge of hygiene in all its branches.

Of both the scope and the importance of the subject with which the Congress has taken upon itself to deal, there cannot surely be two opinions. Having for its principal—or rather it may be said for its sole—aim and object, the preservation of health (or in other words the *prevention* rather than the *cure* of disease) the subject of hygiene may well occupy the attention, and claim the interest, of all who desire the welfare of the human race.

As we, the British members, are well assured, it is because the object of this gathering is one which is in an especial degree calculated to benefit the community at large, that it enjoys the patronage of our honoured and beloved Sovereign Queen Victoria, and that it is supported by the Presidency of the Prince of Wales; by his presence at our opening meeting yesterday His Royal Highness has given personal proof that he feels a genuine interest in the success of the cause which we all have at heart.

It will not, it is to be hoped, be devoid of interest, if I here offer a few remarks on the progress of modern legislation in this country in respect of sanitary matters.

About the year 1838 the public mind of Great Britain became first aroused, so to speak, to the serious and growing evils arising from the absence of proper precautions for the preservation of the health of the dwellers in our large towns and cities generally, and more especially in this Metropolis in which we are now assembled.

Between 1838 and 1848, the question of Public Health in the United Kingdom was dealt with in the course of frequent debates and discussions in Parliament; it also formed the subject of inquiries by Committees and Commissions. At the end of that decade these investigations and discussions culminated in the establishment of an entirely new Department, which was entitled the "General Board of Health"; ten years later on, that body was superseded by an Act of the Legislature, under which the important Department known as the "Local Government Board" was created.

Many names might be mentioned in connexion with the work of the two decades just adverted to, but amongst them there stands out most prominently that of one man, the late Sir Edwin Chadwick, whose untiring zeal and well-directed labours contributed more than those of any other single individual to the success of this great movement, and to the adoption of those important measures which have conduced in so great a degree to the improvement of public health in this country.

When speaking to a body of civil engineers, as I have now the honour of doing, it would be remiss to omit to mention the name of another gentleman, whom we have the privilege of including in our list of Vice-Presidents; I refer, of course, to Sir Robert Rawlinson; his eminent services, first in the organisation, and, secondly, in the direction for many years, of the Engineering Department of the Local Government Board, have deservedly received the marked approval of the Sovereign.

The importance of a correct knowledge of the laws of hygiene being granted, this importance becomes accentuated in every place where human beings are congregated together in considerable numbers, as in the case of large towns and cities, the greatest and most notable example of which is this mighty Metropolis, this "City of immensity," as it has well been called. Is there not therefore a peculiar fitness in the holding of this Hygienic Congress in London, which contains the greatest congregation of human beings the world has even seen?

Permit me to mention a fact or two which may serve to give some of those whom I now address a more exact idea of the magnitude of this London of ours.

The population of the metropolis is, in round figures, 5,660,000. The vastness of this number will perhaps be somewhat better realised by my stating the fact that it is considerably greater than the numbers of the inhabitants of the cities of Paris, of Berlin, of Vienna, and of Rome, all combined.

As a matter which cannot fail to be of special interest to engineers, let us turn for a moment and see what has been done in the way of works that have been executed for the special purpose of improving the health of London.

The main intercepting and principal branch sewers which have been constructed for the conveyance of the sewage of London to the two outfalls into the River Thames, at Barking and Crossness respectively, measure about 80 English miles, equal to 130 kilometres.

Since the year 1856, when the now extinct "Metropolitan Board of Works" was formed, there has been expended on the main drainage works alone the sum of nearly 6,000,000*l.* [120,000,000 marks or 150,000,000 francs].

As a by no means unimportant factor among the changes which, in modern times, have resulted in the better health of our capital city, a reference to the supply of water of improved quality, and in larger quantity, must not be altogether omitted. Up to the end of 1890 the several companies (eight in number) had expended upon works for the supply of water to London, a sum very closely approximating to 15,000,000*l.* [300,000,000 marks or 375,000,000 francs].

The average quantity of water delivered last year to the inhabitants of London, for domestic purposes alone, was 24·75 gallons per head of population per diem, and in point of quality but little, if at all, surpassed by that supplied to any other city in Europe; this water is conveyed through pipes, the united length of which is about 4,760 miles. The total volume of water delivered for domestic purposes only in 1890 was 64,000,000,000 gallons [290,623,000 cubic metres]. For raising this large quantity the companies employed no less than 184 steam pumping engines, having an aggregate of 21,659 horse-power. I may here make a passing remark with regard to this large quantity, upwards of 21,000 horse power. As you all know, six hours a day of continuous work is good work for a horse; therefore in that view this quantity might be multiplied by four, making it 80,000 horse power. That is not quite correct, because during the night these pumping engines slow down to some extent; but you may multiply the 21,000 by three. Supposing you were to employ animals to do that amount of work you would require over 60,000 horses to pump the water daily required for London; that it is from two-and-a-half to three times the number of horses in the entire British Army, both at home and abroad. Taking that fact into consideration, it will assist in giving some idea of the labour involved in supplying water alone to this great city of ours.

As another illustration of the magnitude of London it may be mentioned that the streets and roads within the Metropolis, if placed end to end in one continuous line, would measure about 2,500 miles, equal to the distance from London to Land's End, and thence across the Atlantic Ocean to the mouth of the Gulf of St. Lawrence in Canada on the west, or, going eastward, would extend across the entire Continent of Europe, and beyond the Ural Mountains into Asia.

Whilst admitting that extensive drainage works have been executed, and that large expenditure has been incurred for improving the health of London, it cannot yet, by any means, be said that all has been done which might be done in this direction. Nor will it be possible to say as much as long as the sewage of the Metropolis is allowed to flow into any part of the Thames without previous purification by the most perfect method as yet known, *i.e.*, by being filtered through land. The only alternative would seem to be the conveyance of the sewage to the sea coast beyond the mouth of the estuary of the Thames.

Nevertheless, and notwithstanding the room which exists for further improvement in the disposal of its sewage, the reduction which has been brought about in the death-rate of London in modern times is as noteworthy as it is satisfactory. A few facts will show the benefits that have accrued from the better understanding, and the more effectual application, of the laws of hygiene in our Metropolis.

In the latter half of the 17th Century the average mortality of London is said to have been not less than 80 per 1,000; at the end of the 18th Century it had dropped to 50 per 1,000; in the decade ending in 1850 it was 25 per 1,000; in that ending in 1870 it was 24·0 per 1,000; whilst in that ending in 1890 it had further fallen to 19·8 per 1,000.

It is gratifying to note that for the year 1889, taken *per se*, the rate was as low as 17·4 per 1,000, and there is no reason for supposing that it would not have been equally low for the year 1890, had it not been for the unfortunate epidemic which then prevailed, in consequence of which it rose in 1890 to the same proportion as that at which it stood in the early part of the last decade, viz., 20·3 per 1,000.

In the opening part of this address it was stated that it had been the anxious desire of the Organising Committee to provide on this occasion such papers as would contribute to a further knowledge of the subject of hygiene; I will now only add, in conclusion, that as far as regards our own particular section, we, speaking on behalf of the Engineering Committee, have, in this respect, endeavoured to fulfil our part, and have also made arrangements for your inspection of works of professional interest from a hygienic point of view.

We trust that the papers to be read and discussed, and the visits which have been organised, will prove to be not altogether uninstructive, and that they will result, in some degree at least, in furthering the aim and object of this International Congress, *i.e.*, the advancement and diffusion of sound and useful knowledge relating to the all-important subject of sanitary science.

Sewage Disposal with Reference to River Pollution and Water Supply.

BY

Professor Henry Robinson, M. Inst. C.E., F.G.S., F.R.M.S.

Too great stress cannot be laid on the necessity for effectually and promptly removing the excremental and other refuse from the midst of the communities producing them. In an International Congress it may be desirable, however, to say that great care is required not to apply indiscriminately the systems which have been found suitable to this country or to western habits. It is very doubtful whether to centres of population in eastern countries, the water-closet system is applicable; in many cases it is quite unsuitable. The traditions, climate, habits, or religious prejudices of oriental races render impossible the application of systems which have been successfully adopted in the west. The wide diversities of race in the centres of populations under British rule call for special care in providing appropriate remedies for the terribly insanitary state in which vast numbers of our fellow subjects now live, and in avoiding the mistake of applying remedies which may prove to be worse than the evils they are intended to remove.

It is of the utmost importance that the sewerage of towns in the future should be carried out in the light of the experience that has been gained in the past, and that the sewers should be designed to remove, and not retain, the foul matters that are delivered into them. It is considered to be impossible to accomplish this if the sewers are made of a size to carry off the bulk of the rainfall. During long periods of dry weather, the sewers retain much of the solid matter, which deposits, decomposes, and evolves unhealthy and filthy smells. This was recently experienced in many parts of the metropolis after the late winter drought. The existence of such a state of things in hot climates would be disastrous to health. Relief sewers to meet the conditions that occur during heavy rainfall it is thought should be more relied upon than is now the case, so as to enable the sizes of the sewers to be made sufficient for sewage proper, and to avoid their being sewers of deposit, which they too often are. Sewers ought to be self-cleansing, and the sewage which is removed by them ought to be brought to the point of discharge in a fresher state than is possible where the sewers are calculated to convey the bulk of the rainfall with the sewage. They then inevitably become sewers of deposit in dry weather, and give off dangerous gases. The first heavy rains flush the sewers, and carry the highly decomposed matter to the outfalls, increasing the difficulties of dealing with it; and if it is discharged into rivers, a destructive effect on fish life is produced.

The discharge of sewage or manufacturing refuse into streams to avoid the expense of previously treating it must be protested against. The rivers must no longer be regarded as the natural vehicle for removing it. What was at first an evil of comparatively small extent has, with the rapid sewering of towns, became one of great magnitude. Public opinion is favourable to the adoption of drastic measures. The Rivers Pollution Prevention Act of 1876, requires amendment, so that it is mandatory instead of permissive. There is no justification for delay, inasmuch as even in 1872 it was stated (in the Fourth Report of the Second Commission), that "methods have been "described in our Reports involving no excessive expenditure, by which "the foulest liquid waste from manufactories can be adequately "cleansed. We believe that the adoption of none of them will inflict "any injury at all upon manufacturers; indeed, we have every reason "to conclude that their adoption will save the manufacturers of this "country from inflicting considerable injury upon themselves, whilst by "preserving the whole course of rivers in a comparatively clean and "useful condition they will tend powerfully to the extension of "manufactories upon their banks. One of the most crying evils in "manufacturing districts is the want of clean water, and therefore "every successful effort to make dirty water again usable is a gain to "manufacturers."

Standards of purity should be arrived at so as to enable the conditions which exist at any place to be fairly considered and dealt with. It would be inequitable were expensive works for purifying town or manufacturing refuse to be insisted on where the point of discharge enables it to be quickly carried seaward, or is remote from sources of supply of drinking water. The necessity for such standards is obvious, and is well recognised. Mention should be made in this connexion of the intelligent action that has been taken by which standards of purity for all liquids discharged into the River Spree have for years been in operation owing to the pollution which arose from the sewage of Zurich being passed into that river.

The discharge of the waste products of human life into rivers used for domestic water-supply must be attended with more or less danger, inasmuch as they will probably always contain a proportion of the germs of the various diseases which are capable of being disseminated and propagated in water.

The action that has been taken by the State Board of Health of Massachusets to protect the purity of inland waters deserves to be specially commended as an example of broad and wise policy in instituting the systematic investigations by engineers, chemists, and biologists of all that bears upon the purification of sewage, and on the filtration of water. By an Act of this State examinations are made of all waters for the purpose of ascertaining whether they are adapted for domestic supply, or are in a condition likely to impair the interests of the public or to imperil public health. The exhaustive reports under these different heads may be fairly stated to be far in advance of anything that has been attempted in this country.

The history and condition of a river into which sewage is discharged requires to be studied from several points of view, as conclusions arrived at in regard to one river may be totally inapplicable to another.

A very remarkable investigation was made at the beginning of this year by Professor Von Pettenkofer with reference to the sewage pollution of the river Isar between Munich and Threising when the river was at the lowest level from the long drought of last winter, and consequently when the proportion of fœcal matter to volume was at its maximum. The relative volumes of this river were 50 cubic metres per second during this dry period compared to 350 cubic metres per second during a previous flood time. A comparison was made between the amount of oxygen that was required to destroy the organic substances in the water at the time of minimum flow, and the amount that was required in previous periods of flood, and the observations of Professor Von Pettenkofer led him to the singular conclusion that no evil results followed the discharge of raw sewage into the river, and he undertakes to prove that bacteriological investigations do not support the view that injury is done to this river by sewage being discharged into it.

The chief characteristics of fresh sewage are free ammonia (or decomposition in progress) and chlorine. When sewage is discharged into a river it becomes diluted, and the ammonia is reduced by oxidation and through absorption by plant life. If it were not for the natural purification which rivers are capable of, the constant discharge of polluting matter into them would have made the evil cumulative. Fortunately the innumerable organisms which exist in rivers and which thrive on organic matter act as scavengers. They are aided by minute plants, which, under the influence of light, liberate oxygen and help to oxygenate the water.

It has been ascertained that entomostraca consume dead animal matter, and that where this is wanting they do not live, but where it is in abundance they thrive. It follows, then, that these minute animals exercise an important function in absorbing sewage impurities. They multiply prodigiously in these impurities, and are both created by them and fed upon them, converting foul and dangerous matters into harmless ones, in a similar way to that which is referred to hereafter as nitrification when speaking of the action of bacteria in the soil.

In a sluggish river pollution is less capable of being naturally removed than in rivers with falls, rapids, and swift currents. Some observers attribute the self purifying action of rivers more to the natural action of deposition, bacteria, and plant life than to any chemical influence of oxygen.

To new countries whose rivers are now free from pollution but where centres of population are springing up a warning should be given to avoid the evil results that older countries are now suffering from. Efforts are being made to divert sewage from the river Seine, and nine main sewers which used to discharge into the Siene at the island of St. Louis have been diverted by a syphon under the river, and this grave cause of pollution has been removed. The river Thames will soon be no longer the recipient of the crude sewage of London which has for so many years been a subject of strife. It is now admitted (after long and costly inquiries) that the outfalls at Barking and Crossness must be adapted to the clarification of the sewage, and the London County

Council, under the advice of their able chief engineer Mr. Alex. R. Binnie, C.E., and the intelligent supervision of his colleague Mr. Santo Crimp, C.E., are now adapting the Crossness Outfall Works to chemical treatment as was done at the Barking Outfall by the late Sir Joseph Bazalgette, the chief engineer of the Metropolitan Board of Works (the predecessors of the London County Council).

A clause was inserted in the Local Government Act, 1888, enabling county councils to deal with river pollution, and it is to be hoped that some good will result. An effort has been made by the authorities of Chester, Lancaster, Derby, and others interested in the river Irwell (notorious for its foul condition), by which the Rivers Pollution Prevention Act of 1876 could be put in force by the granting of a Provisional Order conferring powers on them. An application was made at the end of 1890 for such powers, and this forms an important precedent which will probably be followed up throughout the country. Objections were raised to such joint action on the ground of interference with the existing powers of the several local authorities who have ostensible control, and that such concurrent jurisdiction would create difficulties.

Where land is obtainable in sufficient areas, and of a porous nature, the fertilising properties of sewage can best be utilised on it, both from an agricultural and a sanitary standpoint. This is seldom possible, and where attempts have been made to purify sewage on unsuitable soils, commercial and sanitary failure have resulted. Experience has proved that where clayey or impervious lands have been deep-drained so as to ensure the passage of sewage through it, the result has been that the sewage has passed into the subsoil drains only partially clarified, and in a recent case the deep drains have had to be done away with, and the land used for broad irrigation. Twenty years ago the application of sewage to land was advocated under all circumstances, but experience has shown that the result of applying more than a very limited amount of sewage to non-porous soils is that it is not purified, and that sanitary mischief arises. The sewage may be to some extent mechanically strained, but the absence of the necessary free oxygen in the pervious soil prevents purification. When sewage irrigation or filtration is carried on without care and without the knowledge of the chemical and biological laws which require to be considered, there is a risk of pollution to subsoil waters and streams into which the sewage effluent passes. If an area of porous land can be obtained sufficiently large to enable the sewage of about 100 persons to the acre to be applied intermittently, then good agricultural results will ensue. Where sandy soils exist, as at the Craigentinny meadows near Edinburgh, or at Gennevilliers, where part of the sewage of Paris is treated, then large volumes can be applied with advantage to vegetation, and enormous crops can be produced. These are adduced as conclusive proof that sewage ought to be applied to land. Hungry soils of the nature referred to will no doubt pass immense volumes through them, and the crops will retain and assimilate that which they require to the great advantage of the agriculturist. If, however, the subsoil waters were examined, insanitary conditions would be disclosed which should point to the necessity of taking a broader view of the subject than has too often been the case when irrigation enthusiasts have had their own way.

Mr. Robert Warington, in his experiments at Rothampstead, long ago established the fact that micro-organisms perform an important function in sewage filtration, and that the action of an earth-filter is not mechanical, but partly chemical and partly biological. The destruction of the organic impurities in sewage was shown to be brought about by a process of active fermentation or decomposition (termed nitrification) caused by bacteria. A question of great practical importance in connexion with both sewage disposal and water supply is whether any of these organisms can escape destruction. The conclusion that is arrived at by the American investigators in the before-mentioned Report of the State Board of Health, Massachusets, is that the belief that bacteria cannot survive to pass through sand-filters is fallacious, although the great bulk are destroyed. It follows from what has been said that in the disposal of sewage upon land or in filtering impure water, the necessity arises for exercising great care. Experiments upon sewage filtration have been made by Mr. Hiram Mills, C.E., of the Lawrence Experimental Station in America, which confirm the view that nitrification ceases if the filtration is not conducted intermittently. Also that sewage effluents that have been passed through sand-filters covered with soil, in which nitrification took place, resulted in the destruction of bacteria, and that the effluents from such filters were not favourable to the support of bacteria. This is due to the fact that the free and albumenoid ammonias in such effluents, being the residue of a much larger amount that has been destroyed, are much less able to support bacterial life than fresh organic substances containing the same amount of free and albumenoid ammonia.

Dr. Sedgwick, of the Lawrence Station, experimented specially to ascertain whether bacterial organisms could live to pass through 5 feet of coarse sand filters, worked intermittently. He found that they could, especially the bacillus prodigiosus, which appears to be a tolerably hardy specimen. It may be taken as proved that although the large bulk of organisms are destroyed by efficient filtration, nevertheless, some do pass when the filters are composed of sand alone. When the filters were of fine sand, but were covered with soil, the bacteria appeared to be all nitrified, and the effluent, even from sewage, was harmless, and might be drunk. The practical question is, are sources of water supply that require filtration to be condemned? The answer appears to be that, where possible, such sources of supply should be avoided, as circumstances might arise to cause some disease-producing bacteria to exist in the water, and as they are capable of increasing with enormous rapidity under favourable conditions, it would be unwise to disregard the possible mischief that might follow. With filters, however, properly constructed and manipulated, the mischief is avoidable. The data which are now available clearly indicate to engineers that the efficacy of the ordinary sand filter can be increased greatly by covering it with a soil suitable to developing the nitrifying action in the filter.

Chemical precipitation of sewage is now very frequently resorted to for the purpose of destroying the noxious properties in sewage. The hopes, however, of the first workers in this field of invention of doing this profitably have long since disappeared. The sanitary and commercial aspects of the matter have to be kept in view, and the experience that has accumulated enables simple chemicals alone to be adopted. These are able to effect sewage purification by themselves, where the highest standard of effluent is not required, or can be supplemented by subsequently passing the effluent through filters. Crude sulphate of alumina, proto-sulphate of iron (or copperas, the waste products of tin-works), are chemicals easily obtainable and are most usually employed to produce precipitation. A small amount of lime is used as an alkali, care being taken not to have an excess of lime if the effluent is to discharge into a stream where the secondary decomposition resulting from a lime effluent would be objectionable. If a high standard is necessary it is usual to pass the effluent through a small area of filter specially prepared, so that it effects the changes referred to elsewhere when speaking of nitrification. An artificially prepared material called polarite has attracted much attention recently. This is an insoluble, porous, and magnetic material, used by the International Sewage and Water Purification Company, which appears to have the property of destroying organic impurities in fluids in a remarkable manner. Dr. Anderson, C.E., has lately introduced the use of scrap-iron in a revolving cylinder as a medium through which impure water can be passed and purified.

The sludge deposited from any process of chemical treatment has a very doubtful value for agricultural purposes. That known as the A.B.C. process (where alum, blood, and clay are the precipitants) claims to have a higher value than chemists assign to it; and, as recent researches show how much has yet to be learnt about the changes that take place in the soil, the simple test of agricultural results appears a fair one if applied commercially. At the Metropolitan Outfall Works at Barking the sewage is treated by the addition of milk of lime in the outfall sewer, then proto-sulphate of iron or copperas is added, and in the summer months permanganate of potash in addition to both.

Where the sludge does not command a sale for manurial purposes it has to be got rid of in the most economical way, so as to avoid creating a nuisance. This is sometimes done by partially drying it in mechanical presses, and so converting it into a partially solid material (having about 50 per cent of moisture) by which it can be carted away and sold or used to fill up low-lying land. At Barking it is taken in steamers specially constructed for that purpose, and is conveyed to the sea, where it is disposed of.

It has been impossible in this paper to do more than touch upon the many important matters that arise in connexion with these subjects. If the observations, however, that have been made elicit opinions from the many experienced and distinguished gentlemen who are present at this Congress, one main object in making this communication will have been accomplished.

L'Assainissement des Villes en Italie.

PAR

Prof. PACCHIOTTI, Sénateur.

L'Italie est en train de se transformer par des réformes sanitaires. Gouvernement, Parlement, Municipalités, hygiénistes, ingénieurs, tous les journaux d'hygiène d'accord veulent rajeunir, embellir, assainir les villes.

Ma communication s'arrête à la question de l'assainissement (*drainage, fognatura*). Deux partis sont en présence, ceux qui défendent le tout à l'égout et ceux qui préfèrent le *separate system* selon Waring.

Parcourons l'Italie. Rome possède depuis 2,500 ans le tout à l'égout, fondé par les Tarquins, continué par la République, l'Empire, les Papes et depuis 1870 par notre Gouvernement.

Le tout à l'égout est en voie de construction à Naples (qui cependant a aussi le *separate system* dans sa partie basse), à Milan qui a introduit depuis 300 ans le *sewage farm*, à Côni aux pieds des Alpes, à Venise et à Florence.

Ce système est à l'étude à Spezia, Ancone, Bari, Catane, Messine, où d'excellents projets sont préparés.

A Palerme et à Massa Carrara nous trouvons deux projets du système Waring. Dans la grande capitale de la Sicile une lutte ardente domine. Dans la petite Carrara on a construit un petit échantillon.

Et maintenant deux mots pour Turin, dont je viens plaider la cause devant le grand Jury du Congrès, où je présenterai tous les projets, avec une description de la ville.

Voici en peu de mots l'histoire. Première Commission nommée en 1880. Présentation d'un projet du tout à l'égout en 1883. Renvoi à une deuxième Commission qui propose le *separate system* en 1886. Discussions entre les deux partis. Nomination de M. Bechmann pour faire un nouveau projet du tout à l'égout. Nomination d'une Commission de quatre éminents ingénieurs et un savant hygiéniste pour faire un choix entre les deux systèmes. Vote unanime de celle-ci pour le tout à l'égout. Nouvelle hésitation de la Municipalité.

Je suis un partisan convaincu du tout à l'égout à Turin, qu'on dirait faite exprès par la nature pour ce système avec dépuration des eaux et irrigation agricole de vastes terrains très près de la ville.

Je viens implorer un conseil dans cet Aréopage de savants de toute l'Europe.

Je défendrai les propositions suivantes :

1. Chaque ville doit choisir le système qui lui convient, car il n'y a pas un seul système pour toutes les villes sans exception.

2. Toutes les villes qui veulent entreprendre leur assainissement, si elles ont assez d'eau et une pente assez convenable pour entretenir la

libre circulation et empêcher toute stagnation, selon l'aphorisme de Sir Edwin Chadwick, doivent adopter le système du tout à l'égout qui s'approche, plus que tous les autres systèmes connus, de la perfection.

3. Toutes les villes qui possèdent plus ou moins près d'elles des terrains perméables et propres à l'épandage des eaux d'égouts, doivent en profiter pour servir à leurs dépurations et favoriser l'agriculture.

4. C'est contraire à l'hygiène de déverser, *quand on peut l'éviter*, les eaux d'égouts dans les cours d'eau environnants les villes, parce que les analyses chimiques et bactériologiques modernes démontrent qu'elles produisent autant que les eaux cloacales la pollution des fleuves.

Sanitation in India.

BY

BALDWIN LATHAM, Mem. Inst. C.E., Mem. Inst. M.E., F.G.S., F.S.S., F.S.I., P.R. Met. Soc.

There is no country that requires greater attention to be paid to sanitary measures than India, and there is, probably, no country which will repay the labours of the sanitarian better than India, as is already shown by the results accruing from the prosecution of sanitary works and the adoption of sanitary measures which have, wherever introduced, been immediately followed by a marked improvement in the state of public health.

The supply of wholesome water, the construction of sewerage and drainage works, and an effectual and safe method of dealing with the waste products of the vast populations are matters of urgent necessity throughout India. The general habits of the majority of the native population are such as to lead to the pollution of the air, the ground, and all unprotected sources of water-supply.

The dense population living in Indian cities—a density which is in excess of that in any European country—is a condition that points to the urgent necessity of efficient sanitary measures being adopted. There is no wonder that the death-rates in Indian cities are large, as the average density of population may be taken as 100 persons per acre, and in many parts of the cities there is still a greater congestion of the population.

Under existing arrangements the ground of all Indian cities is more or less impregnated with filth and the urinary excretions of man and beast, and so great is this pollution that in most cities local wells have become brackish as a result of ground pollution. Nor is this state of things confined to the cities, for in the villages there is just as great neglect of sanitary requirements, and the cattle often occupy the lower rooms of the habitation, thus adding to the unhealthiness of the dwelling and the pollution of the ground.

The inhabitants of the cities, towns, and villages in India, die of diseases arising from insanitary conditions at a rate of which we have no conception in this country. There are also other causes of death in India (some of which are common to other countries) that influence the death-rate, such as exposure and insufficient clothing during the wet and cold seasons. The natives of some parts of India are also subject to causes of deaths unknown in European countries, such as death from snake-bite, and being killed by wild beasts, but deaths from these causes may be excluded, as they are less than half per cent. of the total deaths in the district most subject to this form of mortality.

The climatic conditions of India cannot be considered absolutely unfavourable to the promotion of good health. The high temperature of the plains of India, having regard to the polluted state of the ground and of the water-supplies, is a condition certainly not favourable to the health of its inhabitants. On the other hand, probably, if it were not for the influence of the sun in drying up and destroying much of the polluting matter, the health of the inhabitants of India might be much worse. The most unhealthy periods in India are certainly not the hottest periods of the year. The high temperature of the ground is unfavourable to health in all those places in which the refuse from the population is stored in receptacles below the ground level. The favourable health statistics of large towns like Bombay and Calcutta show that it is not climate that causes the frightful mortality in many parts of India, but that this is due to the downright neglect of the simplest sanitary precautions.

The fixed wet and dry seasons of most parts of India can be depended upon with a degree of certainty. The excessive rainfalls of one period, compared with the long absence of rainfall in other periods, tend to show that the separate system of sewerage is one which is the most proper for certain places in India, and that the rainfall in these districts should, as far as possible, be completely segregated from the sewage proper. The rainfalls in some of the larger cities are excessive, for in Bombay falls exceeding 4 inches per hour have been recorded, while in a single day over 16 inches of rain have fallen. The average of the heavy falls of rain in Bombay exceeds 2 inches per hour, whilst the average of the daily heavy falls exceeds 7 inches per day. In Calcutta, the rains are not so heavy as in Bombay, but occasionally heavy falls exceeding the rate of 3 inches per hour have been recorded, though on an average rainfalls exceeding 5 inches per day are only recorded once in three years.

The sanitary appliances in use in India are of an extremely varied character. In many cases conservancy is unknown, and the refuse of the population rots at each man's door. In the cities, for the most part, the Halalcore system is adopted, a system by which the solid nightsoil is collected in a basket placed below the closet seat, an arrangement which allows the liquid parts, including the water of ablution, to flow away, usually to the street gutters. Under this system the stercoraceous matters are collected by men and women every day and then carried in baskets on their heads to some central point where they are deposited in a barrel on wheels and are then carted to some place for disposal. In the cities where they have sewers, these matters are mixed with water and flushed into the sewers; where they have not sewers, the matters are either trenched or buried in the ground or manufactured into poudrette.

The trenching of nightsoil cannot go on in the time of the monsoon, and at this period the material is generally buried in deep pits, to be sometimes resuscitated and manufactured into poudrette. As a rule, the effect of burying this matter in deep pits in the hot soil of India causes a violent fermentation to take place, and an indescribable nuisance to be created. The trenching grounds, too, are extremely obnoxious, and the position of these trenching grounds is ordinarily fixed as a matter of convenience, and often pollutes the underground water, the soil, and the atmosphere of the neighbourhood of a town to a most injurious extent. At Poonah an attempt has been made to manufacture the material into poudrette by admixture with wood ashes and drying in the sun, and under sheds in the monsoon; and it is found that a manure very valuable for some crops can be produced, but that the sale of the manufactured article does not return more than one half of the cost of its collection and manufacture.

In most cities privies are of common occurrence, and the author has seen a structure of this kind in Calcutta, in which the excreta drops into the basement of a many-storeyed building of considerable altitude, where it accumulates to a considerable depth and from whence it is removed in semi-liquid condition by the Sanitary Department. Cesspools constructed in brick, stone, and other materials are in common use, and large earthenware jars sunk into the ground are also used as cesspools, and are emptied at periods more or less remote. The surface of the street in most cities is the receptacle for a large part of the sewage.

In the Holy City of Benares they have had a system of covered sewers in operation for a long period, but these sewers are more or less imperfect in form; yet, bad as they are, Benares is in a much better state of health and has had a lower death-rate than many of the towns that do not possess any such system; and this, in face of the fact that Benares is the home of large numbers of persons who go there especially to die, and is a very crowded city, is a matter that speaks well for the advantages of works of sewerage.

Earth-closets also have been used in India, but it is found that owing to the large amount of earth required their use among natives is not general, as the waters used for ablution necessitate about 5 lbs. weight of earth being used to each inhabitant per day.

With the exception of some of the large cities, the water-supplies are extremely defective. The supplies are usually taken from tanks which are, for the most part, nothing but filthy polluted ponds to which generally the drainage of the village or town has direct access. The tanks in use in the suburbs of Calcutta may be taken as a fair description of those ordinarily used throughout India. Analyses of the water of these tanks show that by far the largest portion of them might naturally be classed as containing raw sewage.

As an example of the polluted state of the tanks, and of the effects of often filling them in with vegetable and animal refuse, Dr. Simpson, the medical officer of Calcutta, gives a very interesting example in one of his recent annual reports as to the state of these tanks after being partially filled up. A woman residing on the banks of one of these tanks in Shampooker lit a fire for cooking purposes, but after the fuel was consumed the fire continued to burn with a continuous flame, and she was able to cook her food every day for more than a fortnight without being put to the expense of buying fuel. She kept the secret for some days, but at last told her neighbours, who were invited to come and see the wonderful light. Her visitors, however, became so numerous that she made a charge of a pice per head, and by this means, in one day, she realised no less than four rupees. It was a matter of great astonishment, the flame being looked upon by her visitors as the tongue and breath of the devil. The income of the woman was, however, stopped by some of the inquisitive visitors digging up the ground around the house and so allowing the gases of decomposition to escape, after which the fire went out, or only burned fitfully.

The supply of water from wells also is largely in use. The water of all wells within Indian cities must be looked upon with suspicion, as all these supplies are liable to pollution, and in many instances they have become so polluted that they can be no longer classed as fresh water. The wells also, in a very great measure, are liable to pollution from the mode in which the water is drawn by the utensils of each individual using the water, and also by reason of the site of the well often being used for the purpose both of ablution and washing of clothes, and the liability of the polluted waters to return to the well. The running streams of India, to which the natives have access, are polluted from their very sources downwards; but, as a rule, the districts supplied from running streams are healthier than those drawing their water-supplies from either tanks or wells.

Cholera, which is more or less prevalent in many parts of India, is almost entirely due to the defilement of wells, tanks, and rivers. The consuming thirst of the cholera patient leads directly to the speedy contamination of all unprotected water-supplies. This has been shown in the enormous reduction of cholera in Calcutta by the introduction of the public water-supply into that place, and even the recent extension of the Calcutta water-supply to some of the suburbs of Calcutta has produced an immediate and enormous diminution in the deaths accruing from this very fatal disease.

The experience in India in connexion with water-supplies taken from rivers shows that the rivers undergo a process of purification, and that the waters taken from them, after a sufficient length of flow, and if perfectly filtered, are among the most wholesome supplies in the country, as the case of Calcutta fully demonstrates. There is also abundant experience that the introduction of water into a district will not of itself promote good health, especially if the water supply is taken from a place liable to immediate pollution; for example, the city of Ahmedabad until the present year has had waterworks, the source of the supply being the Sabarmati River, the intake of the works being actually located within and at the lowest part of the city, below all the points where the river is used for ablution, washing, and other purposes, and is liable to receive the filth of the city washed in with the rains in the monsoon period. Under such a state of things, and in the absence of proper sewerage, Ahmedabad has been very unhealthy, the death-rate of its people having, at times, exceeded 70 per 1,000; and on an average of 11 years—1875 to 1885—it has had a death-rate of 53·15 per 1,000. This state of things at Ahmedabad has just been remedied by moving the intake of the waterworks to a point in the river above the city.

In the city of Poona there is also a water-supply, but no sewerage; and this city, which is much more healthy than most cities in India, does not enjoy that high standard of health which is secured in cities which have both drainage and water supply. For some time it was a question of doubt in India whether or not, owing to the peculiar religious tenets of some of its inhabitants, they could use water which had been filtered and supplied through pipes. However, it appears that the Brahmins have announced that filtered water brought through pipes can be used for all purposes except religious ceremonies.

The quantity of water used in the cities of India would be extremely large, under existing arrangements, if the supplies were constant, as generally the native has cleanly habits, and will not bathe in his own house in water in which anyone else has previously bathed, and, as a rule, water is continuously running to waste all the time he is taking a bath. This habit contrasts strangely with the filthy habits of bathing when using the polluted water of tanks or rivers in common with others.

In Calcutta the intermittent water-supply of 14 hours per day is over 44 gallons per head per day, and in Bombay it is over 20 gallons per head per day; and it is very questionable if the waterworks which are now being carried out in India will afford a sufficient supply of water for the demands of the population, having regard to the way in which the water is used when once introduced into the city. It is imperative, therefore, in all waterworks, that such water fittings shall be adopted as will prevent the waste of water.

The sanitary appliances for the removal of the refuse of the population by water carriage in India must not only prevent the waste of water, but must be of such a character as not to even splash with water the person using them for fear he is polluted; yet these same natives ordinarily bathe in common, and use waters for all purposes of the vilest character, to which there has been access of all those matters which are looked upon as a cause of pollution to the particular individual when he has to use sanitary appliances within his own residence.

Such is the sanitary state of India, that it is recorded that in the North-West Provinces alone, according to the authority of Dr. Hutchinson, the Sanitary Commissioner, that in 40 out of 106 towns in the year 1889 the deaths exceeded the births. He mentions that the rate of mortality in the small town of Lalitpur, which had a population in 1881 of 10,614 persons, was 81·48 per 1,000, of which 27·32 per 1,000 was due to deaths from cholera.

Small-pox also not infrequently produces a very high death-rate in the districts in which vaccination has been neglected, and in the town of Sandila, containing in 1881 a population of 14,865, the death-rate from small-pox alone, in 1889, was 17·02 per 1,000.

The deaths from fever in India have a different signification as compared with England, for in some places nearly the whole of the mortality is ascribed to fever. This is due to the imperfect system of the registration of deaths, as most authorities in India agree that in all probability the actual mortality from fever does not exceed 25 per cent. of the total deaths. The general cause of death, except in the case of cholera and small-pox, is not distinguished by the native collector of statistics, and consequently every disease in which there have been feverish symptoms is usually put down to fever. As an illustration, in Cawnpore, the death-rate from fever is stated to be 39·92 per 1,000 of the population, whereas the death-rate from all causes stands at 49·60. The city of Cawnpore, in the year ending March 1890, had a death-rate of 53·11 and a birth-rate of 40·46. It should be noted that in India very many deaths are not recorded, so that the death-rates in all cases may be taken as being higher than is actually given by the figures.

As a rule, the towns in India are very much more unhealthy than the districts in which they are located. In the North-West Provinces the average death-rates of all the towns exceeded, on an average, during the past five years, that of the districts in which they are located by 5·13 per 1,000. It is also found that women, who are more exposed to the insanitary conditions of home life, suffer more than the males. Dr. Simpson's returns for Calcutta show that the deaths of males for four years, from 1886 to 1889, was 23·4 per 1,000, whilst it is found that the deaths of females in the same time was 31·4, or the female rate of mortality was 36·5 per cent. greater than that of the males. It should also be noted, especially with regard to the position which females occupy in India, that the suicides amongst females are three to one of the males, or exactly in the reverse proportion to that of England. This is, in a great measure, attributed to the restraint put upon females.

As a result of sanitary work in the case of the city of Calcutta, we have the means of comparing the health of that city, which receives a good supply of wholesome water, and has been sewered, with that of the suburbs, which have received neither of these advantages. From Dr. Simpson's return for the 12 years 1877–1888 it is found that the average death-rate of the city of Calcutta was 28·7 per 1,000. In the same 12 years the average death-rate in the suburbs of Calcutta was 47·25 per 1,000. The population was almost twice as numerous in Calcutta as in the outside district, yet the outside district had an average death-rate exceeding that of the city itself by 64·63 per cent. These figures at once show the incalculable advantage to any place adopting sanitary measures, for it cannot be said that in Calcutta the sanitary works, as regards its system of sewerage, are by any means perfect, and nearly the whole of the benefits which have accrued in the case of Calcutta has been shown to be due to the introduction of a wholesome supply of water; and this may again be inferred from the fact that in the suburbs of Calcutta that have been supplied with wholesome water and have no sewerage works, the death-rates have immediately been reduced. Moreover, it was found that when Calcutta was first supplied with water in 1876, before its sewerage works were carried out, the average death-rate for five years, before the supply was introduced, was 38·2 per 1,000, while the average death-rate for the subsequent five years was 24·6 per 1,000, or a reduction in the death-rate of 35·6 per cent. The authorities in India usually calculate that for every death recorded there are at least 20 cases of sickness. In all probability the number may stand much higher, as by reference to the report of the Commissioners at Poona, I find that in the year 1885, out of a population of 100,000 persons, it is recorded that 51,842 were admitted to the hospitals in this city in one year.

Investigation of the sanitary state of India shows the urgent necessity that exists for sanitary measures, and it is gratifying to know that the Sanitary Commissioners of India are fully alive to the advantages of such measures, and, aided as they are by the supreme authority and by the Governments of the various provinces, it is hoped that in the course of a few years much will be done to mitigate the evils arising from the insanitary state of the large towns and of the country generally.

French and English Systems of Sewerage.

BY

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The author desires to call the attention of the Congress to the systems generally prevailing in the two countries.

In the year 1884, the author prepared a report upon "The assainissement of the Town of Hâvre," by the direction of the French Government, and in so doing, he had many opportunities of comparing the French and English systems. It is a common practice to discharge the soapy water, the urine, and the dirty water from the kitchens into the open gutters or channels of the streets by means of pipes placed against the external walls of the houses, with small troughs or receivers at each story.

In those streets with little fall, evaporation takes place from the arrest of the flow, or by the deposit of matters in suspension, and nuisances, detrimental to the public health, constantly arise from the dirty condition of the channels or gutters referred to. As these gutters discharge themselves into the sewers by untrapped openings under the kerbs of the footway, the smell arising from the sewers is freely discharged into the air immediately under the noses of the passers by.

It is true that this state of things is somewhat modified by the waterposts which continually discharge themselves into the gutters, and keep up a small flow of water.

This attempt to wash down the gutters cannot be called a flush, it is feeble at the best of times, although the same quantity of water consumed by a proper arrangement of flushing-tanks would be sufficient for the purpose.

The modes of disposal of excrementitious matters which have come under the notice of the author are three in number, the first, or least imperfect, which is applied in the new houses, consists of a watercloset with a small supply of water, discharging by means of soil pipes into a cesspit, generally situated in the yard of the house.

This cesspit is generally in masonry, and is divided into two parts to separate the solid matters from the liquid, and from the portion containing the liquid a pipe is connected with the sewer.

The solid matters remain in the first compartment, the liquid passing through the perforated divisor into the second.

By this means the emptying of the cesspit is postponed to a more distant time.

The second system consists of closets, supplied with water or not, situated on the various floors or in the yards, and connected with one cesspit, also in masonry, conserving the solids and the liquids until it is full. This cesspit has to be emptied frequently.

The third system is principally found in the old parts of the towns in which the population is the most crowded. It consists of a tub placed in the attics or the cellar, sometimes without either ventilation or light, near to inhabited rooms.

In some of the lowest class of houses the condition of these tubs defies description. They are emptied more or less regularly, and in order to do so it is sometimes necessary to carry them down narrow stairs, and even through the rooms, to the carts in the streets, from whence they are removed to the outside of the town, leaving noxious and pestilential odours behind them on their route.

It is impossible to conceive any system more calculated to spread cholera, typhoid fever, or other diseases amongst the inhabitants. It may be said these are matters more affecting house drainage than town sewerage, but the latter entirely depends on the house sanitation, and it is impossible to separate them.

The French system of sewerage consists in the establishment of sewers, called collectors, in the main streets, into which smaller sewers discharge themselves from the inferior streets.

These collectors are of large sectional area, and are designed to take the rainfall and the washings of the streets, no intercepting gulleys being used; the result is, deposit rapidly accumulates in them, and special means have to be adopted to flush it out or remove it by hard labour.

The system may be briefly described as "All to the sewer from the streets, and as little as possible from the houses." Some French engineers have now become converts to the principle of "Tout à l'Egout," "All to the sewer," and if that be adopted, an entire revolution of the French system must naturally follow.

The English system consists in the rapid and entire removal of all excrementitious matters from the houses to the place of disposal before decomposition sets in.

Much has been said and written against the English watercloset, but it still holds its own as the cleanest and best receptacle yet devised by man. With the best description of closets and well ventilated soil pipes, there is no fear whatever of what are called sewer gases.

In connexion with the watercloset we have the water carriage system, and the English mode is to adapt the dimensions and fall of the sewers to the work they have to do, so that in ordinary working there shall never be less velocity than two feet per second.

Pipes made of glazed stoneware are now almost universally used in England for small sewers, with man holes or inspection shafts about every 100 yards, and the sewers laid at right-angles therefrom. They afford an effective means of rapid sewage removal, and are in every respect superior to the sewers of masonry, brickwork or béton used in France.

The English system differs from the French system in one important principal, and that is the removal of the polluted water from the houses is always the first consideration, whereas in France the removal of the washings of the streets is considered more important.

It is alleged that the water carriage system as carried out in England, increases the difficulty at the outfall; this is no doubt true, but in towns where waterclosets are not generally used, local authorities are compelled to deal with the sewage to prevent pollution of rivers.

Various modes of purification have been adopted in England, such as irrigation, intermittent filtration, precipitation, &c., and in some cases a combination of the two modes. In the large majority of cases these various systems are effectual.

By the French method, the volume of sewage is less, but the decomposed sewage from the cesspits, which is discharged into the sewers, causes as much pollution at the outfalls as the English system, in which the use of waterclosets is general and 20 to 30 gallons of water per head per day are consumed.

Something no doubt can be said in favour of the French subway, but the same arguments may also be used in favour of the English subway, the only difference being that the sewer channel is open in the former, and covered in the latter.

In the opinion of the author there is only one true principle of sanitation, and that is, the rapid and constant removal of all excrementitious matters from the houses to the place of disposal. It is urged that the system adopted by the best English sanitary engineers affects this object in the simplest, most efficient, and most economical manner, and that the French system does not.

The best test of all sanitary work is the effect upon the public health. In the best drained towns in England you have a low death-rate, and although this is also due to good water, healthy dwellings, and other causes, house drainage plays a most important part, and without it you cannot get a low rate of mortality.

The author would compare two seaport towns in the respective countries with which he is very familiar, viz., Hâvre and Southampton. There is no reason whatever why Hâvre should not be as healthy as Southampton, yet the death-rate in Hâvre is more than double that in Southampton.

The same comparison may also be drawn between the inland towns of France and England to the disadvantage of the French towns, and, in the opinion of the author, the cause is to be found in the want of efficient sewerage and house drainage.

The Removal of Sewage after leaving Buildings.

BY

REGINALD E. MIDDLETON, Mem. Inst. C.E.

The writer proposes, in the following remarks, to give a short description of different systems for the removal of sewage matter from houses and streets to the sea, to land, or otherwise; he desires to set forth as simply as possible the difficulties attendant on each system which has been adopted in the endeavour to find an efficient, economical, and rational means of removing sewage from its point of origin to that of disposal.

The system of sewerage which has been most generally adopted in this country, and which has existed from the earliest times, is that of large sewers calculated to admit of the passage of all the sewage matter and storm-water which the district receives.

So long as it was possible to turn the sewage thus collected into the nearest river or stream, or into the sea direct, this system of large sewers was the natural sequence of such disposal. But the injurious consequences of this course having become apparent, in the dangerous pollution of rivers and streams, and the offensive condition of the sea-shore in many places, whereby the country was to a considerable extent deprived of its most natural and least artificial source of water supply, it became necessary to enact that sewage matter shall not be turned into rivers unless it has been previously rendered innocuous. This enactment obliged engineers to consider the most economical and efficient means of transporting sewage to much greater distances than was formerly thought necessary; and as storm-water forms a very large proportion of the mass of sewage to be carried, one of the first questions to arise was as to whether the sewage matter might not be separated from the storm-water, and each disposed of in a different manner.

The systems to which attention is called and which have been tried with the object of meeting these requirements are the earth system, the pail system, the system of sealed cesspits, and the separate system.

The first-named system fails because it is impossible to ensure its proper use, because urine and slop water are frequently mixed with the dry earth, which then ceases to be a disinfectant, and because it does not deal with the kitchen and bath water, with soap and fat, which must be turned into cesspits to ferment, or into watercourses to pollute them.

The pail system is an outcome of the earth system, and need not be more particularly referred to.

In the sealed cesspit system the sewage matter is discharged into what purports to be an hermetically sealed cesspit, and is removed by pumping into specially constructed sewage tumbrils, and is carted away and deposited on land. It is clear that when any discharge is made into the cesspit the gases of fermentation come out by the same passage. The removal into the tumbrils is also offensive, and the system is not believed to be a successful one, though it has been largely used abroad.

The most important of the proposals which have been made is that of separating the sewage proper—that is to say, the fœces, the urine, fat, soap, kitchen water, and the water of transportation—from the storm-water; returning the latter to the nearest watercourse, and only transporting the former to a distance, where it may be treated on land, chemically, by precipitation, by electricity, or by two or more of these systems combined, the effluent being then returned to the watercourse.

Under the conditions which exist in this country the proportion which the sewage matter at its maximum bears to the storm-water at its maximum is probably about 1 to 25, while in tropical countries this proportion is greatly exceeded, while the duration of the rainfall is much concentrated, and the length of the time during which there is no rain is correspondingly increased. Assuming the above figures to be correct, sewers to carry storm-water must be 25 times larger than where sewage only is to be transported; these dimensions must be much increased when the rainfall is tropical; and these same sewers will in time of drought be almost empty, the rate of delivery in them will be very slow, and they will become foul to an excess, and must be dangerous to health, especially under tropical conditions of great heat and long periods of continued drought.

When brought face to face with these facts it seems to be almost obvious that the sewage proper should be dealt with alone, and that the storm-water should be separated from it, more particularly as the heavier portion of the matter to be transported and that which is most apt to produce deposits and obstruction is introduced into the sewers with the storm-water; the question, however, is not quite so clear as it seems to be at the first glance.

If the sewers are to be separate from the watercourses, the gradients of the former will be much steeper than those for the latter conduits. It would in most cases be necessary to have two sewers in each street, for all the house drains could not be connected to one, considering that the covered watercourse would be in the middle; the crossings of streets would also offer considerable difficulties. But nothing is impossible; and these difficulties could no doubt be surmounted, indeed, this has been done. The question then arises, however, of how far it is safe to pass water mixed with the sweepings of streets, of courts, and of yards, and the washings from the roofs of houses, directly into the nearest watercourse without purification.

It has been contended lately that the number of microbes present in the dust of streets is greater than in sewers, due it is said to the more free circulation of air in the open than in the covered sewers, and this has been used as an argument against the ventilation of sewers. It may be that the number of microbes is greater in the streets than in the sewers, but this does not prove that the larger number are more dangerous to health than the smaller supply, nor does the view that more is to be feared from street sweepings than from sewage agree with experience, it having been frequently noted that foul watercourses remained innocuous so long as they were open to the air, but became exceedingly injurious to health when covered in. However this may be, the question remains, is it safe to turn water which has passed from the roofs of houses, and over the surface of streets and yards, direct into the nearest watercourse, and the writer does not feel able to deal with the chemical view of this subject.

The advantages which the separate system offers appear to be :— (1.) The use of very small sewers. (2.) A fair amount of regularity in the amount of sewage passing through the sewers, which will not vary greatly either in quantity or quality, and which will at certain known times in every day carry a known maximum and minimum of sewage. (3.) The gradients can be arranged to give a minimum rate of flow which shall not allow of deposit. (4.) Where pumping has to be employed, the volume to be pumped is reduced to a regular diurnal unit, as against a quantity which may vary in the proportion of from 1 to 25 or more according to the rainfall, and which necessitates the use of pumping machinery, tanks, and other appliances calculated to deal with the larger quantity. (5.) The comparatively small alteration of level of the sewage matter in the sewers, and the fact that the variation in the rate of flow would be reduced and the average rate made higher, should tend to prevent pressure from the evolution of gases, and should shorten the time of delivery—and therefore that in which fermentation can take place—and should tend to health. (6.) The heavier matter, such as road scrapings, coaldust, etc., is not passed into the sewers, but into the watercourses, and the former should, therefore, be maintained free from deposit with great facility. (7.) From the small size of the sewers and the comparatively regular flow of sewage in them they offer great facilities for more thorough and regular ventilation than has been hitherto found possible in the larger sewers.

Against these advantages must be placed the increased complication of the drainage system, not as a whole, but in the streets; and the fact that as the gradients of drains of small size must be steeper than of those which carry a larger volume, the height through which the sewage has to be pumped, where pumping becomes necessary, will be greater than for large sewers, though the quantity to be dealt with is much less, the proportion can, however, be only decided for each particular case.

The separate system appears to offer many advantages for the collection of sewage, in very flat districts, in receivers of limited capacity placed at comparatively short distances apart, whence it may be discharged or pumped to a higher level by steam power or by water or air pressure supplied from a central station. It is thought that the use of air is most advantageous for this purpose, as very much smaller pipes can be used for its transmission than is possible when water is employed as the motive power; a speed of 60 feet per second being quite admissible when air is used, while 3 feet per second would be about the limit for water; and there is no shock with the first-mentioned form of power, while there is considerable shock with the second. The efficiency obtained with the use of compressed air is considerable, and might, it is thought, be greatly increased by its more careful and scientific employment, both as regards the construction of receivers, the height of the lift, in the compressing machinery, by the reduction of waste space, and in heating, and by the expansive use of the air.

Where water is used as the motive power, space must be provided in the sewers or watercourses for the exhaust water, while the air may be discharged into the sewer without taking up useful space, and may serve to ventilate it. On the other hand, this air, which has been in intimate contact with sewage matter (presumably, however, little fermented) may be discharged into the streets through some opening, and may become a source of danger.

The writer wishes to call particular attention to the necessity which exists for considering each locality on its own merits and conditions, and for providing a system of sewerage which is applicable to those conditions. The same sewers which may do very well in a hilly country are not adapted to one which is flat. A system which is successful in a temperate climate, where the rainfall is moderate and much diffused, is not necessarily adapted to a tropical country, where the heat is great, and the rainfall is excessive and concentrated. The separate system is, no doubt, not universally applicable, but the writer believes it to have many advantages which only require consideration to be recognised.

The Sanitation of a Mining Settlement.

BY

A. Mault, Engineering Inspector of the Central Board of Health, Tasmania.

In the neighbourhood of Mount Zeehan, on the West Coast of Tasmania, there occur immense deposits—perhaps the largest in the world—of lead and silver ores. These deposits are attracting a large population. Six months ago there were about 400 people in the district, either working the mines or prospecting the country; to-day there are more than 4,000, and the number is continually increasing.

Under the existing mining law it is impracticable to constitute any municipal authority in the district, as the inhabitants of municipal towns acquire rights that would interfere with mining. This law is to be amended in the next session of parliament. In the meantime the Government has undertaken the more urgently needed of the works required at the rapidly-growing town. A local board of health has been appointed. It has no rating powers, but has ample authority to compel the carrying out of such works as are usually done by owners or occupiers of property in their individual capacity; the works usually done by communities in their collective capacity are those undertaken by the Government.

The principal part of the settlement has taken place along three quarters of a mile of the road leading from Trial Harbour—a small inlet available only in fine weather—through Zeehan to Mount Dundas. It began, as all mining settlements begin, with a few huts and tents on each mining claim. Publicans, tradesmen, and store dealers followed. The surveyors of the Lands Department laid out a township on what they considered a suitable site, and the whole of the building lots upon it were immediately bought. But as it is about a mile and a half from the principal mines yet developed, hardly any building has taken place upon it. What has induced building has been, not suitability of site or of ground, but proximity to work; and consequently the great majority of the houses are built upon land quite unfit for such occupation.

At a height of about 550 feet above the level of the sea, and 13 miles distant from it, there is a little valley traversed by several rivulets flowing into the Little Henty River, covered with thick forest, and surrounded with hills that shelter it from every wind. The prevailing rock is slate, which comes up close to the surface in most places; and what little soil there is on the swampy flat forming the bottom of the valley is the retentive clay produced by the weathering of the slate. The forest is of what would be extraordinary density in any place outside Tasmania. On an acre of it, and not an exceptionally densely covered acre, there were counted 96 trees girthing from five feet to 22 feet, 1,560 spars and saplings girthing from one foot six inches to five feet; and the undergrowth was of "tea tree, with its upright spear-like stems growing so thickly together as to be impassable without chopping a track. The yearly rainfall is probably over 110 inches. The rivulets traversing this swamp were so blocked up with fallen trees and branches as to render it difficult, except in very dry weather, to determine which were their real beds; and in the midst of this the settlement was formed.

In its beginnings a mining settlement is not a savoury place. The huts or tents are usually not kept scrupulously clean. They are surrounded with emptied and partially-emptied preserved meat and jam tins and bottles, with bones and potato parings in addition if fresh meat and vegetables are to be had. There are no latrines, and the surrounding bush is polluted with ordure. If horses be kept, the manure is never removed. When the huts and tents are replaced by houses, the refuse is still simply thrown out of the back door, and the latrine is often a seat with or without a hole dug in the ground. There are no drains, and the slops are thrown on the ground close to the door. At Zeehan all this naturally aggravated greatly the original unwholesomeness of the swamp. Yet in it houses, hotels, and shops were built as fast as materials could be procured. Some of the hotels accommodate more than 100 guests each, and others still larger are being built.

The first work done was to clear out, straighten, and lower the beds of the two principal rivulets. This was not a very easy work to do satisfactorily, as the ground, where not rock, was one mass of tangled roots of all sorts. None of the forest trees here have tap roots, consequently the whole surface of the ground is covered with the ramification of roots—some of enormous size. The following of definite lines, and the making of clean slopes is consequently difficult. The work has already produced a marked improvement; the level of the "ground water," which was formerly practically identical with that of the surface, has been lowered three or four feet; and it is now possible for the inhabitants to drain off the large quantities of stagnant water that covered much of the surface in wet weather, and left a corresponding surface of green fœtid slime in dry. Many of the houses were built on short piles on land in this condition.

With respect to the sewerage, the preliminary difficulty was to procure material. The 13 miles of road to Trial Harbour is of such a nature, and in such a condition, that not only does haulage at present cost £5 a ton, but it is also practically quite impossible to secure the safe transport of any breakable material. Earthenware pipes were, therefore, out of the question. The use of wood was discarded for various reasons, and that of rivetted wrought iron pipes adopted. Sheet iron of No. 18 gauge was employed in six-feet lengths, the ends being slightly spigotted and faucetted so that the joints might overlap about two inches—the spigot end being left unrivetted for that length. After rivetting, the pipes were heated and plunged into a bath of boiling pitch and tar which, when dry, formed a hard adhesive coating, sufficiently elastic to form a practically watertight joint for sewers not subject to the pressure of a head of water. The junctions were easily made with branch pipes at an acute angle, each one having also a short vertical branch, to serve as an inspection hole, and large enough to remove any matter that would choke a four-inch house drain. While being laid, the position of each inspection-hole was permanently marked on the surface, and also fixed by recorded cross measurements. Curved pipes were expensive to make, so their use was as much as possible avoided by putting a manhole at every change in the direction of the sewers.

Zeehan is a mining town, and the whole district is a mining district; consequently, when lead concentrating work is largely carried on it will be quite impracticable to prevent the metallic poisoning of the streams running through it, rendering their waters unfit for animal consumption. But such water does not give off the noxious emanations of sewage. So, though it has not been thought worth while at present to purify the sewage before its discharge, care has been taken to make provision that the eventual outfalls shall be at a distance from all settlement.

As no good bricks are yet made in the district, and the bad ones made cost £10 a thousand, the manholes of the sewers, and the trapped and ventilated catchpits for house and yard drainage were made in wood. Huon pine, *Dacrydium Franklinii*, is an admirable wood for these purposes, being almost imperishable. Water troughs, laid partly in the ground for intermittent irrigation work, are still quite sound after 40 years' use; and the slabs of it set up instead of headstones on the graves at Settlement Island, Macquarie Harbour, though dated 1825 and 1826, are still quite as good both above and below ground—the arrises only being very slightly weathered. The wood of the Blue Gum (*Eucalyptus globulus*) is also almost equally indestructible, and it was principally used.

While the sewerage works were being carried on, the local board of health, having obtained from the Government the grant of a suitable piece of land as a depositing ground, entered into arrangements for the periodical removal and burial or destruction of all refuse. As there is no water supply at present available for waterclosets, notices were issued to every householder to construct and maintain a proper earth-closet of a certain pattern, and to provide suitable receptacles for house refuse; and the weekly cleansing of both these forms part of the arrangements above referred to. Notices were also served for the thorough cleansing of all yards and outbuildings. As the sewers were being designed, the details of all house drains were also settled, and the owners of all property were called upon, immediately a sewer was available, to construct the drains accordingly.

Nothing was done by the Government with regard to a water supply as a private company is promoting a Bill in Parliament for establishing waterworks. At present nearly all the houses have galvanised iron roofs and large tanks, and the large rainfall ensures a pretty constan supply.

Apart from the population settled in houses, there is an almost equally large population dwelling in huts or tents. Where these are occupied by miners, and erected upon the claims of the companies for whom they work, the companies are held, under the byelaws of the local board of health, to provide for their sanitary condition. The difficulty is with people otherwise employed, and apparently too poor to build houses or rent them. They are allowed to pitch tents on the unoccupied parts of mining claims. These tents and their surroundings are usually indescribably squalid and filthy. Where a Government reserve or other land is available for the purpose, it is arranged that camping shall only be allowed on it, and under the control of the local board of health, which sees that proper sanitary provision is made in return for a small weekly payment. Hitherto this has not been possible at Zeehan; but some of the tents have been dealt with. They had been put upon ground already polluted with filth and sewage. They were taken down, the ground levelled, the surface burnt, and then the actual site to be occupied by the tents covered with a layer of charcoal—very easily procurable here—a wooden platform or floor constructed, and the tents re-erected thereupon.

All this is not a record of engineering difficulties overcome, but a narrative of how the exceptional condition of things that is sometimes met with in new communities, and which urgently required to be immediately dealt with, was so dealt with in a simple, economical, and, above all, effectual manner. Some of the work done is necessarily of a temporary character; but none of it is useless, all of it is well worth what has been spent upon it. When the railway is completed to Zeehan other means will be available, and the work will have to be greatly extended, commensurately with the extension of the settlement.

DISCUSSION.

Professor H. Pacchiotti said that one of the great sanitary reforms in Italy had reference to drainage, which had been overlooked for centuries. In Rome, in the days of the Tarquins, the great canalization was begun, on the lines of what the French called *tout à l'égout*, and it had lasted for 2,500 years. The system of *tout à l'égout* had acted perfectly well under the Monarchy, the Republic, and the Empire, as well as under the Popes, and under the present Italian Government. During the last ten years the same system had been followed in Naples, Milan, and Turin; and it was now being studied at Spezia, Reggio, Emilia, Ancona, Bari, Catane, and Messina. The same system, too, had been adopted by the great men who had formerly lived, and were still living, in London. There were some who preferred the separate system. The Waring system had been advocated by some, but not with great effect in Italy. There were only two towns where that method had been tried. The separate system, however, was one thing, and the Waring system was another. For the last 10 years in Turin a great struggle had taken place with reference to the drainage. He was himself a member of the Municipal Council, and he had worked and spoken a great deal on the subject of the *tout à l'égout* principle. The town was of such a character that it seemed made almost on purpose for that system. A little town had begged M. Bechmann, of Paris, to prepare a plan according to the *tout à l'égout* system, which had succeeded very well, and it had been approved by a commission to whom it had been submitted. He had already presented a summary of the conclusions arrived at by this commission. Professor Pacchiotti finally alluded to the movement then on foot in France for erecting a monument to the memory of Durandclaye, whose earnest and energetic labours deserved the cordial sympathy of sanitarians throughout the world.

Col. Alfred Jones said he should like to enforce almost every word contained in Mr. Middleton's paper. His attention had been drawn to the subject for the last 20 years, during which he had worked a great deal at it with the view of ascertaining whether sewage farming would pay or not. The paper had referred to the necessity of the separate system. He had been arguing for the separate system for years from a practical point of view, maintaining that it was almost impossible to utilize sewage which was subject to extreme variations due to the weather. If they once admitted the rainfall into the sewers there was no limit whatever. As the author had pointed out, the flow of sewage due to the water-supply alone was a comparative constant quantity; it might vary from hour to hour, but as compared with the ungoverned forces of the rainfall it was very easily calculated. With regard to any lifting power that was required in the transport of sewage from the house to the land, Mr. Middleton had very wisely said that the separate system was very necessary to equalize that pumping power. He would not go into the question as to whether water-power or air-power was best, but he entirely agreed with Mr. Middleton that air was not subject to the disadvantages of water. If they employed water-power to lift, they only added to the quantity of liquid to be lifted, they had to lift all the clean water they used, whereas the air was dispersed at once, blown off, and used for ventilating the sewers.

M. Bechmann (speaking in French) said that Mr. Lemon had made a comparison between the two systems, and had easily shown the superiority of the English system to what he had called the French system. He (Mr. Bechmann) wished only to protest before the meeting against that appellation, which he considered to be thoroughly inaccurate, and which he should not like to see introduced into the technical language of the Congress of Hygiene. As Prof. Pacchiotti had said, the honour of having opened the way of hygienic reform was due to England. The method which Mr. Lemon had called the French system was simply the practical mode formerly adopted in countries which had not entered upon the gigantic sanitary movement of later days, the initiation of which was due to England. That system was not peculiar to France. All the great towns were endeavouring to find the means—not always easy, since they were not as rich as English cities—of adopting a system of drainage which should have the effect of diminishing mortality. He might cite the example of Marseilles, the second city in France, which had very recently obtained an Act of Parliament authorising the expenditure of 33,000,000 francs in order to establish what Mr. Lemon had called the English system of sewerage. There was no general mode of procedure applicable to all places. In each country it was necessary to modify the system in order to adapt it to the customs and ideas of the people. He asked the members of the Congress to admit with him that there was no system of "French sewarage"; the universal system was that which England had initiated, and which other countries were adopting.

Mr. Richard Read (Gloucester), in commenting upon the paper read by Mr. Middleton, said the separate system, as was generally known, had its origin in consequence of the difficulty of dealing with storm-water at the sewage outfall. Anyone who had to deal with the sewers of a town knew the difficulty of having a duplicate system to which connexions could be made, and the confusion which arose from making connexions with two separate systems of sewers in the same street. He thought the better plan of dealing with the separate system was to have all the connexions made with the foul-water sewers, and in order to do that to take a definite small proportion of the rainfall into those foul-water sewers. In that way they would get the dirty water, which is the first flush of the rainfall, into the foul-water sewers, and then the comparatively clean storm water, which followed afterwards, would, by means of weirs and overflows, find its way into the storm-water sewers. The street gullies could then be directly connected with the foul-water sewers, and they should be very numerous; being numerous, they should also be easily cleaned so as to keep the greatest possible amount of solid matter out of the sewer. It was suggested that the system of weirs or overflows from the foul-water sewers into the rain-water sewers might in some cases necessitate pumping; but he took it that if all the rain-water flowed into one set of sewers, it had to be dealt with at the outfall by pumping. It was, therefore, a choice of evils; but in many cases weirs or overflows could be taken directly into the rain-water sewers without pumping, and he believed that would be the best plan, where possible.

Mr. J. T. Noble Anderson (Melbourne) asked Mr. Mault the dimensions of the wrought-iron pipes he used, and if he could give any idea as to their cost. He (Mr. Anderson) had carried on similar works to those which Mr. Mault had in charge, on some camps and public works in Victoria, and found that he could get the red gum tree troughs constructed for about one-third the cost of wrought-iron pipes, and they appeared to be more durable and more easily flushed. No doubt it was a question of economy that led to the use of wrought-iron pipes, but his own impression, from seeing these pipes used, not only in the Melbourne and Victoria water supplies, but also in the preliminary sewage works of Melbourne, was that they had been very much over-estimated with respect to durability. The asphalt coating corroded very rapidly, and allowed a rapid corrosion of the pipe. The Melbourne people had at the present time sent several of their leading practical engineers over to America to study the American modes of coating the wrought-iron pipes. He would like to ask Mr. Mault if economy was the chief reason for choosing wrought-iron instead of wood troughs for conveying away the water? Also his experience with respect to the length of time wrought-iron pipes would last?

Mr. Gilbert Thomson (Glasgow) wished to make one or two remarks on the separate system, chiefly with regard to its applicability, to a limited extent, in the case of small towns or large villages with from 2,000 to 5,000, or 8,000 inhabitants. Such a town or village very often came into the hands of the sanitary engineer with a system of drainage more or less deficient; the whole of the storm-water, together with the sewage water, being carried off by a natural watercourse, which ran either through or close by the town. Such villages or towns had a very large drainage area compared with the roof area, and the streets of these villages were practically country roads in place of being highly-polluted town streets. The pollution from these streets consisted mostly of road detritus, and to a very small extent of the manure which formed a large portion of town mud. The practice he had adopted in such a case was to allow the roof-water to go into the sewage system, while the street-water and the storm-water was allowed to go by the old system of sewers into the drainage system of the place. He believed that such a compromise was best suited for such places, because, if they kept out all the roof-water as well as all the storm-water they would require to have, in the first place, for every house two sets of drains, and that meant an expense to the owners which they would be very unwilling to incur; in the next place the roof-water, which was a comparatively small proportion of the total rainfall, was an advantage in helping to flush and cleanse the sewers. He, therefore, believed that in the case of such a small town as he referred to, the proper course would be to allow the roof-water to go along with the sewage into the new system of sewers, and that the old system of sewerage might be allowed to take the street-water and all the other rainfall from the district, and convey that into the nearest watercourse, which probably up to that time would have received the whole of the drainage.

Mr. James Thomson (Edinburgh) said that one of the dangers of the separate system was, that unless it was under complete supervision there was risk of having the rain-water pipes ventilating the common sewers. With regard to the drainage of villages, one of the best ways of dealing with a separate system, if it was desirable, was to put in overflow sewers. Wrought-iron pipes had been referred to. He had had some little experience of wrought-iron pipes in connexion with main sewers. He had seen pipes which had been in for 40 years, and were uncoated, which were in first-rate condition. They seemed to be preserved by the coating which formed upon the interior from the sewage, and unlike clean-water pipes, they did not seem to corrode.

Mr. Sijmons (Rotterdam) wished to speak of a system which had been working in Amsterdam for the last 10 years, and in which very great improvement had been lately introduced. The Liernur system, as employed in Amsterdam, was arranged for populations of 100,000 and of 50,000. It was directly connected with a pumping station. Until recently all the collected fæcal matters were dealt with at the public cost, but the town had now given over its fæcal matter to be dealt with by a company who treated it with sulphate of ammonia. The cost of this process up till some time last year was 61 cents per head, nearly 1*s.*, but since this fæcal matter had been treated with sulphate of ammonia the cost had been reduced from 61 cents to 44 cents, that was to nearly 9*d.* By the Liernur system fæcal matters were excluded from the public rivers. He knew very well the difficulty of applying every system to an old town. In the new parts of cities they would adopt the best system in existence, and could construct a good separate system like that at Vienna.

The President wished to say a word with regard to the question of the durability of wrought-iron pipes. It should be remembered that there were two factors which affected the life of a wrought-iron pipe, first the soil in which the pipes were imbedded, whether it contained any amount of salt, such as was found near the sea shore in a porous soil, and also (and this was a very important consideration) the character of the fluid that was passed through the pipes. If they were near a town with large chemical manufactories they could very well understand that the life of the pipes would be very much diminished by reason of the chemicals passing through them.

Mr. H. A. Roechling, (Leicester), said that reference had been made to what Professor Pettenkofer had lately demonstrated at Munich, viz.: that the sewage of Munich could be discharged into the Isar without any detriment to the river itself. In order that this statement might not be misunderstood, and that the veteran sanitarian might not be misrepresented, he wished to give the following particulars in addition to those given in Professor Robinson's paper. Professor Pettenkofer, in 1867, in his report on the drainage of Basle, advised that town to exclude all fæcal matter and urine from the sewers, as London had proved the fallacy of looking upon public river-courses as the channels for conveying away the liquid refuse of towns. This certainly looked as if Professor Pettenkofer had then been an opponent of the "water-carriage" system. In 1876 he had, however, altered his opinion, having, in the intervening years, examined the question very thoroughly; and he now held that the system of carrying away by water all fæcal matters, &c., was right in principle. When the late Mr. Joseph Gordon, who for some months held the appointment of Chief Engineer to the London County Council, designed his scheme for the main drainage of Munich in 1878-80, he recommended the adoption of the system of "water-carriage" pure and simple, and was backed up in this by Professor Pettenkofer. The authorities however, took a different view of the matter; they adopted some portions of Mr. Gordon's scheme, and made the sewers big enough to carry, eventually, the sewage and the rain-water, but they did not admit fæcal matters into them; that was a question left open for the future to decide. The matter had now again cropped up in Munich, as another main intercepting sewer would have to be constructed, and the Mayor thought this was a good opportunity to re-open the whole question. He, therefore, recommended the construction of this additional main sewer, the admission of all fæcal matters, &c., into the sewers and the discharge of the sewage direct and without purification into the river Isar; but he added to this recommendation, that all sewers should be kept at such a level as to admit of the treatment of the sewage by precipitation or by broad irrigation, should such a course be hereafter found necessary. Professor Pettenkofer thoroughly supported the proposition of the Mayor, having examined it very carefully. He was of opinion, that the direct discharge of the Munich sewage into the Isar would not produce pollution, as was generally feared; the velocity of the river and the quantity of water flowing in it, even during the time of minimum flow, being sufficiently great to prevent it. He based his figures upon a ratio of dilution at low water of 1 in 40, reckoning that about 1 cubic meter of sewage would be mixed with 40 cubic meters of river water in the course of a second. The minimum discharge of the Isar was 40 cubic meters per second with a velocity of 119 centimeters per second; the average discharge 110 cubicmeters per second, with a velocity of from 145 to 188 centimeters per second; and the maximum discharge amounted to 300 cubic meters per second, with a velocity of 211 centimeters in that time. From his examination of the river above and below Munich, at times of low water and during periods of flood, he felt convinced that the sewage of Munich would not pollute the Isar. Far more organic matter than would ever be carried to the Isar by the sewage was in the river at flood times. It would lead too far to follow Professor Pettenkofer through all his analyses and arguments; it must be sufficient to say that his reasoning was so close, that, theoretically speaking, the deductions from his figures could not be otherwise than correct. It remained, however, to be seen whether this theory was borne out by the actual state of the river after the whole of the sewage had been discharged into it for some time, or whether some of the premisses from which he had argued had not been sufficiently examined. Should it be ascertained that pollution of the Isar had commenced, or should the farmers of the district express a wish to utilize the sewage, then it was a comparatively simple matter, to divert it from the river and to employ it in the cultivation of the soil. Professor Pettenkofer's deductions had reference only to the case of Munich, and every case required a fresh and very careful investigation, as it was the proportion existing between the velocity and quantity of the river water and the velocity and quantity of the sewage that governed the decision. Wherever the self-purifying powers of a river would be overtaxed, then pollution, would be the natural result. With regard to the remarks of Professor Pacchiotti, he, (Mr. Roechling) could not agree with his opinion that, as far as sewarage and sewage utilization was concerned, France occupied the foremost position on the Continent. Having carefully gone into this matter, he believed that the sanitation of German towns, especially of Berlin, was far above that of Paris. Whilst Paris was in the unfortunate position of not knowing what to do with its sewage, Berlin had solved this problem, and utilized its sewage on large irrigation farms; it had thus set an example to the whole world. The total acreage of all these farms amounted now to nearly 19,000 acres, of which 8,000 received sewage during the last year. The utilization of the Berlin sewage did not cost quite a penny in the 1*l*. of the rateable value, and the results from a sanitary point of view had been marvellous. He had gone through all the analyses taken since 1882, and it appeared that since that year, on an average 98 per cent. of the organic pollution had been abstracted from the sewage on the farms, a result which he believed had never been attained before by any process for any length of time.

As to the separate system referred to in Mr. Middleton's paper, this question required to be considered under two heads, viz.: first, in connexion with an existing drainage scheme, and secondly, in connexion with the construction of a new one. When he was with Mr. Gordon at Leicester, they had to consider how far they could relieve the old sewers of the town of storm-water. The deep sewers, which had been laid down by Mr. Wicksteed in 1854, had become much too small, and had consequently more work to do than they could perform; they laboured further under this disadvantage—that when the pumping engines were overpowered, which occurred very frequently in wet weather, the sewage had to back up to a height of about 9 feet, before it could discharge into the river; which meant nothing else than transforming the system of sewers into a subterranean lake at almost every ordinary shower of rain. It was therefore absolutely necessary, to provide a remedy. The question that had to be considered was, whether they should retain the old deep sewers for the sewage only and relieve them of the rainwater, or whether they should construct new sewers altogether, to take both the rainwater and the sewage, with frequent storm overflows. In one district of the town the separate system has been carried out so far as it was thought advisable; there were duplicate sewers in all streets, but the house drainage had not been re-modelled, and consequently the storm-water sewers received the rain falling on the surface of the streets, and only in a few cases that falling on the front part of the roofs. To re-model, the drainage of every house would have involved too great an outlay, from about 10*l.* to 15*l.* per house, to say nothing about the inconvenience to the inhabitants. In this district they had careful gaugings taken, and found that only 33 per cent. of the total rainfall went to the storm-sewers, the rest going to gorge the deep foul sewers. With such facts before them, it would have been mere folly to extend the separate system, and they decided to recommend the authorities to construct entirely new sewers, which were now being carried out. They had divided the town into various high and low-level districts with one main intercepting sewer to each, which joined at its lower end the main outfall sewer to the pumping station. Each district had its separate storm overflow, calculated to discharge ¼ inch of rainfall per hour over the area of the district, which meant practically a capacity of ½ inch of rainfall per hour, on the assumption that only 50 per cent. of the total fall reach the sewers. In dry weather, the main outfall sewage conveyed the sewage to the pumping station, where it was lifted on to a large sewage farm; but in wet weather the rain-water would flow forward in two main storm outfall culverts to a point some 4 miles below Leicester, where the levels admitted of a free outfall. These main storm-outfalls were calculated to take a rainfall of 2 inches in 24 hours over the whole area of the town. All the storm-outfalls were connected by solid weirs with their main intercepting sewers, the cills of which were fixed at such a level as the circumstances of the case required, and only when the waters had risen to this height could they leap the weir and flow forward in the storm overflows. Such an arrangement insured that the foulest liquid, which was generally poured into the sewers at the commencement of each storm, must go forward to the pumping station, and could not reach an open watercourse. No general rule could be laid down concerning the separate system. What might be right in one case might be wrong in another, as every case required to be dealt with on its particular merits.

Mr. Buchan said that prevention was better than cure. Cholera had been the scourge of nations, and he believed, in the opinion of some medical men, India was perhaps the original seat of cholera. Cholera was due to disease, and those who believed in the germ theory as the origin of disease must insist upon the destruction of these germs at their source. Consequently, the paper read by Mr. Baldwin Latham was worthy of their serious consideration in that respect, as insisting upon better sanitation in India. He understood, from various sources of information, that of late years the French had been following the English system, which was a matter of credit to English engineers. In most towns the "separate" system would involve too much expense; and also the effect of preventing rain-water from going into the drain, which carried off the soil deposits, would be, he thought, a step in the wrong direction. More especially would that be the case on account of the law, which he thought was a very bad law, enacted in London and in many other cities, limiting the flush in water-closets to a couple of gallons. The value of water-carriage for sewage as being so much better than any other system was now a matter beyond discussion.

Mr. A. Mault, replying to the questions that had been asked by Mr. Anderson of Melbourne, said that it was not simply the question of economy that induced him to use iron pipes for drainage, rather than wood; it was, also, because of his experience of wooden drains since he had been in the colony. There was a very great difficulty in keeping wooden drains clean. The soap and grease, especially from kitchens, adhered to the surface of wood in a way in which it did not adhere to the surface of iron. In addition to that, there would certainly be the question of feasibility. It was utterly impossible to get earthenware pipes there. If they had imported earthenware pipes from Hobart they would have been very lucky if they got one pipe in ten delivered on the ground whole. The enormous weight of the pipes in comparison with wrought-iron was also important. As to the question of cost, the sizes used were 9-inch, 6-inch, and for house drains, 4-inch. The 9-inch pipes cost complete at Hobart on shipboard, 1*s.* 1*d.* per foot run. The 6-inch pipes cost 9*d.*, and the 4-inch 7*d.*; and the cost of carriage exactly doubled that by the time they arrived at Zeeban. As to durability, he had seen drain pipes that had been used for 14 years, and were as good at the end of the 14 years as they were at the beginning. Mr. Thomson of Edinburgh mentioned that he had known pipes not coated with asphalt that had been in use for 40 years; but, as the President had mentioned, the question of durability of course would greatly depend upon what duty they had to perform. If iron pipes had to drain chemical works they would not last long, but with ordinary sewage he agreed with what fell from Mr. Thomson, that its action—especially that of the grease and soapsuds—had rather a preservative effect than the contrary upon the duration of iron pipes. There was another matter special to the subject that he had mentioned, namely, that even supposing iron pipes did not last long, if they were the cheapest, an engineer who had to face the question of the drainage of a mining settlement was usually quite justified in using them, if they would last only six years. At the end of that time a mining settlement either became a large, important, and wealthy community, or it became a desert. If it became a desert the pipes might wear out if they liked; if it became an important and wealthy community they might very well afford to re-organise their system of drainage.

Mr. Baldwin Latham, in reply, said that it had been stated that a water-closet was no doubt the cleanest sanitary appliance that could be used; but for some reason or other it was supposed not to be applicable to Eastern countries. He could assure the members, from the examination of the working of water-closets in Eastern countries, that there was no appliance so well adapted for an Eastern country as a water-closet. The inhabitants of India, the Hindoos, always used water in large quantities after defæcation, and, therefore, there was no system so well adapted for carrying away fæcal matter as the water-closet system. Even in a climate like India, where the atmospheric conditions were such that very rapid drying would take place, it did not pay to manufacture sewage into *poudrette.* In Bombay, Calcutta, and other large towns where they had water-supplies, all the public latrines which were used by the natives were upon the water-closet system, and these were the only appliances which were anything like sweet in India. They answered admirably, and the Calcutta Municipality had been extending them into the private courtyards attached to the native residences, so that it was now quite a common thing to see a whole row of latrines worked upon something like the trough system, which answered admirably for the purpose, and nothing was better and sweeter. The contrast with the system hitherto in operation where only the solid matters were collected, leaving the liquids to flow away in the street gutters, was something very surprising to those who had any noses. With regard to river pollution, no doubt the rivers did free themselves to an enormous extent from any dangerous pollution. Take, for instance, the case of the Ganges. The Ganges, of course, was a large river; it was a long river; it was a river with a very considerable flow, liable to enormous fluctuation in its flow, but also liable to extraordinary pollution. Not only did the drainage of towns more or less find its way into it, but every person dying of cholera was thrown into it, every person dying of small-pox was thrown into it, every unmarried person under 12 years of age was thrown into it, all the religious ascetics who died were thrown into it, and the ashes of all the dead were thrown into it after burning, but the burning often was a mere farce. He had himself seen bodies floating down the Ganges with the two feet burned off, and the hair on the head not even singed, so that the enormous amount of pollution which passed into the Ganges was certainly some test of the nature of the power of a river for self-purification; because at the mouth of that river, from one of its branches—the Hoogly—Calcutta took its water-supply, and Calcutta since the introduction of this water-supply had been more free than many other parts of India from cholera and other such-like epidemics. They had there an exemplification of the enormous purifying power which nature had provided in the flow of a river. But if they went a step further, even to their own country, they found this remarkable fact, that taking towns of like character and like population, those which were supplied from rivers had the lowest rate of mortality; in fact, the great city in which they were at present assembled was a case in point, for although the water of the Thames was still liable, more or less, to receive the pollution of a considerable population, yet there was no city in the world which would compare with London in regard to its standard of health. Sewage farms, no doubt, were an admirable way of getting rid of sewage, and it was suggested that only farms with porous soils could be used for that purpose. He would like to point out that many of the chief farms in the country, which had been in operation for over a quarter of a century, were on clay soils, and yet they as perfectly purified the sewage to-day as on the first day when the sewage was applied. He might particularly note the towns of South Norwood, Doncaster, Warwick, and Rugby, where the farms were upon the stiffest clay that could be found anywhere. In some of these towns the sewage of as much as 300 people had been applied per acre, and successfully purified. With reference to the separate system, he thought some misunderstanding had arisen. In his own practice he never had yet drained a town in which the whole of the rainfall of the district went into the sewers. In the case of a town which had already got a system of sewers in operation, but which needed a new system in order to deal properly with the sewage, the best thing to do in such a case was to retain the old sewers, as was suggested, and to make use of them for the purpose of the rainfall, or the larger part of it, leaving the new system of sewers to deal with that portion of the rainfall which could not conveniently be excluded from the sewers. Even when the rain was excluded from sewers, there was an enormous fluctuation in the flow, and he might refer to a series of tables which were published by the Thames Sewage Discharge Commission. Those tables showed the daily observations of the quantity of sewage flowing through the sewers, the rate at which the rain fell, and the degree to which it affected the sewers. He found that on one occasion, when only 0·1 inch of rain was recorded in the day—it fell in a limited time,—it actually increased the mean flow in the sewers by 5·9 times. That was in a district in which there was a separate system. On another occasion only 0·25 was recorded in the day, but fell in a very limited time, and that increased the mean rate of flow 5·7 times. It was found, by observing the rate at which the rain fell, that the average fall in the whole of those four years was at the rate of ·065 inch per hour, or if it continued at that rate for 24 hours the average rate was a little over 1½ inch per day. This, of course, affected the sewers to this extent in a district in which there was a separate system. Generally, in English towns, the roof area was at the rate of about 200 people to the acre, but it still gave an enormous fluctuation in the amount of rain when that water had to be dealt with in the sewers. It was, therefore, necessary to make provision for these large fluctuating quantities in any system of sewerage, especially where pumping came into operation. A suggestion had also been made with regard to the system of overflows, that the rain-water should overflow and go to the natural streams when the sewers got to a certain extent over-charged. He had carried out works of that character in the town of Longton, where there was that abominable system inaugurated years ago of building houses back to back, with no yard between them, where all the slops and everything was thrown out into the street. In such a case the only possible way of dealing with drainage was by means of one system of sewers, and the system was so arranged that with a very small dribble of sewage it flowed down the ordinary sewer and went into the foul sewer, but when the rain came in large quantities it leaped over the opening which was provided for the sewage proper, and passed away direct to the streams of the district. That system had been in operation for over 20 years, and with the most perfect success. No complaint had ever been made with regard to the fouling of the streams in the neighbourhood, so that the suggestions which had been made had really got their practical exemplification in this country at the present moment. As to the Liernur system, which he had thoroughly investigated, it was not a system which would guard rivers entirely from pollution. The Liernur system only dealt with one part of the sewage, and therefore there was still greater liability under that system of river pollution. As to automatic pumping of air and water, mentioned by Colonel Jones, all he wished to say was that none of those objections which were mentioned by Colonel Jones did arise. The water which was used for the transmission of power was never allowed to pass into the sewers; or if it was, it was only used for the purpose of flushing the sewers, and so saved other water which would otherwise be used for that purpose. Wooden sewers were very largely used in America. They were very successfully used in the drainage of Boston, especially in the case of roads in which the ground had been recently filled up above the low levels of the district. Those sewers had been built as large wooden barrels, with a view that when settlement had taken place, ultimately their interior should be lined with brickwork in the ordinary way.

Mr. D. Balfour, M.Inst., C.E., F.G.S., (Newcastle on-Tyne), in reference to sewage disposal considered land-schemes, either by broad irrigation or intermittent filtration, to be generally most efficient and economical, wherever both properly designed and managed. Surface-water generally should be kept separate from the sewage, rendering less land necessary in accordance with the sanitary maxim, "the rainfall to the river, and the sewage to the soil." Moreover, all sewage work should be kept in the hands of the local authority, as letting to a tenant is always found to result in deterioration and dissatisfaction. Chemical schemes, with or without land, should only be resorted to for exceptional local conditions.

Mr. Lemon said he wished to say a few words in reply to the French engineer, Mr. Bechmann. He regretted that he (Mr. Lemon) could not follow his observations as clearly as he could have done if they had been in his own tongue, but he understood Mr. Bechmann to say that what he had called the French system was not the French system now. No one was more glad to hear that statement than himself. What he had written in his paper was the result not of mere second-hand information, but of his own personal observation. He had seen towns in France where what was called the tinette—that was a tub in which they put the solid excreta—was placed in the roof of the house. He had seen that overflow, and in one house he went into, a fair sized house, the inhabitants were obliged to throw the excreta on to the roof of an adjoining house. Anything tending more to produce a high rate of mortality than that he did not know. With regard to what was called the *tout à l'égout* he had used the term in contradistinction to the old French way of conveying away solid matter in carts, and allowing the liquid to find its way into the sewers. What a French engineer meant by *tout à l'égout* was the removal of all the excreta and foul water from the houses to the sewer. That was no doubt coming into operation in France, and France was very eminently indebted to that eminent engineer, M. Duranclaye, for the very excellent change which had taken place in the sanitation of France.

Mr. Baldwin Latham said he should like to make one explanation. It had been pointed out to him that in Calcutta none of the bodies were thrown into the river, that the municipality saw that they were not so thrown in. He (Mr. Latham) was speaking of districts above Calcutta, and not of those which were within the jurisdiction of the Calcutta Municipality.

Professor Pacchiotti said one of the speakers had referred to Rome. Rome had one system of sewerage which had prevailed for 2,500 years, and had been worked without any difficulty, and with very great success. What the Italian Government was doing now was a new thing, and it was this: instead of sending the drainage into the river, it would before long be sent to the Campagna, in order to get rid of malaria, and to get rid of the bad soil. Sewage farms had been spoken of. At Milan, for 300 years, they had worked a sewage farm successfully. Paris was a little behind in some respects. In Paris there were still 80,000 cess-pits, holes at the bottom of the houses where sewage matters were kept for five or six months in a year and then taken away by carts.

Professor D. van Overbeck de Meÿer said he was rather afraid he should throw an apple of discord into the meeting, but he could not pass silently the different conclusions which had been reached that morning. He was really opposed to them all, and if he was not asking too much of their patience he would give his opinion in the form of the following conclusions. The *tout à l'égout* and the separate system were noxious in the town itself, because (1) proper ventilation of sewers was impossible so long as the houses were different in height, and the street openings, manholes, &c., were not abolished; (2) the *tout à l'égout* was a fiction wherever the storm-water was admitted in the sewers, because overflows could not be avoided; (3) it was impossible to get rid in a proper way of the deposit in the sewers; (4) the danger to health lurked not in all parts of the house refuse, but in the fæcal matters only; (5) the diminution of the death-rate in sewered towns was not due to the *tout à l'égout,* but to the supply of good water and to other sanitary improvements which were the necessary and therefore constant forerunners of a sewerage system; (6) the best existing system was the Liernur system, the only good system from a sanitary point of view.

Sewer Ventilation.

BY

W. Santo Crimp, Mem. Inst. C.E., F.G.S., &c.

There is probably no subject in connexion with sanitary science regarding which more has been written, but fewer experiments made, than the ventilation of sewers. The question is undoubtedly one of extreme difficulty, as the conditions vary in almost every sewer, and one would therefore have thought that writers would have at least made an attempt to ascertain the actual conditions prevailing before proposing methods that would in all likelihood fail in consequence of their being designed upon wrong principles. In nearly every paper or work on the subject examined by the author, the writer has assumed that temperature is practically the only agent causing movements of sewer-air, an assumption greatly wanting in basis, as we shall see later on.

As a result of this assumption, it has been widely believed that sewer-air constantly passes from the lower parts of a drainage system to the higher, to the discomfort of the inhabitants of the higher parts of the district sewered. As a matter of fact, the sewer-air as often passes downhill as the reverse way.

Having constructed some works in connexion with the ventilation of sewers, which were designed in accordance with the views then prevailing, the author was disappointed with the results, and he determined to undertake an extended series of observations on the movements of sewer-air. This he did during the year 1888, and the results were communicated to the Institution of Civil Engineers, and may be found in Vol. XCVII. Experiments were made continuously for a year in one 12-inch sewer, having a gradient of 1 in 8 to 1 in 100. The sewer was trapped off from the main into which it discharged, and an air-inlet was provided at the upper end of the syphon trap, whilst at the end of the sewer, 1,860 feet distant, a 6-inch ventilating pipe was carried above the roof of a building near. Two anemometers were placed in the sewer, together with two self-registering thermometers, and these were read daily.

The temperature of the sewage was lowest in February, when the average was 44·75° Fahr.; that of the sewer-air was lowest in March, when the average was 42·0°; the highest temperatures were of the sewage 56·70° in September, and of the sewer-air 57·75° in August. The month of February was the coldest month, the mean temperature of the atmosphere being 34·75, whilst August was the warmest, the mean temperature being 59·10°. The greatest difference between the temperature of the sewer-air and that of the atmosphere was during October, when it averaged 8·40°, the sewer-air being the warmer; on one day, the 8th, the difference was equal to 16·5°, and this was the greatest variation registered.

Now, if temperature were effective in causing movements of sewer-air, we have sufficient data to enable us to calculate the number of times the air in the experimental sewer would have been changed, say, during the month of October, using the fundamental formula relating to falling bodies $v = \sqrt{2gh}$: but, as a matter of fact, up-hill currents in the sewer were only measurable by an anemometer on three days, whilst down-hill currents prevailed on 12 days.

These experiments had not been continued very long before the author found that for all practicable purposes the wind was the only agent producing movements of sewer-air that could be measured by an anemometer. Not only were experiments made in ordinary sewers, but also in surface-water sewers, at a time when they contained no water, and precisely the same results were obtained as in the sewers proper. Having, therefore, ascertained the true cause of the movements of sewer-air, their direction and strength could, after some little experience, be fairly well foretold, so far as the experimental sewer was concerned; for when northerly winds prevailed the sewer-air travelled up hill, and when southerly winds were experienced the sewer-air passed down hill. In other sewers that were being experimented upon at the same time the opposite conditions prevailed; and this is easily explained, for in passing over a town the course of the wind is broken up and deflected, and it will affect the openings upon the sewers in different ways, in some cases inducing currents out of them, in others passing down into the sewers and driving out the sewer-air elsewhere.

On taking charge of a part of the enormous main drainage system of the Metropolis, the author soon found opportunities of ascertaining the conditions prevailing, and he found that they were identical with those in the smaller sewers at Wimbledon; light air and calms mean stagnation in the sewers, whilst brisk winds cause rapid movements of the sewer-air. Of course an abnormal rise of temperature due to the admission into the sewers of hot liquids will produce a local disturbance, but this in nowise affects the main question.

The author ventures to formulate his views in the subjoined summary:—(1.) That the wind is the only agent which produces measurable movements of sewer-air in an ordinary system of sewers. (2.) That the fullest use of the wind should be made in effecting the proper ventilation of sewers. (3.) That the offensiveness of sewer-air should be lessened to the fullest practicable extent by systematic flushing and cleansing of the sewers and by keeping them structurally in a thoroughly effective condition. (4.) That small pipe-sewers need not be ventilated to the same extent as those large enough to admit of men working in them, vents high overhead being alone required. (5.) That in all systems where practicable, ventilating pipes should be carried up high buildings or other objects, where they may discharge their foul contents into the atmosphere high overhead, and that street ventilators should then be reduced to a minimum. (6.) That if every house were properly drained and proof against sewer-air, ventilation of sewers, as ordinarily practised, would be unnecessary.

Sewer and Drain Ventilation.

BY

R. READ, Assoc. M.I.C.E., M.S.I., City Surveyor, Gloucester.

Introduction.—A system of drains and sewers consists of a number of lengths, or branches, of underground pipes, of gradually increasing diameter and varying gradients, converging towards the lowest point or outfall of the system, where the sewage, more or less diluted, is discharged by gravitation.

The drains are the units of the system, and their total length is largely in excess of that of the sewers, to which they are connected.

The great majority of drains and sewers in a town consist of glazed stoneware pipes, and the remainder of brick or concrete culverts.

The flow through the drains is intermittent, but a sufficient number are always in use together to keep a continuous stream flowing through the sewers, but varying, both in volume and velocity, with the time of day, the amount of water supply, and rainfall.

The fluctuations in the volume of sewage are frequent, the maximum flow in dry weather occurring between 9 a.m. and 2 p.m., when about half the daily water supply of a town passes into the sewers; but rain may cause a sudden or gradual increase at any time.

Sewer always full.—The remaining space above the sewage in a drain or sewer is always filled with air, watery vapour, or gas, or a mixture of at least two out of the three.

Minimum Velocity.—In a sewer running half full, a minimum velocity of 180 feet per minute is necessary to prevent the deposit of solid sewage, unless special means of flushing are adopted to prevent it; but this velocity will discharge sewage at the outfall from any part of a town long before decomposition can take place.

When solid deposit occurs in any drain or sewer, decomposition quickly ensues, and sewer gas, as distinguished from sewer air, is produced in increasing quantity, until the obstruction is removed.

Compression and Expansion.—Sewer air is alternately compressed and expanded against the crown of the sewer by the rise and fall of the sewage, and also by the increase and decrease in barometric pressure; the latter action is particularly observable before a storm.

Watery vapour is constantly given off from the surface of the sewage as from any other wet surface in contact with air; and both the watery vapour, and sewer gases, if any are present, diffuse themselves throughout the sewer air until the point of saturation is reached in an unventilated sewer; the percentage of moisture in the sewer air is lowered by ventilation, and the more perfect the ventilation the nearer the sewer air compares with the outer air.

Temperature.—The temperature of sewage and of sewer air is generally lower than that of the outer air during the summer, and higher during the winter.

Forces at work.—Motions of sewer air are produced by compression, expansion, diffusion, differences of temperature, and barometric pressure; these motions cannot be measured by the anemometer, but are made visible by the condensing of the watery vapour in cold weather, or by the introduction of smoke.

Down-hill Currents.—A velocity of 180 feet per minute in the sewage will generally carry the sewer air down-hill with it, and the motion is accelerated by every intermittent discharge from the drains.

Wind.—The most powerful agent in producing motion in the sewer air is the wind, which acts by inducing a vacuum in, or by blowing directly into, any opening in the sewers or drains, according to the position of the opening, and the direction and force of the wind.

Unventilated Sewers.—All attempts to keep sewer air and gas bottled up within the sewers and drains having failed, ventilation was reluctantly adopted, for want of something better; and it is now a generally recognised fact that unless some provision is made to ventilate sewers and drains, they will ventilate themselves in a dangerous manner.

Earliest Ventilation.—The first ventilation was most probably unintentional, by untrapped rain-water pipes, and by overflow pipes from rain-water cisterns becoming untrapped in dry weather, and allowing the passage of sewer gas into houses.

Street Gratings.—To relieve the pressure upon the sewers and drains, manholes, at long distances apart, were ventilated by open gratings at the street level, and these have been gradually increased in number and area of openings, on the assumption that the nearer the approach to an open trench the better; and now they are placed from 40 to 200 yards apart, and the openings range from 30 square inches to 72 square inches area.

This method of ventilation by gratings at the street level only, simply provides overflows, or safety valves, to prevent too great an accumulation of gas: but it is vent only, without ventilation, as the movements of the sewer air are very slow, feeble, and uncertain, unless there is a good wind, a rising barometer, and a fast running stream of sewage.

The difference in height between any pair of adjacent gratings at the street level is generally so small that there is no marked tendency for either to become an inlet, in preference to an outlet, and puffs of wind may make them act feebly both ways, within a few seconds, without greatly affecting the air within the sewer.

With a falling barometer the watery vapour and sewer air acting by expansion and diffusion rise out of the street gratings, and should there be decomposing deposit in the sewer, or in any drain connected with it, a nuisance will be apparent, for which the gratings will be blamed, although they only call attention to the existence of defects which they did not cause and can only partially remedy.

Shafts above Roofs with Street Gratings closed.—In consequence of complaints, the street gratings in some towns have been closed, and iron pipes, erected against buildings substituted. This is still vent only, without ventilation, and a reproduction of the action of the street gratings at a higher level, without dealing with the first cause of the nuisance.

Partial Ventilation.—Neither of the above systems of venting to relieve internal pressure by partial ventilation, inducing a mere tendency to vacuum in the mouths of a number of outlets, whether at the street level or above the roofs, can be anything more than a manufactory of gas, the currents of air having no power to penetrate far beyond the mouths of the openings. At intervals, however, discharges of gas must take place, and the longer the interval the more dangerous the gas becomes.

The constantly changing conditions under which a system of sewers and drains act are such, that it is as impossible to stop at partial ventilation, as it is to have no ventilation at all.

Comparison with a Mine.—The leading idea which for a long period governed attempts to ventilate sewers, was, that it was a similar problem to the ventilation of mines, whereas the conditions are entirely different. In a mine, all the air entering the down-cast shaft must traverse the workings and pass out through the up-cast shaft, these being the only two possible openings. But any attempt to draw air through a sewer will not be felt at a greater distance than 400 yards, and only under very favourable conditions will the distance exceed 100 or 200 yards. This was conclusively proved in 1858, by Sir J. Bazalgette and Col. Heywood, by experiments on a large scale, with a furnace at the Westminster clock tower.

Wimbledon.—More recently, in 1887–8, Mr. Santo Crimp, at Wimbledon, had 600 yards of 12-inch sewer trapped off at the lower end, an opening, 28 inches area was made at the street level, just above the trap, and a 6-inch opening at the upper end, all other known openings being closed. There was 100 feet difference of level between the two openings, and a fan attached to the upper one, drew air from the sewer at the rate of 300 cubic feet per minute for 14 hours, and during the same period the sewer air continuously discharged itself from the lower opening 600 yards away at a velocity of 42 lineal feet to 104 lineal feet per minute, thus showing that one or more accidental openings must have existed, and that the friction of the flow of sewage, and the effect of the wind, was sufficient to bring the sewer air down to the lower opening, in spite of the powerful fan at work at the upper end.

On removing the fan the 6-inch pipe was carried up a building 25 feet high, and anemometers attached to the lower opening showed that during 1888 the air current was down hill at that point on 273 days and up-hill on 97 days. Unfortunately no anemometer appears to have been used at the shaft at the upper end.

Notwithstanding these facts, the favourite recommendation by newspaper correspondents has always been to connect to a factory chimney, on the assumption that it will entirely clear a whole system of sewers, and cremate the gases. Factory chimneys are usually confined to one quarter of a town, and although velocities from 500 feet to 2,000 feet per minute can be obtained by connecting to them—and in some towns costly stacks 100 feet high have been specially erected for the purpose—their effect upon ordinary sewers is only local, and very limited in extent; so that it is like shooting at a sparrow with a 100-ton gun.

Keeling's " Destructor."—The most recent apparatus for ventilating sewers by artificial means is " Keeling's patent sewer gas destructor," an arrangement of lamp column with a 6-inch connexion from the sewer for passing sewer air through an atmospheric gas-burner fixed in the base of the column, the outlet being about 10 feet above ground, under an ordinary street gas-lamp, placed at the top of the column; a consumption of coal gas from 6 cubic feet to 10 cubic feet per hour is required to keep them burning, and produces a heat of about 600° F. at the burner, and about 100° F. at the outlet, where the velocity is about 200 feet per minute, or equal to about 40 cubic feet per minute of air extracted.

The advantages claimed for this apparatus are that sewer gas is entirely cremated, and that one destructor will suffice to ventilate fabulous lengths of 12-inch sewer, variously stated, or inferred, as somewhere between 1,000 yards and nine miles; but no such distances can be affected by any such apparatus if a fan or a factory chimney of 10 times the power cannot do it.

The apparatus cost about 15*l.* fixed complete, and about 10*l.* per annum for gas, and is a useful luxury as an aid to natural ventilation if properly applied at the lower end of a sewer, instead of at the upper end, as recommended by the patentee.

Their greatest use is for dealing with the emanations from a very foul sewer; but this is treating the symptoms of the disease, instead of the disease itself, for such a sewer requires re-construction first, and ventilation afterwards.

True Ventilation.—Nearly all attempts to maintain a constant current of air flowing in one direction have failed, because they have not been in harmony with the forces at work within and without the sewers. The streets are the only places where municipal authorities are free to ventilate sewers as they please; therefore, the gratings at the street level have always been more numerous than shafts above the houses; and as long as this is the case, no constant current of air inwards at the street gratings can be maintained. There can be no true ventilation without a system of both inlets and outlets; the street gratings should be comparatively small to always act as inlets, and the outlets should always be above the roofs of the houses, and much more numerous than the inlets. It is necessary, therefore, in order to give a strong initial velocity at the inlets, and to localise the ventilation, that the street grating inlets should not exceed 30 or 36 square inches area, placed from 60 to 100 yards apart, and that the outlets should be distributed over these lengths in such numbers of 4-inch or 6-inch shafts that the sum of their sectional areas, between each pair of inlets, shall exceed the sectional area of the sewer as much as possible.

This arrangement can only be obtained by terminating every house drain by a 4-inch soil-pipe, or 6-inch shaft, carried above the roof as an outlet, with no obstruction between it and the sewer; the fresh air will then constantly enter at every street grating, with a minimum velocity of 100 to 200 feet per minute, travel down the sewer with the sewage, and up every drain and outlet pipe or shaft above the roofs. Each length of 60 or 100 yards of sewer between a pair of inlet gratings, and all the drains connected therewith, will then be thoroughly ventilated by a localised continuous current which cannot be reversed, and which will require no traps, flaps, valves, or other obstructions, except at the gullies and w.c.'s, to isolate or direct its course; the velocity of the current will only increase with the wind, from whatever quarter it may blow, and sewer gas will have no chance of existence.

Interceptors.—The above system requires the abolition of the so-called "Interceptor" traps, which obstruct the flow of the sewage, and render the true ventilation of the sewers impossible. They are the only form of unventilated syphon trap now tolerated, and oppose the inertia of about three gallons of stagnant sewage to each discharge through the drain; this sewage in the "Interceptor" never gets entirely changed, and is constantly manufacturing gas on its own account and providing a greater danger to the inhabitants of the house than the sewer to which the drain so trapped is connected.

Flushing.—Every w.c. should be provided with a mechanical apparatus, or cistern, for flushing after each user, to keep the drains properly clean in the intervals between rainfall, because the water so applied must of necessity pass through both drains and sewers, while whatever the quantity of water used by the municipal authorities for sewer flushing it can only pass through the sewers, leaving the drains untouched, and thus wasting a large quantity of water which would be more usefully and economically employed if passed through the drains as well as the sewers.

Object of Ventilation.—The true object of sewer ventilation is not to let out at intervals quantities of sewer gas of increasing foulness, but to introduce into properly constructed sewers and drains such a constant current of air, as will prevent the formation of gas altogether.

The systems of partial ventilation now in use, merely provide sufficient oxygen to facilitate the formation of gaseous compounds, without rendering them harmless.

The Better Ventilation of Town Sewers.

BY

W. D. Caröe, M.A. Cantab., F.R.I.B.A.

The following paper took shape in an inquiry, at the instance of the Grosvenor Estate Board, into the possibility of supplementing in some manner the present system of ventilating the sewers by means of open grids at the street level, so as to mitigate the complaints constantly directed against the open grid ventilators. In forming conclusions from such an inquiry it was essential to admit no theories, however attractive, which had not been verified by practical tests, but to base every argument for remedial measures upon the solid foundation of past results and wide experiences.

The general system of rendering pipes for the conveyance of sewage refuse innocuous to the inhabitants of cities or districts—the system of open or ventilated drains and sewers—is now so thoroughly accepted in principle by sanitary experts, and the laws relating to the action of sewer-gases themselves, and of fresh air admitted into open sewers to dilute them are so well ascertained and available, that it would demand excuse rather than apology to enter into fundamental explanations of the open system, or to propose discussion upon the authenticated principles of the dilution and diffusion of sewer-gas.

In an unwavering acceptance of the open system, I conceive, nevertheless, that every sanitary expert should take note of the singular conditions which rule Bristol (population, 221,665), where the city engineer is to be found congratulating the Council upon the principles of the "Open system" being violated in every essential particular, and the medical officer claiming an almost complete immunity from diseases having their origin in sewer-gas emanations,* and imploringly asking his committee to pause before they make any such changes in the sewer non-ventilation as will reduce his city "to the level of other towns."

Believing, however, that the case of Bristol is exceptional on account of the large amount of water readily available without cost for flushing purposes, and the great difference of levels in the several parts of the city and suburbs; and, even so, that the conclusions reached

* Report, 1884.

by the advisers to the Bristol authorities are not to be accepted without question, I assume the advantage of the completed open system, even if applied to Bristol. I am, however, prepared to admit that (given the very essential requisite of *perfect* house drainage) the present disgraceful emanations from the street ventilators and gullies (of, for instance, the Chelsea and Fulham end of the Metropolitan Northern low-level sewer), form a strong argument in favour of closed sewers as opposed to those ventilated by open grids only, and a pernicious example of the failure of what I venture to call the incomplete system.

I will now briefly postulate:—1. Ventilation as applied to sewers properly means the *Dilution* and *Diffusion* of sewer-gases to such an extent as to render them innocuous and inoffensive. (Sewer-gas is to be prevented from forming in any quantity, and that which must of necessity be given off is to be dispersed in the most diluted state possible.) 2. The effective agents of Dilution are fresh air, deodorising chemicals, and an adequate supply of water for flushing. 3. The effective agent of Dispersion is *fresh air* only. And I will add as an axiom:—

Inlet and outlet ventilators are equally important, and these should be at different levels.

I will base my inquiry upon the above statements, all of which are admitted to be axiomatic in connexion with house drainage. I believe, however, that the importance and value of deodorising chemicals and water-flushing are thoroughly recognised by our authorities, and although not used to the utmost as yet, no efforts are being spared to extend their use. The last depends, of course, upon the exigencies of water supply, about which there is ample stir at present.

I confine myself, therefore, in the main to the consideration of the atmosphere as a diluter and diffuser.

It is surely a matter of common sense that where the same openings have to act as both ingress and egress ventilators, the system must be inadequate. It generally happens that open grids become a greater nuisance when there are not enough of them; in other words, that the process of dilution is insufficiently operative. In the metropolis there is no uniformity or system in this respect; and it would be, doubtless, well as a preliminary, if the proper spacing of such ventilators were made compulsory.

I believe it will be undisputed that, on account of the numerous inlets, apart altogether from open grids, sewers cannot be treated by the same simple systems of ventilation as mines; and that, given open grids, special supplementary shafts at intervals—aided by fans or furnaces or extractors in which gas is the agent employed—have been tried with more or less efficiency, but have generally been found insufficiently operative to justify the cost of either their erection or maintenance. In place of any such non-automatic arrangements, I would here advocate the completion of the open grid system by a multiplicity of special shafts having *egress* at a high level complimentary to the low-level *ingress* of the open grids. Special shafts of this nature are generally known as *Pipe Ventilators.*

I urge not only that this system has common sense upon its side, and is the system likely to prove finally effective, but that it has the most reliable authorities and experience already amply in its support to justify its adoption where possible. Here it is necessary for me to meet an objection which has been, and doubtless will be, urged against the system *per se*, and which can be urged, though not with equal force, against the ordinary system of house drainage, since it is regulated virtually by the same principles. The system depends upon differences of temperature between the external atmosphere and that of the sewers. It follows from the statistics of sewer temperature, that on certain summer days the pipe ventilators become inoperative. But are we then in a worse position than if the pipe ventilators did not exist? They themselves, if inoperative, will be inoffensive; and if there is pressure in the sewers it will only find its way out as it does at present at the readiest egress outlet—the street grids. This is the time specially when we should fall back upon our other means of dilution—deodorising chemicals and ample flushing.

But there is a great difficulty to meet which is not inherent to the system. I allude to the question of owners' or occupiers' prejudices. Unfortunately the sense of the average householder is not "common" in his own interests, and at present his consent has to be obtained to the pipe ventilators being carried up his premises; and compulsory legislation, however salutary, would be undoubtedly difficult to obtain. This is a matter of the greatest importance because it has to be insisted that the system is not carried out efficiently by the erection of an odd ventilating shaft here and there, but by numerous shafts acting in conjunction. We thus find that one local body condemns pipe ventilators because it has erected one shaft and found it ineffective. Another erects an isolated shaft at a considerable elevation, which proves such a nuisance that it has to be removed. A multiplicity of the pipe ventilators being essential to the success of the system, it follows, therefore, that the difficulty of obtaining householders' consent constitutes the first obstacle to be overcome in its application, and it would at present seem practically impossible to apply the system in districts already built upon. As an example of this difficulty, the Commissioners of Sewers of the City of London lately resolved that in all instances of the erection of new houses the owners should be treated with to this end, but within 12 months not a solitary instance of consent had been secured.

In new districts, however, or upon large properties under one ownership, where there is a large area of rebuilding, or where new streets are formed, there would seem to be no such difficulty if the freeholder or authority were to make the adoption of the system part and parcel of the building contracts. It is to be borne in mind that the system of shafts in any given area will always work in connexion with the nearest open grids within that area, and will not carry off the gases from sewers at any great distances even although these be not adequately ventilated. In recommending the adoption of the open grid system, Sir Robert Rawlinson points out that while the air in one mile of street sewer may be taken at 1,000 cubic yards, the air in the street above would be approximately 500,000 cubic yards changed and renewed many times in the day, so that the air in the sewer will be several million times less in comparative volume than the air in the street, and the dilution of any sewer-gas will be in the same proportion. By the addition of pipe ventilators, the open grids which, without this supplement, are acting as both inlets for fresh and outlets for foul air, become active fresh air inlets, excepting only in certain conditions of the atmosphere referred to. The sewer-gas would generally become thus further diluted, and the amount of it dispersed through each of the many shafts proposed would be practically unnoticeable.

Before discussing the practical application of the system a few statistics of existing pipe ventilators may be useful. The metropolis is behindhand in this respect, possessing over its whole "greater" area only 582. In 12 districts they are stated to be satisfactory, but in the bulk the number may be said to be quite insufficient to rely upon for results of the successful adoption of the system. Coventry has 1,500 pipe ventilators, while other provincial towns have many more than London, and a much smaller area, of course, to deal with.

Blackpool seems to be the solitary exception where owners' prejudices have been overcome and no difficulty experienced in erecting shafts up the houses, and in answer to the query as to the means of ventilation employed, the surveyor is in the position to reply "By open "grids in streets, by shafts up house gables, by five street lamp "vents, and four 40-feet shafts used for electric lighting, and sundry "chimneys." He further adds his opinion "that very frequent open "grids in the streets are part of the proper system of ventilation, but "these are of no use unless counter shafts be placed to extract foul air, "and the grids become inlets."

The city engineer of Liverpool informs me that he has 900 pipe ventilators in use, and has had no complaints. I need not multiply instances however, but merely state that wherever the system has been tried to an even moderate extent (for in no instance has it yet been adequately adopted) it is spoken well of.

I will now briefly remark upon the practical construction of these pipe ventilators recommended. The vestry of St. Pancras being strongly in favour of the adoption of the system (whereby they state that probably no gas would ever be generated or accumulate to such a degree as to become offensive or perceptible) advocate its application thus:—Each main house drain should not be disconnected from the sewer, but each branch house drain should be disconnected from the main house drain and the latter carried up to a high point as a ventilator to the sewer.* This arrangement would secure, undoubtedly, the same principle of sewer ventilation, but it might in many cases lead to such difficulties and complications in systems of house drainage and ventilation that it is not to be lightly recommended.

Sir Robert Rawlinson and others assume that the best arrangement is to connect the pipe ventilators with the crown of the sewer, and

* Metropolitan Board of Works Report as to Cleansing and Ventilation of Sewers, 1886.

thence conduct them up the fronts of the houses. But here again the greatest advantages of the system are not obtained. The construction should be as follows:—Each tenement having the usual disconnecting trap and chamber serving to cut off the sewer from the house drain, and at the same time acting as an inlet for fresh air to the whole system of house drains, every separate branch discharge into this chamber being carried up to the roof full-bore as a ventilator to that branch; at the back of the disconnecting trap (that is, on the sewer side) there should be a junction, and at this point the pipe ventilator should be connected, and thence carried up to the house-top, being disposed as will be hereafter suggested. By this arrangement two great advantages are secured: (1.) A current of air is constantly introduced through the short length of pipe between the disconnecting trap and the junction of the house drain with the main sewer, preventing it from forming, as by the usual arrangement, a dead or stagnant length in which sewer-gas can accumulate. (2.) The breaking of the water-seal of the trap by siphoning or pressure is rendered impossible. This latter point is of the utmost importance. If, whether by excessive rainfall or by flushing with large and sudden quantities of water, the sewage rises in the main sewer so as to cover the whole of the orifice by which the house drainage enters it, the water-seal of the disconnecting trap is apt to be broken. A broken water-seal means, of course, the possibility of the main sewer discharging its sewer air or gas in close proximity to the lower windows of a town house.

If every house is to have such a shaft as that recommended, its *disposition* becomes a matter of importance. It is an advantage that the shaft should rise vertically from its connexion with the drain as soon as possible, and have as few bends as possible. There can be no doubt but that the best position for the shaft is up the front of the house. The open end should be removed from windows and chimneys as far as can be.

As regards the size of the shafts, inasmuch as a 6-inch drain is employed to carry off the output from very large houses, or even large blocks of flats, it may be said generally that, with a pipe at every tenement, none need be larger than 6 inches, and probably 4 inches would be found ample. This, however, is a matter of calculation, as the collective area of outlets in any district should be fully equal to the area of inlets formed by the open grids in that district.

However much appearance may have to give way to practical or sanitary considerations, it is appalling to think of the possible effect of a series of 6-inch or 4-inch pipe ventilators up the front of each tenement, a forest of fresh ugliness vieing with the tall-boys which already so disfigure our skylines. But fortunately both artistic and sanitary considerations can be fully regarded. In many cases the fortunate favour with which gables towards the street front are now being regarded comes to the aid of the architect. There can be no better place for the discharge of a pipe ventilator than the apex of a gable, which fact indeed adds another point in favour of this treatment, so that the picturesque and the sanitary go hand in hand in this case.

The pipe, in which there can be no pressure, can be carried up either in the core of the wall or in one of the many projecting pilasters or architectural features at present so much in vogue. It can discharge either by a finial at the apex of the gable constructed on purpose, or at the back of the coping. There is no architectural difficulty whatever. Where, however, there is no gable, it can be built in the party-wall as suggested by the City of London authorities, and undoubtedly this arrangement overcomes the difficulty which might arise from the varied height of street buildings. But even where there is no gable and the party-wall is impossible in a new building, it is merely a matter of the exercise of ingenuity on the part of the architect to conceal the eyesore, than which many more difficult problems will arise for solution in almost every day of his practice.

Cases may arise, especially if an owner's prejudice can be overcome and a pipe ventilator added to an existing house, where it is impossible, or may be considered too unsightly, to erect it on the façade. It may be insisted that there is no serious objection to its being carried under or through the house and up the back. It will not act quite so freely in this case, but it will act freely enough, just as a ventilating pipe to a house drain does, which always takes the same course. The suggestion of the St. Pancras Vestry, already alluded to, embodies this arrangement of conducting the sewer-air under the house of necessity, as in almost every town-house drains under the basement are essential. A dry pipe, with no pressure within it, laid by the side of the house drain can have no reasonable objection urged against it.

I summarise as follows:—

1. That the system of open grids in the streets, supplemented by shafts from the sewer side of every disconnecting trap upon the main house drains, be recognised as the effective automatic means of sewer ventilation, and its adoption be aimed at in all possible cases.
2. That it be made compulsory over new areas of building, or over large areas of rebuilding.
3. That the flushing and deodorisation of sewers be made compulsory, and in new districts that the former be part of the charters of the water-company.
4. That the vestries be called upon to exercise rigidly their statutory powers, not only in respect of new drains, but in respect of existing drains; also to adequately ventilate the dead ends of all drains.

The adoption of the system as suggested in new districts, or in large areas of rebuilding, would be a fitting stepping-stone,—and possibly the only one—to its spreading by the force of example and success to the older parts of our great towns.

I cannot better conclude than with the words of the Vestry of Tooting Graveney, who, in a well-considered memorial to the Metropolitan Board upon the subject, say, that " several persons have had " shafts from the sewers carried up the sides of their houses at their

" own expense, which have answered in their immediate neighbourhood, " but to be successful the scheme should be general." And they go so far as to suggest that parliamentary powers should be obtained.

DISCUSSION.

Dr. T. W. Hime (Bradford) said the subject was one of very great importance. It was one not less associated, at all events, with the craft which he himself practised than it was with that of engineering, and it was one which he might say had at the present time been so unfruitfully cultivated that it was worth while venturing to say a word or two about it. Although it was unfruitfully cultivated in the main, he particularly wished to except from that remark the admirable paper just read by Mr. Crimp, a paper so essentially opposed to the ordinary views, and to the classic statements which one met with in all works upon the subject of sewerage and sanitation, beginning with the official volumes of their own Government and going down to the humbler handbooks. With regard to the contents of sewers which were to be ventilated, perhaps a word might be said. He had heard, and he generally heard when he came to places where there were discussions of sewers and sewage, a great deal about sewer-gas. He might be pardoned the heresy of saying that there was no such thing in existence as a special sewer-gas. The gaseous contents of a sewer were a mixture of gases of a highly complicated and highly composite character. There was one thing which it was tacitly assumed was contained in the so-called sewer-air or sewer gas, and that was the germs of disease. From the first time when a disease germ was identified up to the present date, he believed there was no authentic record of the disease germ of any kind having ever been found in sewer-air. He had himself aspirated hundreds of gallons of sewer-air, and had drawn it through a material specially manufactured for the purpose of cultivating these disease germs, but never had he recognised one of them. Some exceedingly valuable experiments on this subject were made by the late and too early dead professor of chemistry in Aberdeen, in which he showed that, so far as living organic constituents were concerned, the gaseous contents of the sewers of Aberdeen were very much better than the ordinary atmospheric air around. The same thing had been proved over and over again in Germany, the home of bacteriology; and he might say that these disease germs were things which were as well known and as easily recognised by those who had studied the subject as the ordinary botanical or zoological living specimens on a larger scale. It ought to be taken at once as a fact, and recollected, that never yet had these organisms been found in sewer-air, or at any time got from it. Now it was, of course, very satisfactory to be able to say, "Oh, yes, here is a case of typhoid fever in the house, and we know there is a hole in " the pipe; the virus has come out through the hole, and it has caused " disease and death in the house." Then they simply set the sanitary inspectors and engineers to work, which was exceedingly gratifying. It was much pleasanter to do all this than to be obliged to say, "I have not the remotest idea where the typhoid fever has come from," but that was the fact. It was well that that should be recognised, because the statement as to specific diseases coming in this way from sewer-gas from the sewers was a very dangerous statement, and it was one which must obscure the truth, and lead right away from the direction in which they ought to go. With regard to the character and flow of gases and vapours in the sewers, Mr. Crimp had given some exceedingly valuable facts, and he (Dr. Hime) could verify them from some experiments of his own, made on a large scale in the years 1882–83. It was a fact that they just as often found the gaseous contents of sewers going downhill as uphill, and it was not a fact, by any means, that because the sewer-air was generally warmer than the external air, therefore it was always rising up to the top, and escaped from the highest point of the sewer. Ought they not, instead of wasting their time in talking about non-existent disease-germs in the gaseous contents of their sewers, to see that their houses were in no way connected with the sewers? He did not wish to maintain that because they could not find the organisms of diphtheria and cholera in sewer-air that therefore sewer-air was advantageous and wholesome. Certainly not. He imagined that the proper way to connect houses with sewers was to disconnect them absolutely, so that there might be no possibility of sewer-air getting into the house at all. Rather a serious heresy had been mentioned, viz., that the only dangerous part of the outflow material and waste of their houses was the excrement. He need only draw attention for one moment to the fact that the most fearful disease, the most awful scourge of humanity as well as of our most valuable animals, was tuberculosis; and that undoubtedly the main source of infection from tuberculosis was not from the intestinal excretions, but from the sputa. Then again, another disease which caused a great deal of alarm, but very few deaths, was diphtheria, and it was perfectly certain that the virus of diphtheria never did come out of man's nether vent, but only from the opposite extremity. The cholera-bacillus died quickly in sewage. The dangers from sewer-air were of a different character. Sewer-air must be kept out of their houses undoubtedly, but it was not with the view of excluding such specific causes of disease, because they did not really exist in the sewer-air, and consequently no system of sewer ventilation would ever succeed in getting them out.

Mr. Stephen Holman said he happened to be the unfortunate individual who had been connected with Keeling's system of ventilating sewers mentioned by Mr. Read. Dealing first with Mr. Crimp's very able paper, he (Mr. Holman) knew that the statistics he had placed before them might be taken as correct, as taken by anemometer registration, but how the pipes which were to be run up to the high altitude of a house, and so on, were to conduct the foul air from the sewers into the atmosphere at low temperatures was a mystery. In his experience, in introducing a system for the extraction of sewer-air by means of heat, extending over some three or four years past, one which was in use in such towns as Ealing, Richmond, Winchester, and Reading, with very great mechanical results, whatever the chemical results might be, he had gone into the matter merely as an engineer and not as a chemist. On account of some controversy which arose at Ealing some few years ago, Dr. Russell, Analytical Chemist of St. Bartholomew's Hospital, was called in to make tests and to give a report. In that report it was stated:—"The second "class of experiments were to determine whether the micro-organisms "or germs known to be abundant in sewer air are destroyed by the heat-"ing process carried on in this ventilation. To determine this I drew air "from the top of the ventilator by means of an aspirator for 13 minutes

" through sterilised cotton wool. This wool was carefully introduced " into a flask containing a cultivating medium, and an exactly similar " experiment was made with air from the sewer. After four days the " flasks, which had been kept at a temperature most favourable for " stimulating growth, were examined. In the one which had the wool " through which the sewer air had been drawn, there were at least 7,000 " distinct colonies or growths. Two experiments with air from the top " of the ventilator were made (that is, after the gas had passed through a " destructive heat,) and one gave only six colonies, the other 14. That is " a strong illustration of how efficiently organisms are destroyed by the " method of heating used in this form of destruction." Whether sewer air contained germs which were assumed to be fever germs; whether the air contained germs, or otherwise, might be a chemical question, which he would rather leave to Dr. Russell to determine; but it was a common experience that frequent complaints were made of sewer emanations. Whether they were dangerous or otherwise, they were certainly offensive, and with all their means of trying to prevent the inlet of sewer gas or air into their dwellings, they were nevertheless most offensive when they were emitted in the streets, especially in the midst of dense populations such as were found in their various cities and towns. The system which had been introduced in the towns he had named was that of gas furnaces placed in columns in the streets, standing 10 or 12 feet high, and by the consumption of 8 feet of gas every hour they got through from 2,500 to 3,000 cubic feet of sewer air per hour. The air which would come through the gas furnace undoubtedly would be the lightest sewer-air. Marsh gas was something like half the weight of atmospheric air, whilst carbonic acid gas would be half as heavy again as atmospheric air. Where a destructor or ventilator of that class was in operation, it would extract not the heavy air, but the light air, which came always to the surface. With regard to the means of ventilation by iron pipes up buildings, they were undoubtedly, as Mr. Crimp had suggested, inlets of air under certain conditions of temperature. If there was a prevailing temperature at the surface of 30 degrees and in the sewers of 50 degrees, or if it was 20 degrees colder on the surface than in the sewer—under those conditions air would not come up the sewer through the pipes, but would go down through the pipes. If air was moving only five or six miles an hour it would be found that an iron pipe was a very great refrigerator, a very cooling surface, much cooler than the air in the sewer or in the man-hole in the street, because the iron pipe was often three-eighths or half an inch thick; therefore those pipes became inducts of fresh air or surface air to the sewers, and, as Mr. Crimp had very justly said, when they had inlets of fresh air to the sewers some of the sewer gas must go out. He would give as an instance Croydon, which had a severe epidemic of scarlet fever in 1886–87. Iron ventilators had been put up in large numbers since that time, he was told to the extent of 300. What had been the result during the last year? Last winter, in 1890, they had the most severe epidemic of diphtheria of any town in England. They certainly had had 150 cases, three persons dying in one house. Those 300 iron pipes had not saved Croydon from that epidemic. He had had conversations with doctors in many localities, and they informed him almost invariably that throat diseases were most prevalent amongst persons living opposite to those open gratings in the streets. Sewer air could be dealt with before it reached the outer air, and it should be so dealt with, by passing it through a disinfecting medium, and the best medium of which he knew was fire. In Richmond, four years ago, the authorities were often threatened with litigation because of the offensive emanations from the streets, but if they went to Richmond to-day they would find something like 12 or 15 of those destructors in use, and there were no complaints of sewer emanations there. It was the same at Ealing. If sewer gas was not infectious, why all this anxiety to keep it out of their houses? Was it simply because it was offensive and smelt? Surely not!

Mr. H. A. Roechling (Leicester) referred to the experiments which had been made at Munich, where it was found that the wind had no noticeable effect upon the movement of sewer-air; that the air in the sewers oftener flowed downhill than uphill; and that the cause of the downhill movement was the rush of sewage, which bore the air with it. The observers did not agree on the question of the influence exerted by the difference in the temperature between the atmospheric air and that within the sewers. The gentleman who conducted his observations during the winter months found that this temperature-difference did cause movements of air within the sewers; whereas the gentleman who was at work during the summer months came to the conclusion that this difference had little to do with the movements of sewer-air. He mentioned this to show that Mr. Crimp's chief conclusion, that the wind practically was the only cause of the movements of sewer-air, was not supported by the Munich observations. He would also quote an observation made in this country. Mr. Haldane of Dundee, who some time ago examined the question of the composition of the air within sewers, recorded some observations made on the flow of the air in the Bristol sewers. The Bristol sewers were not ventilated at all, and there were only two places, close to the outlets, where the sewers could be entered without digging. In one of them, close to the Clifton Suspension Bridge, which Mr. Haldane entered, he found that the flow of the air was downhill. Wind could have had no influence upon the sewer-air in this case, as the Bristol sewers were not ventilated; and, as Mr. Haldane remarked that there was a rapid flow of sewage, it was much more likely that this rapid flow bore the air with it downhill. He had quoted these cases, as he was of opinion that it was not wise to form general conclusions from what had been observed in a particular locality and under particular circumstances. There were no two systems of sewerage in every respect alike; in fact, every sewer in every town had its own conditions, under which it had to work. He would like to ask the question, of what did the air of sewers really consist? It had been proved by Prof. Koch, of Berlin, that the air of a sewer was much purer than the air in the street immediately above the road surface. From 50 to 60 litres of sewer-air contained only from one to two germs, whereas a much larger number of germs was contained in street-air close above the pavement. The higher up they went into the air from this point, the less became the number of microbes present. Prof. Koch's statement was even better than the figures deduced by Mr. Haldane, who stated that he had found that the air of some sewers in this country, upon which he had experimented, contained from 10 to 12 germs per litre. He, too, had come to the conclusion that it was, as a rule, the outside air which contaminated the sewer-air with micro-organisms. In Leicester they ventilated, in 1881 and the following years, an old system of sewers; and shortly afterwards complaints were raised about the smells coming through the open grids at the street level. The late Mr. Joseph Gordon, who was then borough surveyor of Leicester, had asked him to ascertain from the returns of the Medical Officer of Health what had been the death-rates of Leicester since the ventilation of the sewers. He had prepared tables and a diagram, in which he had graphically shown the relation existing between the death-rates from various causes during the six years prior to the ventilation and during the six years after its introduction. It could be seen that since the systematic ventilation the following reductions had taken place in the various death-rates; typhoid fever had gone down 49 per cent., measles 48 per cent., diphtheria 30 per cent., diarrhœa 23 per cent., scarlet fever 18 per cent., phthisis 17 per cent., whooping cough 15 per cent. The death-rate from the combined seven principal zymotics had decreased 26 per cent., and that from all causes 11 per cent. Before the ventilation of the sewers they had no unpleasant smells in the streets, but higher death-rates than they had after the ventilation of the sewers, when complaints of bad smells in the streets became frequent. He did not say that the ventilation of the sewers had done all this, but he would put the reverse. Was it possible that, if sewer-gas was really as poisonous as it had been stated to be, an improved sanitary condition would result after admitting the gas in large quantities into every street? He could only come to this conclusion, considering all the circumstance of the case, that sewer-gas, if poisonous at all, lost its power of mischief when mixed with large volumes of atmospheric air; and that, as as Dr. Hine had so well remarked, it hed a mystic effect upon the sentiment of the people, causing them to attribute to it all manners of disease. After all, it was really not so much a question of the ventilation of the sewers as a question of the designing of them. If the sewers were designed with self-cleansing velocities, then nothing that could create a smell would be deposited in them. Where the ground was so flat that they could not get self-cleansing gradients, they would have to assist nature, either by mechanical means—to some of which Mr. Middleton had referred in his paper—or by systematically cleaning out the sewers by hand, as was done successfully on a very large scale at Berlin. When they had clean sewers there would be no complaints of foul smells arising from them.

Mr. Baldwin Latham believed that there was no connexion whatever between the outbreak of diphtheria which occurred in Croydon last autumn and sewer ventilation. It did not occur in the districts where these ventilating pipes had been put up, and it was traced by the Medical Officer of Health to a milk-supply, which not only affected Croydon, but also another district outside, from which that particular milk-supply came. They might therefore disabuse their minds of the idea that the erection of ventilation pipes had anything to do with the outbreak of diphtheria which had been mentioned as being due to the erection of these 300 pipes put up in the case of Croydon. For himself he believed that a great deal too much stress was thrown upon this question of ventilation. He thought, with Prof. Attfield, that if they allowed large volumes of pure air to pass through a sewer in contact with sewage they had large volumes of foul air escaping at some point, and that the great secret in sewer ventilation was not to encourage these currents of air through sewers, but to give such an amount of vent as should prevent any pressure of air being exercised upon the traps of their houses, so as not to allow any escape into the house itself.

Prof. D. van Overbeck de Meÿer wished to say a word with regard to the objections raised to his statements. He explained that, in speaking of fæcal matters, he meant excrementitious matters emanating from the human body. That was what he ought to have said. Secondly, he had to point out that not only were the germs in the sewer-air noxious, but there were gases that were still more noxious. The experiments of bacteriologists were not of very great value, because the conditions under which they were made were not always equally favourable. If they worked with different aëroscopes, using six or eight different instruments, and compared the results, they would find the greatest difference in them. He spoke from experience, and if anyone would make the same experiments, he would get the same results. His first point was that the difference in the results was very great. The second point was, they could not be quite sure of discovering the different pathogenic germs in sewer-air, and that also was a very great point. Finally, he must say to those who had spoken of sewer-air that it was not the germs only they had to deal with, but there were also chemical substances which they did not know at present, noxious substances, so that they must be very cautious in their conclusions. They, therefore, could not say at all that sewer-gas as it existed in the sewers was quite innoxious; on the contrary, it had the noxious property of preparing the body for the action of pathogenic germs. That was stated by different physicians in Germany, Belgium, France, and also in Holland.

The Chairman (Prof. Robinson) said it had been pointed out that sewer-gas was practically harmless, that, in fact, it was so free from impurity one would almost feel inclined to think, instead of leaving town for the benefit of one's health at this time of the year, it would be better to take advantage of some open drain or sewer, and spend the recess there. As far as his own feeling was concerned, he was not prepared to accept that state of things, but he should continue in his own professional practice to exclude sewer-gas from the houses of those whom he had to advise.

Mr. Santo Crimp said that, after all, the question of the movement of sewer-air was one of fact, and could be tested in 10 minutes by going into a sewer. He should be most happy to conduct any number of the members into some of the London sewers on the following day, and if it was windy he promised that they would hardly be able to carry the candles with which they would be provided. If, on the other hand, it was a calm day, the currents would be found to be very feeble indeed. He recently walked down one of the large sewers from Oxford Street to Buckingham Palace, and found that for some considerable distance the sewer air was travelling downhill. At first sight it appeared to be carried along by the sewage, as had been mentioned with regard to the Munich sewers; but the air was travelling a good deal faster than the sewage. It was quite clear, therefore, the sewage could not have been dragging the air in that instance. Some little distance down the sewer they came to a place where the side of the sewer had been removed to form a storm overflow. The sewer-air was all going over it, and not only was the air passing down the sewer going over it, but the air also coming up the sewer from below the storm-water culvert was all going over the overflow, as shown by the smoke, and passing along the storm culvert, which contained absolutely no water whatever. It was impossible to avoid the conclusion in that case, that the wind was really the motive power which was causing this sewer-air to move. Bristol had been referred to as showing the slight connexion there was between sewer ventilation and the death-rate. From the return tabulated by the Registrar-General, he found that in the decade 1870–80 the zymotic death-rate in Bristol was the lowest of that of the large towns tabulated, with the exception of Brighton, and in Bristol the sewers were absolutely unventilated, whilst at Brighton they were most fully ventilated. He ventured to think, therefore, that the connexion between the ventilation of sewers and the death-rate was one of very slight importance indeed. Mr. Holman's difficulty as to stagnation in cold weather was easily got over if they once recognised that wind really caused movement of sewer-air.

Mr. R. Read said he agreed very far with Mr. Santo Crimp as to the wind being a most powerful agent in producing motion in sewer-gas, but it was not the only cause; although the smaller causes, such as temperature, diffusion, and expansion were not in themselves very strong, still, when they acted with the wind, they assisted it, and the flow of sewage down the sewer certainly did carry the sewer- air with it. He had made a number of experiments; in one case, in a 12-inch sewer with a gradient of 1 in 28, he put smoke rockets into the sewer at a street ventilator with their fuzes pointing up the sewer, but persistently in all cases the smoke appeared at the ventilator below, and did not go up the sewer at all. Even when a fresh wind was blowing up the street in the direction of the rise of the sewer, the smoke would persistently follow the sewage downhill. In the case of which he had shown a diagram of a sewer, commencing at the lower end with a gradient of 1 in 154 from the first manhole to the next lamphole above, and of 1 in 224 up to the second lamphole, there was no air going into the first manhole and the intermediate lamphole, but a strong in-current into the manhole at the upper end. That was caused by 10 ventilating shafts, one on a telegraph pole and one to each of the nine houses. They were 4-inch pipes, having an outlet of 12·5 square inches each, the aggregate being 125 square inches of outlet. There was always a sufficient draught from the wind blowing over the tops of those ventilator-shafts to produce an in-current at the upper manhole with an average velocity of 123 feet per minute; a very slight wind, running 250 feet per minute at the tops of the ventilator-shafts, would produce that velocity. The average velocity at the outlet, multiplied by the sum of their areas, equalled the velocity entering the manhole multiplied by the sectional area of the air-space of the sewer. When those conditions were obtained there was invariably an in-current at the upper, or second, manhole only, and an out-current at all the shafts below it. He never got any other direction of current at all in that length of sewer. The houses erected were new houses, and the shafts were added as the houses were built, and it was not until he got that proportion of outlets to inlets that he obtained a constant current of air following the sewage downhill. Before that happened the current could be reversed, but not now, the outlet ventilators being in excess of the inlet. The other part of the sewer was on a new road with very few houses upon it. Therefore the street ventilators, which were upon the usual system of 60 to 100 yards apart, with 36 square inches of opening, were simply overflows; they might act as inlets or outlets, just as a puff of wind might make them, and the same below. But this length of 113 yards of 12-inch sewer, isolated simply by those shafts, showed always a current going in, down, and out of it. As to the temperature that Mr. Holman mentioned, the effects of that temperature had been overcome by wind. If the temperature happened to be in favour of the wind so much the better, but if it was against the wind, the wind would beat it. Mr. Holman had somewhat misunderstood him; he did not mean to say that his sewer-gas destructor was a bad thing at all. He thought it was a very good one, but it was very expensive, and the borough engineer who had to face the ratepayers could not afford many of them.

Assainissement des Villes: Traitement des Eaux d'Egout par les Procédés Agricoles.

PAR

M. Aimé Bonna.

L'assainissement des villes, sous l'heureuse impulsion des Comités d'hygiène, est actuellement l'objet des légitimes préoccupations des municipalités.

La création de distributions d'eau et la construction de réseaux d'égouts pour recueillir et évacuer toutes les eaux impures ou usées, constituent l'assainissement intérieur des villes; celui-ci doit se compléter par l'assainissement extérieur, c'est à dire par le traitement des eaux d'égout avant leur déversement dans les cours d'eau dont la pollution va toujours en augmentant.

Je me restreindrai, dans cet expose, à ce dernier point du vue spécial, c'est-à-dire à l'assainissement des cours d'eau et à l'utilisation des eaux vannes.

La question de l'épuration des eaux d'égout a donné lieu à de nombreuses discussions sur le meilleur système à adopter; mais si des divergences se sont présentées sur les conditions dans lesquelles l'épuration devait se faire pour donner des résultats avantageux, les hygiénistes paraissent aujourd'hui d'accord pour reconnaître que l'emploi agricole est le seul qui permette, par la filtration lente à travers le sol, d'obtenir une oxydation parfaite des matières organiques, et le plus efficace pour ramener les eaux à un état de pureté satisfaisant, tout en utilisant les matières fertilisantes qu'elles renferment.

En France, de louables efforts sont tentés pour obtenir l'assainissement intérieur et extérieur des villes, et l'application faite à Reims par la "Compagnie des Eaux Vannes" de l'épuration par le sol, permet d'apprécier les résultats qui peuvent être obtenus par les villes avec le concours de l'industrie privée, pour assurer, non seulement l'épuration des eaux d'égout, mais encore l'utilisation, sur de grandes superficies, de leurs principes fertilisants.

Il ne parait pas utile d'entrer dans des développements sur les études et discussions qui ont précédé la conclusion du traité passé entre la Ville de Reims et la Compagnie des Eaux Vannes pour l'épuration de la totalité des Eaux d'égout.

Les travaux d'adduction et de distribution, commencés, à la fin de l'année 1887, aussitôt après l'approbation du traité de concession par l'autorité supérieure ont pu être terminés dans le courant de l'année 1889, quelque temps avant la visite des membres du Congrès international d'Hygiène qui eut lieu le 7 Août de la même année.

Pour bien définir les opérations de la Compagnie des Eaux Vannes à Reims, je crois devoir exposer, d'une manière sommaire, les travaux d'irrigation et les améliorations foncières qu'elle a entrepris.

Le réseau des égouts de Reims se devise en deux zones ayant chacune une égout collecteur spécial pour l'adduction des eaux aux champs d'épuration. Les eaux du collecteur supérieur se déversent sur les terrains par simple gravitation, tandis que celles du collecteur inférieur sont relevées en partie par les pompes pour l'irrigation des terrains hauts du domaine de Baslieux.

L'Usine élévatoire se compose de 3 machines indépendantes, d'une force totale de 110 chevaux, capables de refouler, chaque jour, la totalité des eaux d'égout du collecteur inférieur, dont une partie se déverse en temps ordinaire sue les terrains bas du Domaine.

Le service des irrigations se devise également en 3 zones:

La zone supérieure, dont le réseau de distribution d'une longueur totale de 9,200 m., est composé de tuyaux en fonte des diamètres de 0 m. 600., 0 m. 400, et 0 m. 300 ;

La zone moyenne, avec conduites en béton de ciment de 0 m. 800, 0 m. 600, 0 m. 400, et 0 m. 300 de diamètre, répresentant une longueur totale de 8,500 mètres ;

Enfin, la zone inférieure, dont le réseau de distribution, principalement composé de conduites à ciel ouvert, a une longueur totale de 10,000 mètres.

Le drainage pour l'écoulement des eaux de colature a été obtenu par le creusement de grands canaux d'assainissment à ciel onvert d'une longueur totale de 12,000 mètres.

Des jaugeages effectuès pendant l'année 1890, il résulte que le cube moyen débite par les collecteurs a été de 35,717 m^3 par jour, soit 12,635 m. cubes débités par l'aqueduc supérieur et 23,094 cubes par l'aqueduc inférieur ; c'est en moyenne un volume de 0.m^{3}400 par tête d'habitant.

Le chiffre de 35,717 m^3 est une moyenne journalière ; il varie suivant le temps, les saisons, les jours ouvrables ou fériés, et aussi suivant les heures de la journée. La moyenne du débit dans la journée est d'environ 28,000 m. cubes, et la nuit de 8,000 m. cubes, en nombres ronds.

On conçoit la complexité que présentent les eaux d'égout au point de vue de leur composition. D'après les analyses faites par le Bureau municipal d'hygiène de Reims, les eaux contiennent en moyenne par mètre cube, au moment où elles arrivent aux bassins de réception.

Aqueduc Superieur.

Matières en suspension	minérales	0.^{k}498	1.^{k}121
	organiques	0.623	
Matières en dissolution	minérales	0.652	1.^{k}012
	organiques	0.360	
Total des matières fixes			2.^{k}133

Azote total, par mètre cube		- -	0.^{g}091
se décomposant :			
en azote ammoniacal	- -	0.^{g}050	0.091
et en azote organique	- -	0.041	
Chlore	- - - -	-	0.^{g}406
Acide phosphorique	- -	-	0.015

Aqueduc Inferieur.

Matières en suspension	minérales	0.^{g}566	0.^{g}927
	organiques	0.361	
Matières en dissolution	minérales	0.152	0.564
	organiques	0.412	
Total des matières fixes :			1.^{g}491
Azote total, par mètre cube			0.^{g}050
Azote ammoniacal		0.^{g}032	0.050
Azote organique		0.018	
Chlore			0.^{g}0543

Les eaux d'égout de Reims, notamment celles de l'aqueduc supérieur formées en grande partie des eaux résiduaires des peignages de laine sont chargées en matières organiques et azotées et susceptibles d'entrer en fermentation. D'autre part, les éléments utiles à l'agriculture se trouvent réunis dans des proportions comparables à celles que présente le fumier de ferme, ce qui en fait un engrais complet. Ces eaux résiduaires contiennent, en outre, beaucoup de potasse. La potasse est l'engrais complémentaire par excellence des terrains crayeux, et l'efficacité de tous les autres dépend de la plus ou moins grande abondance de cet engrais dans le sol.

Les 2 kgs environ que tient en suspension chacun des 36,000 m. cubes amenés chaque jour aux champs d'épuration représentent, par 24 heures, 72,000 kgs, soit 72 m. cubes, et, pour l'année entiére, 26,000 m. cubes environ de matières solides, minérales et organiques.

L'eau d'égout traitée par un sol perméable comme à Reims est complètment épurée. Voici l'analyse d'un échantillon d'eau pris dans le canal d'assainissement de la Compagnie des Eaux Vannes, à proximité de la ferme de Baslieux :

Degré hydrotimétrique	total	19°2
	après ébullition	3°5
Volume de permangante de potasse décoloré par un litre d'eau :		21 c.c.^{3}
Matières organiques correspondantes exprimées en acide oxalique par litre :		0.^{g}01323
Acide nitrique AzO^5		0.00686
Ammoniaque libre AzH^3		0.000054
Ammoniaque organique		0.0001

Le but poursuivi par la Compagnie des Eaux Vannes, tout en assurant l'épuration des eaux, est de faire de l'utilisation agricole sur de grandes superficies.

L'irrigation à forte dose, lorsque l'on ne se préoccupe exclusivement que de l'épuration, exige des précautions dans la distribution des eaux ;

l'utilisation, au contraire, sur de grandes surfaces, permet de répartir le nombre et la durée des arrosages, d'adopter une méthode d'assolement dans les cultures.

Pour ne pas être astreint à des travaux de drainage trop onéreux, il convient de choisir pour l'épuration des eaux d'égout, des terrains possédant une épaisseur filtrante suffisante ; il faut également tenir compte de leur configuration géologique et topographique. Le choix de ces terrains présente quelques difficultés, car on ne trouve pas toujours à proximité des villes, des superficies assez considérables pour faire de l'utilisation agricole ; cependant les terrains que peuvent être drainés, aérés et amendés sont aptes à l'irrigation. Si la perméabilité du sol laisse à désirer, il convient d'étendre les surfaces, afin de rendre l'opération praticable en modérant méthodiquement les doses d'arrosage.

Le drainage des terrains, indépendamment de l'assainissement du sol, peut avoir encore son utilité, notamment s'il y a lieu d'éviter le déversement des eaux de colature dans un cours d'eau, ou à proximité de sources servant à l'alimentation de villes. Les eaux de drainage seront dans ce cas, dérivées de leur direction normale pour être dirigées vers un autre cours d'eau.

A Reims, le choix de la Compagnie s'est porté sur les terres qui entourent les domaines de Baslieux et des Maretz dont l'épaisseur de la couches filtrante est supérieure à 2 mètres.

Ces terrains sont formés, pour la plus grande partie, de terres calcaires, formant le sol arable de tous les environs de Reims et de la Champagne. Le carbonate de chaux y domine dans une proportion de 80 °/₀ environ ; le sable silicieux représente 15 °/₀ ; l'argile 5 °/₀ au plus avec un peu d'humus. Ces terres ont des pentes généralement modérées facilitant la distribution des eaux d'irrigation.

Le champs d'irrigation sont, d'ailleurs, parfaitement situés, par leur éloignement suffisant des centres habités, et parce qu'en raison de leur position, ils permettent d'évacuer directement à la Vesle les eaux épurées, sans que l'on ait à craindre, pour les communes voisines, le relèvement de la nappe d'eau.

Parmi les terrains faisant partie des domaines achetés par la Compagnie des Eaux Vannes, se trouvent quelques prés-marais formant, principalement sur la rive droite, les bords de la Vesle. La Compagnie a entrepris l'amélioration foncière de ces terrains de mauvaise qualité, de nature un peu tourbeuse, et par conséquent acides. Elle est arrivée à les rendre, pour la plupart, propos à la culture.

La première opération à effectuer était l'assainissement des ces prés afin d'abaisser la nappe d'eau dans cette partie de la vallée. Pour y parvenir, la Compagnie s'est renduea cquéreur de 2 moulins situées en aval, "Macô et Compensé ; " le premier disposant d'une chute de 0m. 80 ; le second, de 1 m. 00. Elle a exécuté, sur une longuer totale de 12 kilomètres, un large canal d'assèchement latéral à la Vesle et un canal d'assainissement traversant tout le domaine dans sa plus grande longueur pour recevoir les eaux épurées provenant des irrigations.

Ces travaux ont transformé complètement des marais absolument incultes, et ont donné à ces prés inondés autrefois la plus grande partie de l'année, une épaisseur filtrante suffisante pour l'utilisation agricole des eaux d'égout.

En même temps que l'on poursuivait l'assainissement, des dispositions étaient prises pour améliorer le sol. Certaines parties étaient rechargées après défoncement, avec des déblais calcaires provenant des fossés d'assainissement; d'autres recevaient des phosphates naturels; le reste, non encore complètement préparé, recevra des scories de déphosphoration, environ 6,000 kgs. à l'hectare.

La ville de Reims a mis à la disposition de la Compagnie des Eaux Vannes 160 hectares destinés à servir de champs d'épuration, ci. -	160 Ha.
La Compagnie, de son coté, a acheté le domaine de Baslieux, le château des Maretz et ses dépendances, ainsi que les terrains avoisinants jusqu'au hameau de Macô, le tout représentant une superficie de - - - - -	425 „
dont 55 hectares de terrains non irrigables, composés d'un château, d'un parc, de deux étangs et des abords immédiats du chateau.	
Ensemble - - -	585 Ha.

Les irrigations ont lieu au moyen de rigoles de distribution à ciel ouvert. Les rigoles principales desservent les rigoles secondaires, qui alimentent, à leur tour les billons séparant les planches cultivées et disposées de façon à eviter la submersion et à permettre à l'eau d'égout de circuler autant que possible sans toucher les plantes.

Les travaux de préparation des billons se font économiquement au moyen d'instruments agricoles spéciaux. Ces instruments, à traction de chevaux ou de boeufs, sont composés de billonneurs pour le creusement de la rigole et sa régularisation.

Le volume journalier des eaux d'égout est approximativement de 36.000 m. cubes pour une superficie irrigable de 520 hectares, ce qui représente une dose moyenne d'irrigation de 25,265 m. cubes par hectare et par an.

Les arrosages reviennent plus ou moins souvent, suivant la nature des cultures et suivant les saisons. Les expériences ont démontré que les arrosages à l'eau d'égout ne sont nullement préjudiciables au point de vue de la richesse des plantes. La seule précaution à observer consiste à susp ndre les arrosages trois ou quatre mois avant la récolte, en ce qui concerne notamment les betteraves à sucre, afin que la végétation ne soit pas poussée trop avant dans la saison et ne retarde pas la maturité de la plante.

Les terrains crayeux consument rapidement les engrais; il convient donc de les leur donner par faibles doses souvent répétées. Les irrigations à l'eau d'égout conviennent, d'ailleurs, admirablement à cette nature de terrain.

Si l'on fait de l'utilisation agricole, il faut disposer l'assolement de manière à pouvoir irriguer certaines cultures au moment où les arrosages doivent cesser sur d'autres parties.

La culture maraichère, celle de la batterave et des autres plantes sarclées, conviennent bien pour les terrains arrosés à l'eau d'égout. Ces cultures laissent le sol libre l'hiver, permettent en cette saison les irrigations et même de légers colmatages ; en outre, les binages multiples ont pour résultat de rompre la croute superficielle du sol entre les lignes, d'enlever les mauvaises herbes, d'assurer l'accès de l'air entre les plantes, et de maintenir la perméabilité des terrains.

La culture profonde, indispensable pour la betterave, est exécutée à Reims d'une manière complète et régulière au moyen d'un appareil de labour à vapeur. Par le mouvement rapide de l'instrument, la terre est mieux soulevée et devient plus meuble en se désagrégeant. L'incorporation des dépôts au sol se fait plus intimement, et au point de vue de l'épuration, le sol se trouve mieux aéré, ce qui facilite la combustion des matières organiques.

La culture en billons, faite avec les instruments spéciaux dont il a été parlé ci-dessus, donne d'excellents résultats, tant au point de vue des travaux de préparation que des façons subséquentes, binages et arrachages.

L'emploi de vannettes mobiles en tôle galvanisée permet également de diriger les eaux avec la plus grande facilité ; on peut augmenter ou modérer les doses suivant les besoins de chaque récolte.

Les résultats, pour la première année d'exploitation normale, ont été très encourageants. La récolte de betteraves à sucre a été notamment remarquable en 1890, car elle a donné une moyenne de 45,000 kgs à l'hectare, avec une densité supérieur à 6 %.

Malheureusement, ces résultats ont été en grande partie compromis par les gelées de l'automme qui ont eu lieu avant l'arrachage complet de la récolte et avant la livraison aux usines.

La Compagnie, pour plus de certitude dans ses résultats au point de vue de la richesse saccharine des betteraves, avait employé, comme engrais complémentaires et à titre d'essai, des superphosphates et des phosphates de la Meuse. La récolte a démontré qu'en irriguant d'une manière méthodique, on pouvait obtenir des produits d'une densité élevée avec un poids bien supérieur à celui obtenu dans les cultures intensives du Nord de la France.

Nous somnes convaincus que le rendement atteindra prochainement 60,000 kgs en moyenne à l'hectare et une densité minimum de 7 % ; ce résultat a été obtenu sur certaines parties de la propriété irriguées depuis deux années.

En ce qui concerne les céréales, les irrigations ont eu lieu avant les ensemencements sur un sol préparé après de légers colmatages.

Le rendement à l'hectare a été, pour les cultures de blé, de 36 hectolitres.

Pour éviter la verse qui aurait pu se produire sur un sol abondamment pourvu d'azote, on avait ajouté, comme engrais complémentaire, des phosphates de Pernes, en proportion variable, suivant la nature des terrains, le nombre et la durée des arrosages.

La production du seigle a été de 40 hectolitres en moyenne à l'hectare, sans engrais complémentaires. La récolte de l'avoine, sur des terrains faiblement irriguées, a été 48 hectolitres.

La récolte en fourrages, ainisi qu'on l'a constaté dans toutes les fermes cultivées à l'eau d'égout, a été très abondante.

Les luzernes, qui conviennent bien aux terrains crayeux de Champagne, ont donné une moyenne de 20,000 kgs. de foin sec par hectare, en 3 coupes, correspondant à 80,000 kgs. d'herbe verte à l'hectare. Cette culture exige une irrigation modérée, nécessitant quelques précautions dans les arrosages.

Le ray-grass d'Italie a donné également de bons résultats. La récolte a atteint une moyenne de 90,000 kgs. d'herbe verte à l'hectare. Ce fourrage a été consommé en vert, la dessication de l'herbe étant devenue difficile par suite de l'abondance de la récolte. Malgré ces résultats nous pensons que la culture de la luzerne comme fourrage artificiel est préférable au ray-grass d'Italie dont les tiges deviennent trop fortes, ce qui nuit à la qualité du fourrage.

Quant aux prairies naturelles, le rendement a été, en deux coupes, de 10,000 kgs. de foin sec à l'hectare. Ces prairies un peu acides sont en voie d'amélioration. Elles seront, d'ailleurs, mises en culture et recevront, ainsi que nous l'avons dit précédemment, des engrais complémentaires sous forme de scories de déphosphoration.

Tels sont les résultats obtenus pour une première année d'exploitation normale.

Lorsque toutes nos améliorations foncières seront terminées et que les irrigations auront pu être faites régulièrement sur tout l'étendue de la propriété, nous pensons augmenter dans de notables proportions notre production agricole.

Pour éviter les inconvénients qui peuvent résulter d'un retard dans l'enlèvement des récoltes, on termine actuellement l'installation d'une distillerie qui permettra de transformer, sur place, les produits agricoles, notamment les betteraves et les pommes de terre. Les pulpes de la distillerie seront utilisées, concurrement avec les fourrages récoltés sur les propriétés, pour nourrir des bestiaux à l'engrais dans les trois fermes de la Compagnie.

L'assolement de l'exercice 1891 comprend 280 hectares de betteraves à sucre, qui produiront approximativement 15,000,000 de kgs. Ce chiffre indique suffisamment l'importance de cette installation.

Il résultera de cette organisation une économie appréciable dans les transports, une plus grande rapidité dans l'enlèvement des récoltes, et enfin une meilleure utilisation des produits de l'exploitation.

La Compagnie des Eaux Vannes, après avoir organisé l'exploitation et fixé les meilleures méthodes culturales, a loué à une Société agricole spéciale tous les terrains irrigués, moyennant un prix annuel par hectare établi comme suit :

100 et 150 fr. pour les 2 premières années ;
200 fr. pour les 8 années suivantes ;
225 fr. pendant 10 autres années ;
et 250 fr. pour les 16 années restant à courir jusqu'à la fin de la concession.

Ce prix de location, sans être excessif, paraît cependent suffisant pour assurer aux capitaux engagés dans cette opération une rémunération appréciable.

Pour permettre de fixer exactement les idées sur les résultats que l'on doit attendre de l'épuration par le sol, il faut éviter de faire supporter par l'exploitation agricole des dépenses qui ne la concernent qu'indirectement, c'est-à-dire qu'il convient de séparer nettement, dans tout projet, les dépenses d'adduction ou d'élévation des eaux—qui doivent être considérées comme dépenses d'assainissement proprement dites,—des dépenses de distribution d'eau ou d'aménagement du sol qui sont spécialement afférentes aux irrigations.

On a fait remarquer très souvent que les exploitations agricoles utilisant les eaux vannes n'avaient pas donné de résultats satisfaisants au point de vue financier; mais en cherchant les causes que ont pu occasionner les insuffisances signalées, il est facile de reconnaître que, dans la plupart des cas, on a fait supporter à l'agriculture des charges qui incombaient aux villes.

Pour éviter une semblable interprétation, il conviendrait d'admettre comme principe que l'évacuation des eaux d'égout et leur épuration constituent une obligation pour les villes.

Les canaux d'adduction ne sont, en réalité, que le prolongement du réseau d'égouts. Si la configuration topographique des lieux ne permet pas l'irrigation par gravitation du champ d'épuration, il y a lieu de laisser également les dépenses d'élévation des eaux à la charge des villes.

Les produits d'une exploitation agricole ne permettent de supporter que des dépenses réellement afférentes à cette exploitation. Il faut, d'ailleurs, tenir compte des frais d'epandage des eaux sur les terrains irrigués. A Reims, pour une superficie irrigable de 520 hectares, le personnel occupé à la répartition des eaux se compose, suivant les saisons, de 12 à 14 ouvriers avec 2 chefs d'équipe. Ces frais augmentent nécessairement le prix de revient de l'engrais répandu sur le sol, et si l'on ajoute encore d'autres frais, tels que les intérêts et l'amortissement des dépenses de premier établissement, on rendra l'exploitation plus onéreuse que dans une culture ordinaire—où l'on est obligé de faire l'acquisition d'engrais chimiques—et l'exercice se soldera toujours en perte.

En résumé, les dépenses concernant l'établissement des conduites d'adduction, l'élévation des eaux s'il y a lieu, doivent être supportés par les villes. Celles-ci ne doivent pas rechercher, d'ailleurs, des advantages ou considérer comme une source de revenus éventuels l'utilisation des eaux; elles doivent avoir pour but de faciliter l'épuration, tout en cherchant, naturellement, à rendre cette opération aussi peu onéreuse que possible pour elles.

Comme conséquence, il y aurait lieu d'accorder aux villes qui désirent appliquer l'épuration agricole les plus grandes facilités pour l'acquisition des terrains, en les autorisant à exproprier le minimum de surface nécessaire à l'épuration, tout au moins au point de vue de la salubrité.

Nous trouvons en Angleterre des examples où le prix exagéré des terrains et le refus d'expropriation ont été un obstacle à la réalisation économique de l'épuration agricole des eaux vannes. Il convient de se préoccuper d'assurer aux communes les moyens de faire usage de ce mode d'épuration dont on reconnait les avantages incontestables, et c'est dans cette pensée que nous croyons devoir demander la sanction du Congrès d'hygiène, pour que les communes ou les départements puissent être autorisés à exproprier le minimum de surface nécessaire à l'épuration des eaux par l'arrosage des terres.

L'on doit, en effet, en matière d'expropriation, ne demander que le minimum de terrains nécessaires pour assurer l'épuration des eaux, sans se préoccuper de l'utilisation.

. La surface de terrains qui a été reconnue nécessaire en France pour l'épuration des eaux d'égout de Reims, a été basée sur une irrigation d'un volume annuel de 40,000 mètres cubes par hectare. La dose de 40,000 m³ a été également déterminée par la loi d'assainissement de la Seine pour les irrigations dans la presqu'ile d'Achères.

Pour les grandes agglomérations urbaines, telles que la ville de Paris, la faculté d'expropriation pour les terrains spécialement affectés à l'épuration des eaux, assurerait le développement des travaux d'assainissement et faciliterait l'épuration agricole des eaux qui est appelée, croyons-nous à recevoir de nouvelles applications en France, où le sol et le climat permettent d'obtenir, au point de vue cultural, des produits rémunérateurs.

La ville de Paris donnant le bon exemple, poursuit son assainissement extérieur en affectant aux irrigations les terrains domaniaux d'Achères. Les projets d'extension actuellement à l'étude nous font espérer que l'épuration de la totalité des eaux d'égout de Paris sera prochainement réalisée.

L'Administration départementale de la Seine se préoccupe également de l'assainissement du fleuve en amont et en aval de Paris, et il y a lieu de prévoir que le Seine dont la pollution va toujours en s'aggravant et s'étend même jusqu'à Mantes, ne recevra plus, dans un avenir peu éloigné, aucune des impuretés qui la souillent dans la traversée des départements de la Seine et de Seine-et-Oise.

D'autres applications sont à l'étude dans différentes villes, mais le plus grand obstacle à l'exécution de ces projets est la question des voies et moyens dont la solution présente généralement de grandes difficultés.

Cette question financière vient de recevoir une heureuse solution pour la ville de Marseille. Cette solution, qui consiste à rendre obligatoire le raccordement avec les égouts, autrement dit LE TOUT A L'ÉGOUT, moyennant le paiement d'une taxe proportionnelle de vidange, permet, par la création de ressources nouvelles, de réaliser l'assainissement de la ville de Marseille, des faubourgs, des ports et des villages suburbains.

Si l'on peut regretter que la situation topographique de la ville de Marseille ne permette pas l'épuration des eaux par le sol, l'on doit se féliciter cependant de l'adoption du principe de l'obligation du "tout à l'égout."

Cette solution nouvelle, que recevra prochainement le sanction de l'autorité supérieure, créera un précédent qu'il sera permis d'invoquer en faveur des autres villes de France pour améliorer leur hygiène en leur permettant de réaliser leur assainissement interieur par la création d'un réseau complet d'égouts, et leur assainissement extérieur par l'épuration agricole des eaux vannes.

On the application of an Intercepting Reservoir, of the Type of Mouras's Fosse, and of a Peat Filter for Sewage to the Separate system of Sewerage.

BY

L. Pagliani, Professor of Hygiene and Director of Public Health, Rome.

I.

In Italy, as in any other country where due importance is given to the improvement of local sanitary conditions, the question of town sewerage is eagerly discussed; but, in Italy, more perhaps than anywhere else, with its great general need of this kind of sanitary reform, do economical considerations influence the question.

Putting aside the hygienic reasons which do not permit the adoption of the French "*tout à l'égout*" system, in most of our towns the necessity of limiting expense compels us to choose a good separate system of sewerage. This system, however, to prove economical as well as hygienic in an agricultural country such as ours, must comply with the following important conditions:—

1st. It must permit the use of very small pipes for carrying the sewage from houses, and it must be free from the danger of obstruction or hindrance to the regular flow of the sewage.

2nd. It must allow the useful elements of that sewage to be available for agricultural purposes.

The use of small-sized pipes is important, not only because of the relatively lower cost of the pipes and of their setting, while permitting the use of more resistant and less permeable material, but because in such pipes it is easier to ensure a constant and thorough flushing. But, to adopt them without fear of inconvenience in their working, the sewage must be sufficiently fluid, and, above all, must never contain solid matters capable of, sooner or later, obstructing them.

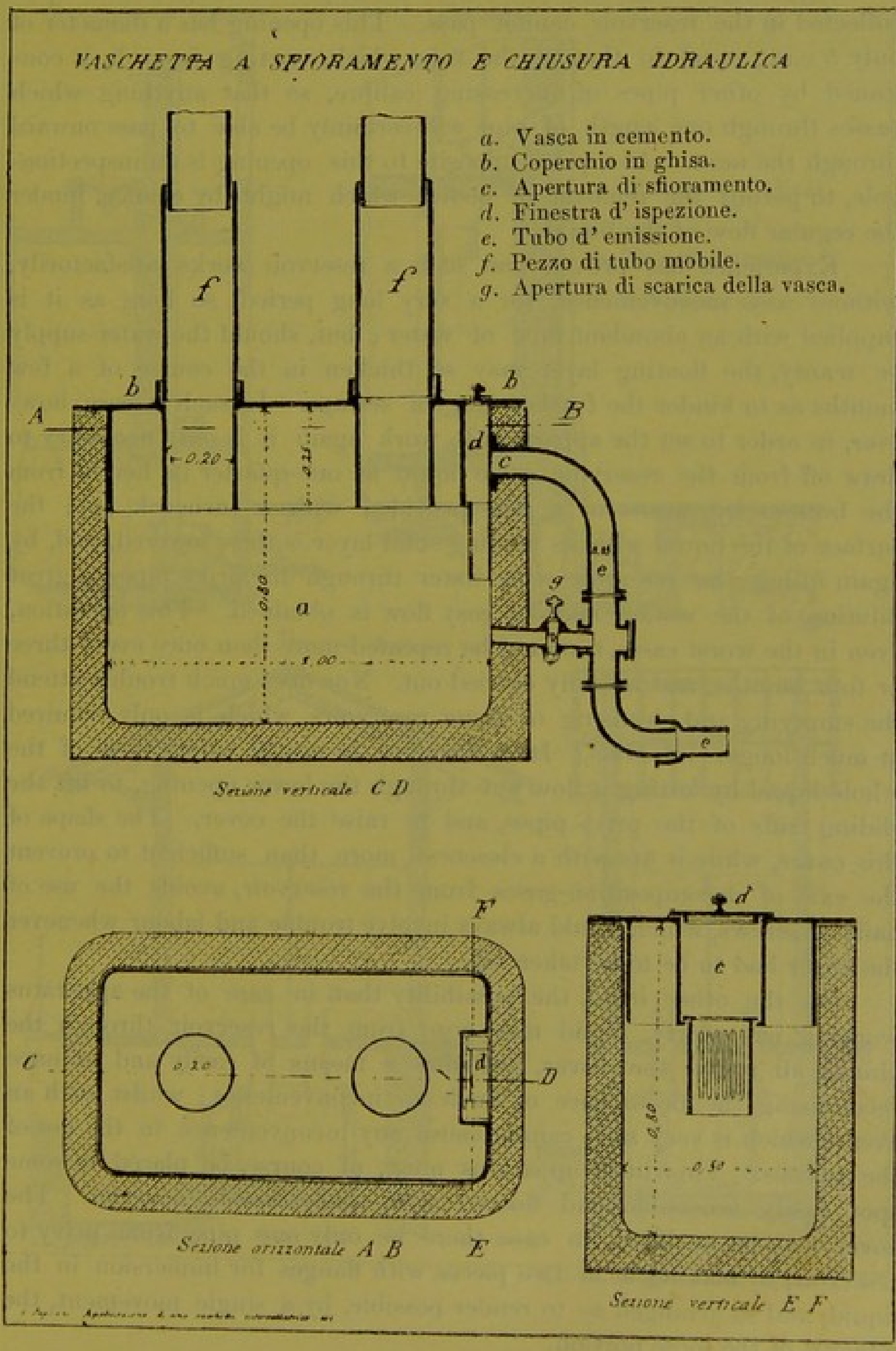
The good derived from using the valuable constituents of sewage for agricultural purposes is, on the other hand, remarkable for the economy obtained with substances which otherwise would be lost, and for the assurance that filth is prevented from polluting waters or soil, and from thus disseminating disease.

Knowing the difficulties met with by municipalities in the choice and successful application of such a separate system of sewerage, I have studied this problem experimentally, with the assistance of competent men working in the scientific laboratories of the Ministry of the Interior. The first question was the selection of a simple apparatus for securing a sufficient dilution of the soluble or emulsionable contents of privies, so that they might be separated from the irreducible and too voluminous portion, in order to enable me to send into small-sized pipes such a liquid as should never obstruct them, whilst the apparatus would allow the removal of all foreign bodies which might have been occasionally introduced into the privy pipes. Secondly, it was necessary to set to work a filter capable of retaining the materials useful for agricultural purposes, but incapable of causing any danger to those localities in which the filtration is carried on—places, for instance, unprovided with land suitable for sewage irrigation.

II.

To solve the first point, I had proposed, in the year 1884, in a project of sanitary reforms for Turin, studied together with

PLATE I.



Signor Augusto Restelli, the application of a miniature Mouras's reservoir, which, after repeated experiments, I found it desirable to modify, as shown in the drawing represented in the Plate I. (figures 1, 2, and 3). The apparatus consists of a small reservoir made of cast iron or cement, whose dimensions are 1 metre in length, 0·50 in breadth, 0·80 in height. To close it, I use a cover made of cast iron (*b*, *b*), provided with flanges, which, with the liquid that very nearly fills the reservoir when at work, make a water-seal all round the edges as well as at the exit of the privy pipes.

As in every Mouras's reservoir, mine has an overflow opening (*c*) formed in this special type by a small watertight receptacle, provided with a grating through which bodies that may be floating in the liquid collected in the reservoir cannot pass. This opening has a diameter of only 5 c.m., equal to that of the tube which, starting from it, is continued by other pipes of increasing calibre, so that anything which passes through one length of pipe will certainly be able to pass onward through the next. At a point opposite to this opening is an inspection-hole, to permit the removal of bodies which might, by chance, hinder the regular flow of the liquid.

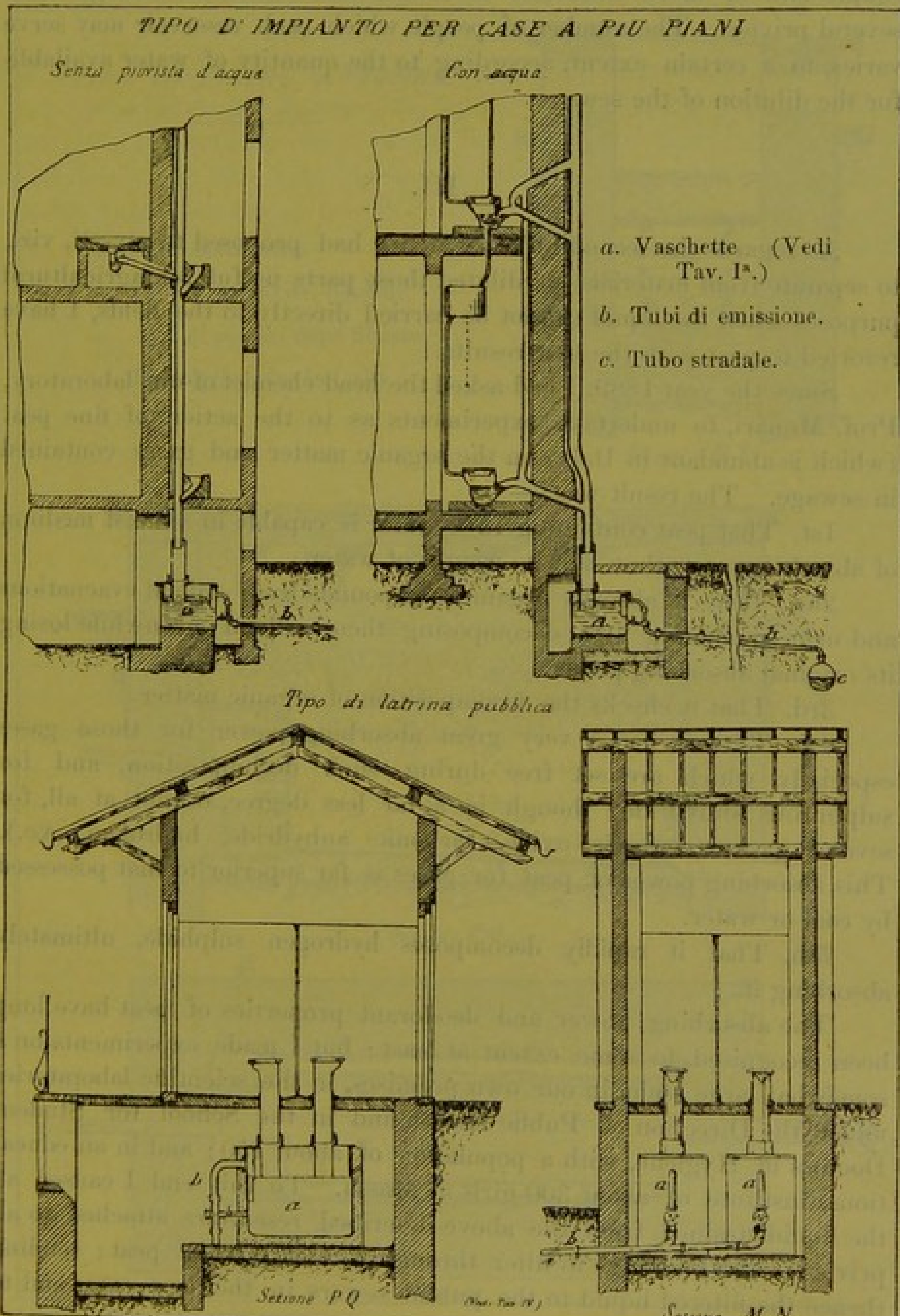
Experience has proved that such a reservoir works satisfactorily, without any inconvenience, for a very long period, so long as it is supplied with an abundant flow of water; but, should the water-supply be scanty, the floating layer may so thicken in the course of a few months as to hinder the further flow of sewage. In such a case, however, in order to set the apparatus to work again it is only necessary to draw off from the reservoir some liquid at one-quarter its height from the bottom by means of a pipe provided with a turncock (*g*); the surface of the liquid with its floating solid layer is thus lowered, and, by again filling the reservoir with water through the privy pipes, a great dilution of the sewage and its easy flow is obtained. This operation, even in the worst cases, need not be repeated more than once every three or four months, and is easily carried out. Nor does much trouble attend the emptying and cleansing of these reservoirs, which is only required at much longer intervals. It will suffice to nearly empty them of the whole liquid by letting it flow out through the lower opening, to lift the sliding cuffs of the privy pipes, and to raise the cover. The shape of this cover, while it fits with a closeness more than sufficient to prevent the exit of decomposition-gases from the reservoir, avoids the use of nails or screws, which would always involve trouble and labour whenever the cover had to be to be taken off.

On the other hand, the possibility that in case of the apparatus working irregularly, liquid may ooze from the reservoir through the chinks all round the cover, furnishes a means of easily and at once recognising the occurrence of such an inconvenience; whilst such an event, which is very rare, cannot cause any inconvenience in the use of the privies. This little apparatus must, of course, be placed in some spot easily accessible and floored with impermeable material. The cover may be modified, in case there be only one pipe from privy to reservoir, by making it in two pieces with flanges for immersion in the liquid, and so arranged as to render possible, by a single movement, the removal of the loose portion.

When thought more convenient for the position of the reservoir, the emptying pipe may be arranged independently of the upper tube, in order to draw off the liquid from the reservoir for agricultural purpose. In such a case the out-flow tube *e* may be disposed horizontally without any bend.

The liquid that comes from this reservoir is at all times such as easily flows out without depositing anything on the interior of the pipes. It would be easy, however, to adapt a flushing apparatus to

PLATE II.



them, as is practically used in every good system of separate sewerage (Plate II., figure 2). Two flushings per day, of 10–15 litres water each time, are enough to assure a perfect cleansing.

In Plate II., I have represented three methods of applying such reservoirs: 1st, when we have to deal with a many-storied edifice unprovided with water-pipes (figure 1); 2nd, when the same is provided with washing-water (figure 2); 3rd, when there are four privy-basins situated on the ground floor, as is the case with a public or school closet, &c., &c. As is indicated in the drawing, the reservoir might be used for only one privy pipe or for two; and it is also possible to couple two or more reservoirs to collect and dilute the sewage from several privies. The number of people which each reservoir may serve varies, to a certain extent, according to the quantity of water available for the dilution of the sewage.

III.

As regards the second object which I had proposed to myself, viz., to separate from materials so diluted those parts useful for agricultural purposes when the liquid cannot be carried directly to the fields, I have resorted to peat with the best results.

Since the year 1889, I had asked the head chemist of our laboratory, Prof. Monari, to undertake experiments as to the action of fine peat (which is abundant in Italy) on the organic matter and gases contained in sewage. The result was:—

1st. That peat containing 15°/₀ water is capable in a moist medium of absorbing more than half its weight of water.

2nd. That it absorbs organic compounds from animal evacuations and urine, including urea, decomposing them without meanwhile losing its original absorbing power.

3rd. That it checks the decomposition of organic matter.

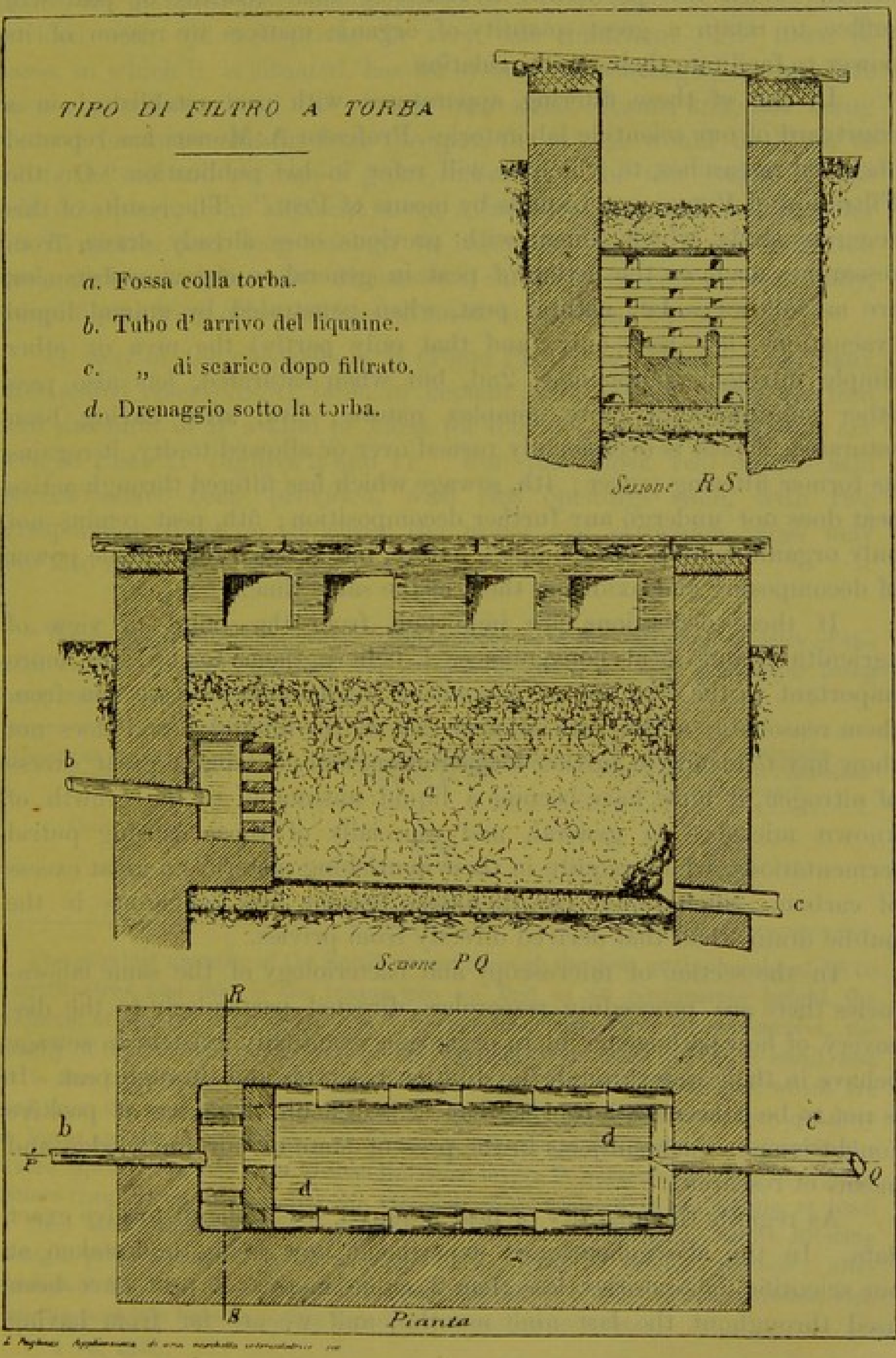
4th. That it has a very great absorbing power for those gases especially which are set free during such decomposition, and for sulphurous anhydride; though in a far less degree, or not at all, for several gases (carbonic oxide, carbonic anhydride, hydrogen, &c.). This absorbing power of peat for gases is far superior to that possessed by coal or water.

5th. That it rapidly decomposes hydrogen sulphide, ultimately absorbing it.

The absorbing power and deodorant properties of peat have long been recognised, to some extent at least; but I made experiments on a somewhat large scale, in our own premises, in the scientific laboratories under the Direction of Public Health and in the School for Student Doctors in Hygiene, with a population of about 150; and in an educational institute of about 300 girls at Massa. To this end I caused all the liquid strained from the above-described reservoirs attached to all privies in the buildings to filter through a thick layer of peat; sending thence the filtered liquid to the public sewers in the first case, and to a metallic tube in the second case.

The filter apparatus for sewage is represented in the third Plate. It consists of a pit walled with bricks and well cemented (figure 1), and roofed in such a way as not to allow rain-water to enter, while permitting a free circulation of air (figure 2). The pit has the dimensions of 2 metres in length, 1·40 in height, 0·80 in width, and is divided into two compartments, in the larger of which the peat is laid

Plate III.



for an height of 80 centimetres. The liquid entering by the tube *b* flows into the first compartment, and thence through a grated wall enters the second one to penetrate the peat. To ensure a rapid flow of the liquid I had to set in the floor of the second compartment a drain *d*, *d* (figure 3). Thus the liquid, after having passed through the peat, comes out from the opposite end of the pit by the tube *c*. The pit is so constructed as to allow from time to time the turning over of the peat contained in it; and to get the full effect, the peat must never be completely immersed, but must always be allowed free exposure to air. With this precaution a relatively small quantity of peat will suffice to retain a great quantity of organic matters by reason of its power to facilitate their rapid oxidation.

In one of these filtering apparatuses with peat established in a courtyard of our scientific laboratories, Professor A. Monari has repeated chemical researches, to which he will refer in his publication "On the Filtration of Putrescent Liquids by means of Peat." The results of this accurate study, which concur with previous ones already drawn from researches made on the action of peat in general on organic substances, are as follows:—1st, natural peat, when penetrated by animal liquid evacuations, lets pass only (and that only partly) the urea or other simple nitrogen compounds; 2nd, but when saturated, lets also pass other substances of more complex nature; 3rd, after having been saturated, if peat is occasionally turned over or allowed to dry, it regains its former filtering power; 4th, sewage which has filtered through active peat does not undergo any further decomposition; 5th, peat retains not only organic matters of a complex nature, but it has a remarkable power of decomposing and oxidising them at the same time.

If these deductions are important from the point of view of agriculture and local convenience, I believe them to be still more important in the direction of preventive hygiene, because we can from them reasonably affirm with Monari that as the filtered liquid does not show any tendency to further fermentation, and contains a great excess of nitrogen, it must have become a liquid unsuitable to the growth of known microbes in general, and especially of those causing putrid fermentations, which require in their nourishing materials a great excess of carbon. Such liquid has, doubtless, become less dangerous in the public drains than that derived directly from privies.

In the section of microscopy and bacteriology of the same laboratories there are proceeding researches directed particularly to the discovery of how pathogenic micro-organisms eventually existent in sewage behave in their way through the dilution reservoir and through peat. It is not to be concealed, however, that it is difficult to arrive at positive conclusions on such subjects in the present state of our knowledge and means of research.

As regards the quantity of peat required, it is difficult to give exact data. In the above-mentioned experiment now being undertaken at our scientific laboratories, less than 2 cubic metres of peat have been used throughout the last nine months; and we are far from having exhausted its activity, for more than half is yet almost intact, and the remainder is not yet in such a saturated state as to preclude its use after having been left to dry in a free current of air.*

IV.

As an example of a somewhat complex application of this system comprising watertight reservoirs, peat filter, and pipe drain, I give Plate IV., compiled by Filippo Danesi, civil engineer, working at the Technical Office of Public Health. In the Institute to which this plan applies, are gathered daily about 300 girls of every age. It was formerly provided with old well-privies in very bad condition. The town of Massa, in which it is situated, has no system of sewerage; it therefore was not possible to send the sewage into street drains, and, not being removed for many months from the spot, the sewage would be likely to pollute the soil and produce a great nuisance. For this reason it was decided to place, in an adjacent street, a cast-iron tube with the diameter of 0·15 metres and long enough to carry the liquid to an irrigation canal, giving to the tube dimensions sufficient to collect, eventually, sewage liquid from other edifices situated in the same street.

To four of the old wells in B (Plate IV.) were connected as many water-sealed reservoirs, C, built in cement; and for the Infant Asylum there was built in B′ a kind of kiosk for four privies, whose sections are given in Plate II. (figures 3 and 4). For this kiosk two of the said reservoirs have been provided, with two openings each, with two corresponding pipes on the cover, the upper end of which pipes may serve also as seats.

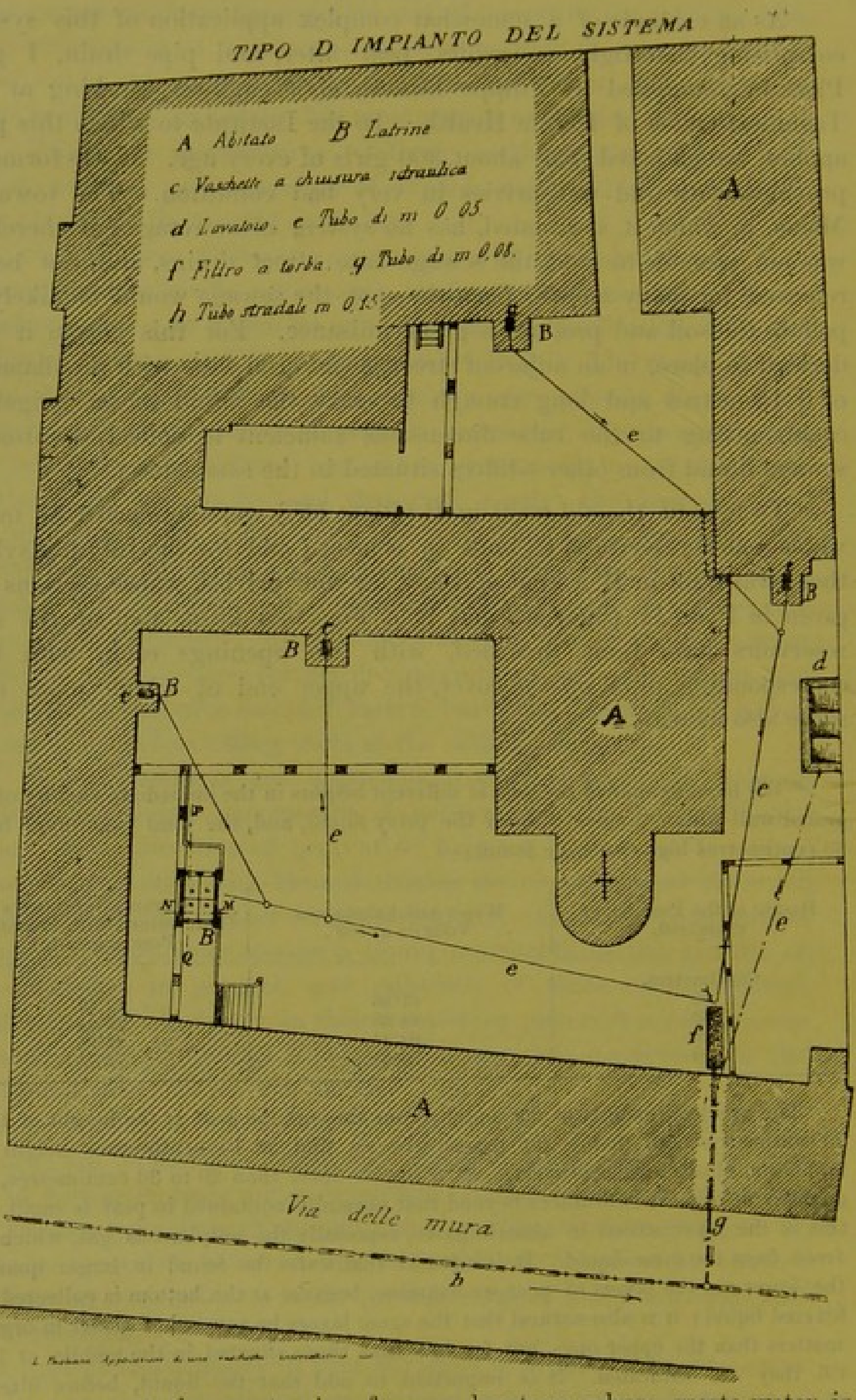
* We have examined the peat at different heights in the immediate vicinity of the grated wall which divides it from the privy liquid, and, the total peat layer being 80 centimetres high, we have found :—

Height of the Peat Layer examined.	Water and Substances Volatile at 100°.	Organic Substances (determined with Potassium Permanganate).
Centimetres.	%	%
50	61·86	12·13
30	64·68	12·04
10	68·24	22·96
0	70·28	13·71

The greatest quantity of the liquid passes through the peat at the height of 10 to 20 centimetres, and that is the reason why we find at 10 centimetres height the maximum of organic substances. At a higher level than 20 to 30 centimetres, the quantity of organic substances beyond that normally contained in peat is small, and this is the layer suited to absorb gases, especially the sulphurous gas, which are freed from the same liquid. It is natural that water be found in larger quantity the lower are the layers of peat we examine, because at the bottom is collected the filtered liquid; it is also natural that the same layers be somewhat richer in organic matters than the upper ones, but far less than those situated in the middle, at least till they are saturated. It is important to add that the liquid, before filtering through peat, contains, on an average, 25 per cent. of organic matters; after filtration it has only about 2 per cent., and this under the existing conditions, viz., when the peat has been in action for nine consecutive months.

The six reservoirs have been provided with tubes, *e*, with a diameter of 0·05 m., for conveying the liquid to a pit, *f*, of the above-described type, containing filtering peat. Between the pit and the street drain was inserted another pipe, with a diameter of 0·08 m., receiving at its

Plate IV.



commencement the waste-pipe from a lavatory, whose waste-water is available for flushing the street tube. These tubes are laid with very little fall, only about 5 per cent.

In this case the installation was made under scarcely favourable conditions, because the water which the Institute may dispose of is small in quantity, and the closets serving the upper part of the building are of old construction, and without water-seal. In spite of all this, the whole thing works regularly, and, having been begun as an experiment, might be improved afterwards.

A similar experiment now being carried out in the premises of the Public Health Direction laboratories, under better conditions, works perfectly, the reservoirs having been placed in an entrance court, without giving rise to any trouble.

V.

As I have repeatedly, before now, declared, I am still of opinion that, in those localities where water is greatly deficient, and is not available for flushing the closets, even intermittently, movable reservoirs are to be recommended in preference to any other system, provided they be not made so as to separate the solid from the liquid matters, but to carry *all* the sewage away from the houses. I hold this idea because I believe it to be a very great mistake to send such matters into drains, when the watery vehicle is not present in sufficient quantity to carry them completely to a convenient distance from dwelling-houses.

In the great majority of cases, however, including the populous centres of some importance, where it is possible to use water for intermittent or continuous flushing of the closets (and, still more, where the waste-water of the town must be, in any case, carried far from the dwellings, whilst there are no running streams such as existed in ancient Rome to flush her enormous canals), I am still of opinion that the tubular system which separates sewage from storm-water is preferable. It is preferable for hygienic reasons, because it is only with these small-sized tubes that we can, with certainty, avoid infiltration into the soil of putrid liquids, and the exit of gases into the air. It is preferable for economical reasons, because it costs far less to provide and to maintain in working order, and because it is possible by this method to utilise the useful constituents of the sewage for agricultural purposes, without the encumbrance of that enormous quantity of water which is inevitable with the system of "*tout à l'égout*," an encumbrance which is greatest under the very seasonal conditions which make irrigation less necessary and more difficult to carry out.

With the desire to help in solving the difficulties which still attend the usual method of working the separate tubular system, I venture to recommend the apparatus described above, with the hope that it may be tried experimentally on a large scale with good results.

Les Procédés d'Assainissement des Villes.

PAR

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La question de l'assainissement des villes, depuis les beaux travaux d'Alfred Durand-Claye, a fait d'énormes progrès; tous les hygiènistes reconnaissent aujourd'hui qu'il n'y a qu'un seul moyen complètement efficace de débarrasser les villes de leurs eaux d'égouts et de leurs matières résiduaires.

L'épuration par le sol.—Il serait intéressant de faire connaître l'état général de l'épuration agricole par les eaux-vannes dans les différents pays d'Europe; nous ne voulons pas présenter aujourd'hui ce travail, nous nous contenterons de tirer de l'installation que nous avons faite à Reims, où depuis plusieurs années toutes les eaux sont épurées par le sol, quelques enseignements pratiques qui pourront être utiles aux villes qui cherchent à appliquer chez elles ce système; nous voudrions résumer le "Manuel de l'assainissement des villes à l'usage des maires."

Pour pratiquer l'épuration par le sol, une ville doit se préoccuper des conditions suivantes:—

L'étude de la nature du sol qui doit toujours être perméable.

Le choix des terrains d'épuration.

La distribution de la canalisation intérieure et des collecteurs.

L'établissement de canaux évacuateurs pour rendre à la rivière les eaux épurées.

L'établissement de réservoirs de chasse à la tête des principaux égouts.

L'établissement de cheminées d'appel avec brûloir pour assainir l'air des égouts.

L'établissement de vastes bassins de décharge pour emmagasiner les eaux abondantes d'orages ou de fonte de neige.

Nous allons examiner sommairement chacun de ces points.

Etude de la nature du sol.—C'est une condition indispensable pour rendre possible l'épuration par le sol de trouver un terrain perméable; il est évident qu'un terrain granitique ou composé exclusivement de terre glaise n'est pas apte à se laisser pénétrer par les eaux.

En dehors de ces conditions, tous les terrains, en subissant des modifications que nous étudierons au cours de cette communication, peuvent être utilisés.

Il ne suffit pas que l'eau pénètre, il faut également que l'air aille jusque dans les profondeurs du sol opérer l'oxydation ou la nitrification des matières organiques, de là, la nécessité absolue de pratiquer des irrigations intermittentes.

Quant à l'épaisseur de la couche filtrante, elle variera selon la nature des terrains ; les germes pathogènes étant retenus par les couches les plus superficielles du sol, si l'on veut assurer une épuration complète, il est bon de donner deux mètres d'épaisseur aux terrains à traverser par les eaux. Cette épaisseur est surtout nécessaire lorsque les terrains sont très-divisés, très-peu compactes ; quand ils sont compactes ou formés par un sable fin, cette épaisseur peut être réduite.

A Reims, où les terrains sont très-perméables, nous avons vu quelquefois, même avec une épaisseur filtrante de deux mètres, l'eau sortir sale ; nous en avons recherché la cause ; nous avons pu constater une fois qu'un trou de taupe établissait une communication directe entre la surface irriguée et le canal évacuateur ; il a suffi de boucher cet orifice pour faire cesser immédiatement cette situation anormale. Ces animaux, comme les vers, peuvent avoir une influence utile pour faire pénétrer l'air dans le sol, mais ils peuvent aussi, exceptionnellement, nous le reconnaissons, entraver la marche régulière de l'épuration.

Choix des terrains d'épuration.—Le choix de ces terrains a une importance capitale, car de là dépend tout le succès de l'opération Il faut, tout d'abord, pour les municipalités, ne pas chercher à réaliser sur ce point des économies ; ces terrains doivent être vastes, plus étendus que ne l'indiquent généralement les traités d'hygiène, car, si l'épuration par le sol permet de rendre un grand service à une ville en la débarrassant de ses eaux-vannes, l'opération deviendra pour elle beaucoup moins onéreuse, si l'on peut utiliser les matières azotées pour faire de l'utilisation agricole ; or celle-ci n'est possible que si, à certains moments, on peut complètement cesser l'épandage pour permettre la maturation complète des fruits ou des plantes.

A Reims, la ville et la société possèdent six cents hectares pour utiliser 36,000 mètres cubes d'eau par jour.

Il faut autant que possible que la zone d'irrigation puisse s'étendre, se développer, soit que la ville utilise ses terrains pour son propre compte, soit qu'elle vende de l'eau aux populations riveraines. On choisira de préférence des terrains où les eaux d'égout puissent arriver par simple gravitation au double point de vue du bon fonctionnement du service et du côté économique du projet ; il ne faut pas craindre d'éloigner les champs d'épuration en donnant plus de longueur aux collecteurs pour obtenir ce précieux résultat. A Reims, l'égout transversal supérieur porte 12,000 mètres d'eaux à six kilomètres de la ville, où elles arrivent par simple gravitation à cinq mètres au-dessus du sol, de façon à permettre des irrigations méthodiques sans le secours de machines élévatoires. Les 24,000 mètres cubes d'eau de l'égout transversal inférieur doivent au contraire être relevés par des machines à vapeur, à cause d'une mauvaise disposition de l'ancien réseau d'égout.

Il ne faut pas toutefois s'arrêter devant la dépense de la surélévation des eaux ; la condition principale est de s'assurer une quantité snffisante de terres où les cultures les plus productives pour la région puissent être employées. Près des villes, la culture maraichère, qui utilise une grande quantité d'eau, devra être choisie de préférence ; si l'on n'a pas de débouché direct pour les légumes, la culture des betteraves donnera d'excellents résultats.

L'année dernière, à Reims, 250 hectares étaient plantés de betteraves; la qualité en sucre n'a rien laissé à désirer; il faut toutefois cesser l'irrigation pendant plusieurs semaines avant la récolte. Il est donc absolument indispensable de posséder des terrains supplémentaires pour épurer les eaux pendant cette période de la maturation des plantes ou des fruits.

Les céréales, qui réclament beaucoup moins d'eau, ne seront employées que lorsque l'on aura des terrains très-vastes et très-secs.

Les prairies artificielles rendront de grands services là où l'herbe pourra être consommée sur place à l'état vert. A Reims, la société fermière s'est arrêtée à la culture de la betterave; elle va établir comme annexe une distillerie; l'utilisation agricole peut donc avantageusement être complétée par une exploitation industrielle bien entendue.

On voit, par ces considérations combien il est important pour les villes, dont l'existence est indéfinie, de choisir tout d'abord les terrains les plus favorables pour l'épuration, puisque c'est le moyen de tirer parti de tous les produits et de diminuer la dépense annuelle d'un des services les plus indispensables pour placer une cité dans les meilleures conditions hygièniques.

La cessation des irrigations au moment de la maturité des fruits ou des plantes a un double avantage: elle donne beaucoup plus de qualité au produit et elle assure une innocuité complète, soit aux fruits soit aux légumes; si ceux-ci avaient été salis par l'eau, l'air et le soleil détruiraient bien vite tous les germes pathogènes.

Nous ne saurions donc trop recommander à nos collègues municipaux de ne pas craindre de faire les plus grands sacrifices pour s'assurer, dans la conception des projets, la plus grande étendue de terrains propres à l'irrigation. Ce qui a été fait à Reims peut servir de précédent, 'état nous ayant autorisés à recourir à l'expropriation publique pour nous assurer, non seulement le passage des collecteurs, mais aussi les terrains d'irrigation. Ce fait est important, car si l'expropriation pour la construction d'un canal ou d'un chemin de fer est limitée par la largeur de la voie, pour les terrains d'épuration, l'étendue ne pouvait être fixée d'une façon précise; la quantité à fixer étant un peu arbitraire, on pouvait se demander si l'etat consentirait à laisser, entre les mains des communes, une arme aussi terrible que l'expropriation publique. L'état a autorisé, il a bien fait; au nom de l'hygiène, nous ne pouvons que l'encourager à persister dans cette voie, l'intérêt général devant toujours passer avant les intérêts particuliers.

Distribution de la canalisation intérieure et des collecteurs.— L'organisation de la canalisation intérieure des villes et la direction des collecteurs, sont une conséquence forcée du choix des terrains d'épuration; deux principes s'imposent: donner aux égouts une pente suffisante pour aller du point de départ au point d'arrivée des eaux, et surtout ne pas gaspiller la pente à l'origine, en vue d'amener les eaux sur les champs d'épuration à une hauteur suffisante pour éviter, si cela est possible, l'emploi de machines élevatoires.

Ce qui s'est passé dans notre ville peut être utile à connaître pour les municipalités qui veulent installer un service d'épuration. Il y a vingt ans, tous les égouts étaient dirigés vers la rivière et s'y déversaient directement ; quand on a voulu supprimer cette pollution de la ville, qui était transformée en un veritable égout, il a fallu construire un collecteur le long de la rivière. Cet égout a deux inconvenients très serieux ; il a une pente insuffisante qui rend le cours des eaux trop lent, et les eaux qu'il charrie arrivant au champ d'épuration à un ou deux mètres au-dessous du niveau du sol, elles ont besoin d'être relevées à l'aide de machines.

Un de nos regrettés confrères, M. le Dr. Brébant, a eu l'idée qui, lorsqu'il l'a émise, a été combattue par tous les ingénieurs, de couper la ville en diagonale par un vaste collecteur. Les eaux du haut de la ville, au lieu de se diriger selon la déclivité naturelle du sol, semblaient remonter pour couper perpendiculairement trois ou quatre petits vallons et arriver en dernière analyse à un vallon plus profond, où, par simple déclivité, elles se trouvent à cinq mètres au-dessus des terrains à irriguer.

Ce collecteur, qui mesure plus de huit kilomètres, a partout une pente suffisante ; grâce à ce travail, l'épuration de 12,000 mètres cubes va se faire à perpétuité dans des conditions faciles et économiques.

Il faut donc laisser de côté tous les anciens systémes et ne se préoccuper que de relier le point de départ ou point d'arrivée par la canalisation la plus directe, avec une pente régulière et suffisante. Une fois la direction du collecteur général arrêtée, les canalisations secondaires viendront s'y rattacher en utilisant, autant que possible, les égouts existants.

Établissement de canaux évacuateurs et suppression de chutes d'eau.—L'établissement de ces canaux joue une rôle excessivement importante dans le fonctionnement de l'irrigation ; il ne s'agit pas seulement d'installer des tuyaux de drainage pour rendre le sol plus facilement et plus rapidement perméable à l'eau et à l'air ; ces canaux évacuateurs permettent à l'ingénieur de changer la hauteur de la nappe souterraine, de transformer la nature du sol et de rendre ainsi irrigables des terrains qui primitivement ne l'étaient pas.

Nous avons cherché à faire ressortir combien il est important de ne pas perdre de pente dans la construction des égouts, afin irriguer la plus grande surface possible de terrains par simple gravitation, sans recourir à l'usage de machines élévatoires ; l'établissement, sur de longues distances, de vastes canaux d'assainissement, a permis à Reims de transformer des près-marais d'une valeur insignifiante, puisqu'ils ne produisaient qu'une herbe ne pouvant même pas servir de litière, en terres de rapport où toutes les cultures réussissent. Sur ces vastes surfacets, où le peu d'épaisseur de la couche filtrante rendait l'épandage des eaux impossible, la nappe a pu être ainsi abaissée de 1 mètre a 1 mètre 50.

Les beaux résultats que la Compagnie des Eaux-Vannes a obtenus par cette transformation lui ont valu du Ministère de l'Agriculture un encouragement de 100,000 francs.

Un autre moyen très-efficace a été mis en œuvre pour obtenir ce résultat : c'est le rachat de chutes d'eau sur la rivière, chutes qui étaient utilisées pour faire mouvoir des moulins.

Il faut donc retenir que par l'établissement de canaux évacuateurs prolongés à de longes distances, et par la suppression de chutes d'eau sur la rivière, l'ingénieur peut à volonté transformer des près-marais impropres à toute culture, impropres à l'irrigation, en terres irrigables et par conséquent productives.

Au double point de vue de l'économie de l'entreprise et de l'installation des champs d'épuration qui doivent être recherchés autant que possible sur les points bas pour éviter la sur élévation des eaux, ces transformations pourront rendre aux municipalités les plus précieux services, et, dans biens des cas, faciliter des travaux d'assainissement qui, sans cela, eussent été impossibles.

Établissement de réservoirs de chasse.—Pour assurer le nettoyage des égouts, il est important de placer, à la tête des collecteurs les plus considérables, des réservoirs de chasse ; cette opération eût été très-difficile à Reims, s'il nous avait fallu recourir, pour ces chasses, à l'eau de source nécessairement restreinte qui alimente la cité ; nous avons heureusement la possibilité d'emprunter au canal de navigation un volume d'eau considérable, qui nous permettra de faire, deux fois par semaine, des chasses puissantes. Cette installation reste à faire dans notre système d'assainissement.

Établissement de cheminées d'appel avec brûloir.—S'il est important de laver les égouts avec de puissantes chasses d'eau, il est bien nécessaire aussi, pour éviter les mauvaises odeurs qui se produisent en été et particulièrement par les temps d'orage, quand la pression atmosphérique baisse brusquement, d'assainir l'air des égouts ; cela est aussi indispensable pour permettre aux égoutiers de faire leur service sans danger.

Nous croyons donc qu'il y a lieu d'établir, dans les points hauts des égouts, des cheminées d'appel d'une aire suffisante et surtout assez élevées pour amener un puissant tirage avec des brûloirs à coke.

Nous avons à Reims une seule de ces cheminées, adossée à un établissement municipal ; le brûloir est constitué par un vaste foyer alimenté avec du coke ; ce combustible est beaucoup plus commode que la houille ou le bois, car il ne produit pas de fumée ; le feu s'entretient facilement et sans grande dépense. Nous songeons sur d'autres points à utiliser les hautes cheminées d'établissements industriels. Les mauvaises odeurs se produisant surtout le soir, alors que cesse l'écoulement des eaux industrielles, écoulement considérable dans notre ville, puisque, sur 36,000 mètres cubes entrés par jour, celles-ci en représentent à peu près 30,000 mètres ; il serait facile de se servir de ces cheminées pendant deux ou trois heures, une fois le travail des ateliers terminé. Nous étudions ces différentes installations.

La ville de Paris qui souvent, dans les quartiers hauts, est infectée, surtout le soir et la nuit, par des odeurs si désagréables, pourrait avec beaucoup d'avantage recourir à ce moyen simple et peu coûteux ; il a en outre un autre avantage, celui de détruire des germes pathogènes avant leur sortie de l'égout.

Établissement de bassins de décharge.—Quels que soient le soin que l'on ait pris et l'importance que l'on ait donnée aux égouts, il est des cas où ils peuvent devenir insuffisants. Lors des pluies d'orages ou lors des fontes de neige, les eaux, arrivant subitement en grande abondance, peuvent déterminer des pressions dangereuses sur les parois des égouts, ou elles peuvent être rejetées directement dans le fleuve ou dans la rivière sans avoir subi d'épuration.

C'est pour remédier à ces graves inconvénients que nous avons installé, en dehors de la ville et le long de chacun de nos collecteurs, de vastes bassins de deux à trois hectares, creusés simplement dans la terre et plantés de peupliers ; en temps ordinaire, ils sont couverts d'herbes ; lors des pluies d'orages, ils s'emplissent, recueillent toutes les eaux qui ne trouvent pas un écoulement facile dans les collecteurs et s'infiltrent dans le sol où, à la faveur des plantations, la transformation s'accomplit sans aucun danger d'infection pour la nappe souterraine.

Il nous a semblé utile de résumer brièvement les conditions essentielles à une bonne épuration des eaux d'égout par le sol ; ce problème prend une importance beaucoup plus considérable depuis que le "*tout à l'égout*" s'impose, pour ainsi dire, à toutes nos villes modernes. La défectuosité de l'ancien réseau d'égouts de notre ville ne nous a pas encore permis de généraliser ce procédé si simple de l'assainissement des villes. Quand on peut créer de toute pièce un système d'assainissement, le problème est relativement facile ; mais quand, dans les vieilles villes, on se trouve en présence de travaux faits depuis de longues années, sans plan d'ensemble, sans esprit de suite, le travail de réparation est souvent bien difficile.

Depuis vingt-cinq années, nous n'avons cessé d'étudier cette question comme hygièniste et comme administrateur, nous serions heureux, si ces quelques conseils pratiques pouvaient être utiles à quelques-uns de nos collègues.

The Wolverhampton Sewerage Works.

BY

R. E. W. Berrington.

It is believed that the Wolverhampton Sewerage Works are the most complete of their kind in this country, and hence a short description of them may not be out of place.

Wolverhampton has a population of about 83,000, and the town forms an important centre of the South Staffordshire Iron Industry. It is essentially the home of the galvanized iron trade, and owing to this fact, coupled with its peculiar inland situation, the town occupies a unique and unparalleled position. It was one of the earliest of the large towns to take up the question of sewage disposal, and it attempted to efficiently deal with its sewage by means of broad irrigation, but this soon showed itself to be an impossibility. Whatever may be done by a sufficient area of suitable soil with an ordinary domestic sewage, it was apparent that for a large manufacturing town like Wolverhampton the removal of certain solid and other constituents from the sewage was a *sine quâ non*.

From the first, Wolverhampton had two difficulties to contend with :—

1. The peculiar nature of the sewage which—after treatment by the manufacturers—contained a good deal of iron and other matters.
2. The smallness of the brook into which the effluent had to be poured: the natural flow of this brook being considerably less than the effluent itself.

Iron in small quantities is said to be beneficial to land, but the application of raw sewage containing variable quantities of iron was found to be destructive to all vegetable life. Besides this, the iron in solution always produced a suspicious-looking effluent.

The Corporation determined to grapple with their difficulties, and they have successfully done so by carrying out the following works :—

a. A complete system of rainwater drains with outlets into the natural brook-courses.

b. Precipitation works capable of being worked on the continuous or quiescent system.

c. Sludge-pressing plant.

d. Preparation of land for the final treatment of the effluent.

By the adoption of the "separate" system the following advantages were secured :—

1. Reduction by millions of gallons in the sewage to be dealt with at the outfall, saving—in chemicals and manipulation alone—a considerable sum.
2. A tolerably uniform flow rendering treatment easy and practicable.
3. Prevention of crude sewage being washed into the brook, and the dispensing with storm overflows.
4. Prevention of sewer gases being forced—by the water pouring into sewers in enormous quantities—through the traps into the houses.
5. Prevention of stoppages in main sewers from leaves, road detritus, &c.
6. The sewers proper are now large enough for many years to come, and will permit of a water-carriage system for the whole town.

The precipitation tanks cover an area of 5,000 square yards, and are connected with a large carrier contouring the farm. There is a large liming house, engine and boiler houses, sludge reservoir, and complete sludge-pressing plant.

In consequence of the very high-class effluent insisted upon, it is necessary to keep the works in operation the 24 hours through, and for this purpose there is an installation of the electric light.

Evidence has recently been given by experts before a committee of the House of Commons showing that Wolverhampton has difficulties in dealing with its sewage peculiar to no other town in England; and that the Corporation have successfully coped with those difficulties says something for their energy and determination in solving one of the greatest problems of the present day.

Die Kanalisation der Stadt Berlin.

VON

Stadtrath MARGGRAFF, Berlin.

Die Entwässerung Berlins erfolgt durch die Kanalisation, welche über das gesammte Stadtgebiet ausgedehnt und in 12 Abschnitte, Radial-Systeme genannt, eingetheilt ist, von denen sich zur Zeit 7 in vollständigem und 2 in theilweisem Betriebe befinden, während 2 weitere Radial-Systeme noch im Bau begriffen sind und ein zwölftes erst in Angriff genommen werden soll, wenn die Bebauung in den dasselbe umfassenden Stadttheilen weiter vorgeschritten sein wird.

Es beträgt unter Zugrundelegung der Ergebnisse aus der Volkszählung vom 1. December 1890 in den einzelnen Radial-Systemen :—

——	I.	II.	III.	IV.	V.	VI.
Der Flächeninhalt in Quadratmetern.	2,727,720	3,492,350	3,897,200	8,616,670	8,078,020	3,691,100
Die Zahl der Einwohner -	177,838	169,483	100,623	341,311	317,493	139,816

——	VII.	VIII.	IX.	X.	XI.	XII.
Der Flächeninhalt in Quadratmetern.	3,077,300	5,596,500	5,178,900	4,607,800	4,185,200	2,900,000
Die Zahl der Einwohner -	87,028	99,918	30,753	93,487	328	17,271

Für jedes der im Betriebe befindlichen Radial-Systeme ist eine Pumpstation vorhanden, nach welcher die Abwässer der im Bereiche des Systems belegenen Grundstücke vermittelst gemauerter Kanäle und Thonrohrleitungen, welche mit Gefäll im Strassenkörper verlegt sind, geleitet werden. Die gemauerten Kanäle sind theils in Eiprofil von 0·9 m. bis 2 m. Höhe und einer Weite von zwei Dritteln der Höhe, theils in 2 m. hohem Tunnelprofil bei einer Weite von 1·5 m. bis 3·1 m. hergestellt; die Thonrohrleitungen haben einen Durchmesser von 0·21 m. bis 0·63 m. Von den Pumpstationen aus, wo die Abwässer in einen Sammelbrunnen gelangen, werden dieselben mittels eines Saugrohrs in die Maschinen aufgenommen und von diesen nach den Rieselfeldern durch gusseiserne, 0·75 m. und 1 m. weite Röhren gedrückt.

Die Länge der am 1. April 1890 in den einzelnen Radial-Systemen vorhanden gewesenen Kanäle, Thonröhren und Druckrohre ergiebt sich aus folgender Zusammenstellung, wobei zu bemerken ist, dass die

Radial-Systeme VIII. und X. erst zum Theil funktioniren, IX. und XII. noch im Bau begriffen sind und XI. überhaupt noch nicht in Aussicht genommen ist.

Es waren vorhanden in den Radial-Systemen :—

Länge in Metern.	I.	II.	III.	IV.	V.	VI.
Gemauerte Kanäle - -	9,958	14,223	10,026	24,220	22,697	9,941
Thonröhren - - -	36,785	54,753	81,091	103,417	80,532	41,185
Eiserne Druckrohre - -	15,142	12,506	21,534	14,301	7,988	1,218

Länge in Metern.	VII.	VIII.	IX.	X.	XII.
Gemauerte Kanäle - -	11,568	9,733	4,903	5,212	3,877
Thonröhren - - -	26,588	16,852	6,957	10,213	3,119
Eiserne Druckrohre - -	20,302	14,069	—	9,110	—

Bei den in vollständigem Betriebe befindlichen Radial-Systemen I. bis VII. betrugen die Kosten, in Mark ausgedrückt, für :—

——	I.	II.	III.	IV.	V.	VI.	VII.
Kanäle und Thonrohrleitungen.	2,241,267	3,212,939	3,655,036	5,496,471	4,291,576	1,697,785	2,087,689
Druckrohr - -	1,973,749 gemeinschaftlich		1,094,587	1,788,257	957,943	2,297,250 gemeinschaftlich	

und speciell für Material und Verlegung der eisernen Druckrohre, pro laufendes Meter berechnet, bei 0·75 m. weitem Rohr im Radial-System I. = 102 M., im Radial-System III. = 87 M., in den Radial-Systemen VI. und VII. = 96 M. ; bei 1 m. weitem Rohr aber im Radial-System I. = 129·5 M., im Radial-System IV. = 125 M., im Radial-System V. = 116 M. und in den Radial-Systemen VI. und VII. = 100 M.

Die Flächenausdehnung der im Betriebe befindlichen 9 Radial-Systeme betrug am 1. April 1891 rund 4,486 ha., der Flächeninhalt der in denselben belegenen Strassen rund 1,121 ha., die Längenausdehnung der letzteren 430 Kilometer. Die Strassenentwässerungsleitungen dieser 9 Radial-Systeme hatten eine Gesammtlänge von rund 586 km.

Am 1. April 1891 waren 20,307 Grundstücke an die Kanalisation angeschlossen, und zwar :

1,677	Grundstücke	im	Radial-System	I.
2,912	„	„	„	II.
3,093	„	„	„	III.
4,820	„	„	„	IV.
3,855	„	„	„	V.
1,544	„	„	„	VI.
1,693	„	„	„	VII.
220	„	„	„	VIII.
493	„	„	„	X.

und wurden aus denselben während des Jahres 1. April 1890–91 an Kloset-, Wirthschafts- und Regenwasser den Rieselfeldern durch Vermittelung der Pumpstationen insgesammt 52,483,102 Cubikmeter zugeführt, welche sich auf die einzelnen Radial-Systeme, wie folgt, vertheilen :—

Aus Radial-System.	Im Ganzen. cbm.	Durchschnittlich täglich. cbm.	Pro Kopf der Bevölkerung täglich. cbm.
I.	5,049,322	13,834	0·085
II.	8,839,134	24,217	0·141
III.	7,515,625	20,591	0·192
IV.	10,461,159	28,661	0·092
V.	10,265,787	28,125	0·091
VI.	5,332,011	14,608	0·130
VII.	3,396,234	9,305	0·097
VIII.	388,471	1,832	0·137
X.	1,235,449	3,688	0·179

wobei zu berücksichtigen ist, dass das Radial-System VIII. erst vom 1. September 1890, das Radial-System X. erst vom 1. Mai 1890 ab, und zwar jedes derselben auch nur zum Theil, in Betrieb gesetzt ist.

Die Rieselfelder selbst bestehen, soweit sie den im vollständigen Betriebe befindlichen Radial-Systemen dienstbar gemacht sind, aus 4 grösseren Gütercomplexen, welche ein Gesammt-Areal von 4,458 ha. umfassen, von denen 3,214 ha. aus Ackerland (Beeten, Wiesen, Bassins), Baumschulen, sowie Weiden- und Erlen-Anlagen bestehend, vollständig aptirt und drainirt sind, während die nicht aptirten, 1,244 ha. umfassenden Complexe in der Hauptsache aus Hofstellen, Gehölz, Fennen, Wasserstücken, Gräben, Wegen, Unland, aber auch aus Deputatland, Gärten, natürlichen Wiesen und Aeckern bestehen.

Die Rieselfelder sind durch Planirung, Aptirung und Drainirung zur Aufnahme der Abwässer aus der Kanalisation besonders hergerichtet worden. Die aus porösem Thon hergestellten Drainröhren liegen 1 bis 2 m. tief unter der Erdoberfläche und münden in Abzugsgräben, welchen sie die durch den Erdboden filtrirte und gereinigte Spüljauche als ziemlich klares Wasser zuführen, das auf seinem weiteren Wege in die öffentlichen Flussläufe gelangt, soweit es nicht verdunstet.

Die Drainwässer, d. h. die nach der Filtration durch das Erdreich vermittelst der thönernen Drainröhren in die Entwässerungsgräben geleitete Sewage, werden unausgesetzt einer regelmässig wiederkehrenden und eingehenden Untersuchung in Bezug auf ihre Beschaffenheit unterzogen. Die Resultate dieser Untersuchungen während des letzten Jahres sind aus den beifolgenden Tabellen ersichtlich :—

100,000 Theile enthalten	Osdorf und Grossbeeren.						Osdorf und		
	Drainwasser von Beetanlagen.						Spüljauchen.		
	Nr. 59. Beet 3 in Osdorf. 1.5.90.	Nr. 60. Beet 161 in Grossbeeren. 2.6.90.	Nr. 79. Beet 3 in Osdorf. 10.9.90.	Nr. 80. Beet 284 in Osdorf. 10.9.90.	Nr. 87. Beet 198 in Osdorf. 15.11.90.	Nr. 94. Beet 2 in Osdorf. 1.2.91.	Nr. 70. Grossbeeren. 15.7.90.	Nr. 93. Aus Schieber 15 in Osdorf. 1.12.90.	Nr. 95. Aus Schieber 11 in Grossbeeren. 1.12.90.
Trockenrückstand	126·24	110·24	115·68	111·44	220·40	88·48	93·44	164·88	133·68
Glühverlust desselben.	21·22	25·36	14·00	15·52	37·60	9·68	22·00	43·76	39·52
Glührückstand	105·12	84·88	101·68	95·92	182·80	78·80	71·44	121·12	94·16
Uebermangans. Kali erford.	2·56	5·88	4·04	3·00	6·10	9·42	30·65	61·90	53·09
Ammoniak Organ. gebund. Ammoniak.	1·28 0·09 } 1·37	1·28 0·09 } 1·37	0·96 0·08 } 1·04	0·32 0·06 } 0·38	0·03 0·11 } 0·14	1·28 0·08 } 1·36	8·81	23·61	17·39
Salpetrige Säure	2·22	1·62	0·98	0·70	0·87	0	0	0	0
Salpetersäure	14·33	5·82	10·81	6·99	57·20	0	0	0	0
Schwefelsäure	—	6·70	—	—	—	—	2·417	8·71	5·01
Phosphorsäure	0·192	0·216	0·16	0·225	0·40	0·34	3·224	3·964	3·248
Chlor	28·16	22·88	30·83	24·57	44·18	24·03	24·52	50·67	37·02
Kali	—	4·43	—	—	—	—	4·46	9·94	6·24
Natron	—	23·70	—	—	—	—	21·27	43·65	28·25
Keime in 1 Cubikcentim.	198,000	12,800	58,080	68,400	146,080	696,000	—	—	—

Grossbeeren.				Osdorf und Grossbeeren.			
Grabenwasser.		Drainwasser von Bassins.		Drainwasser von Wiesen.			100,000 Theile enthalten
Nr. 67. Lilowgraben in Osdorf. 8.7.90.	Nr. 82. Hauptentwässerungsgraben in Grossberen. 15.9.90.	Nr. 61. Bassin XII. in Osdorf. 2.6.90.	Nr. 107. Bassin XII. in Osdorf. 2.2.91.	Nr. 65. Wiese 283 in Osdorf. 1.7.90.	Nr. 66. Wiese 164 in Grossbeeren. 1.7.90.	Nr. 83. Wiese 187 in Osdorf. 15.9.90.	
117·92	88·24	109·76	86·28	126·64	69·60	129·30	Trockenrückstand.
16·72	9·76	27·68	12·08	10·40	10·32	9·12	Glühverlust desselben.
101·20	78·48	82·08	74·20	116·24	59·28	120·24	Glührückstand.
3·70	2·69	16·48	7·51	3·25	4·27	2·62	Uebermangans. Kali erford.
0·64 } 0·72	0·24 } 0·28	1·76 } 1·84	1·76 } 1·90	0·04 } 0·03	0·14 } 0·20	0·03 } 0·03	Ammoniak.
0·08 }	0·04 }	0·08 }	0·14 }	0·02 }	0·06 }	Spur }	Organ. gebund. Ammoniak.
0·67	0·34	0	0·74	0	6·48	0	Salpetrige Säure.
9·38	7·95	Spur	0·41	3·78	8·64	13·80	Salpetersäure.
10·41	—	—	7·80	0·256	0·304	0·13	Schwefelsäure.
0·275	0·208	0	0·26	31·25	17·84	33·09	Phosphorsäure.
27·73	18·02	29·74	26·15	—	—	—	Chlor.
2·87	—	—	3·86	—	—	—	Kali.
24·13	—	—	22·35	—	—	—	Natron.
17,600	22,400	23	120,000	16,800	—	3,880	Keime in 1 Cubikcentim.

100,000 Theile enthalten	Falkenberg und Bürknersfelde.						Falkenberg und Bürknersfelde.					
	Nr. 71.	Nr. 91.	Drainwasser von Beetanlagen.			Nr. 81.	Nr. 57.	Nr. 73.	Nr. 74.	Nr. 100.	Nr. 101.	Nr. 102.
	Spüljauche aus Schieber 33 in Falkenberg.	Spüljauche aus Schieber 41 in Falkenberg.	Nr. 77. Beetanlage 444 in Bürknersfelde.	Nr. 92. Beetanlage 121 in Falkenberg.	Nr. 109. Beetanlage 126 in Falkenberg.	Drainwasser von Wiese 12 in Falkenberg.	Graben bei Schlag 39 in Bürknersfelde.	Wasser aus dem nördlichen und südlichen Sielgraben.	Hohenschönhausener Grenzgraben bei Schlag 468.	Nördlicher und südlicher Sielgraben.	Wuhle oberhalb des Sielgrabens.	Wuhle an der Neuahrensfelder Chausseebrücke.
	15.7.90.	1.12.90.	29.7.90.	2.12.90.	16.2.91.	15.9.90.	15.4.90.	21.7.90.	21.7.20.	15.1.91.	15.1.91.	15.1.91.
Trockenrückstand	134·64	135·84	148·64	124·16	119·04	117·68	141·44	107·76	96·48	93·76	31·60	107·68
Glühverlust desselben.	60·24	55·84	17·44	43·76	12·72	10·80	14·16	12·48	11·76	10·80	4·48	11·52
Glührückstand	74·40	80·00	131·20	110·40	106·32	106·88	127·28	95·28	84·72	82·96	27·12	96·12
Uebermangans. K erford.	45·50	60·67	2·78	2·40	2·37	3·03	2·81	5·85	5·88	4·55	1·15	2·97
Ammoniak }	11·50	18·68	0·12 } 0·18	0·10 } 0·14	0·11 } 0·16	0·16 } 0·21	0·12 } 0·17	0·56 } 0·70	1·60 } 1·74	0·72 } 0·83	0·03 } 0·04	0·72 } 0·80
Organ. gebund. Ammoniak. }			0·06	0·04	0·05	0·05	0·05	0·14	0·14	0·11	0·01	0·08
Salpetrige Säure	0	0	0·25	0	0·29	0	0·42	1·44	0·61	0·55	0	0·42
Salpetersäure	0	0	21·77	13·87	15·29	14·60	19·41	1·45	2·82	4·91	0	6·87
Schwefelsäure	3·876	3·616	Spur	0·40	0·13	0·11	0·08	Spur	Spur	0·208	Spur	0·18
Phosphorsäure	3·76	4·41	—	—	—	—	10·93	—	—	—	—	—
Chlor	18·69	32·71	21·75	24·12	22·70	24·70	23·00	22·76	22·03	19·90	20	23·97
Kali	6·71	9·47	—	—	—	—	2·89	—	—	—	—	—
Natron	22·35	30·23	—	—	—	—	21·75	—	—	—	—	—
Keime in 1 Cubikcentim.	—	—	2,200	14,080	16,200	1,800	1,040	51,000	52,800	114,200	7,120	4,860

100,000 Theile enthalten	Malchow, Blankenburg und Wartenberg.						Malchow, Blankenburg und Wartenberg.			
	Spüljauche.		Drainwasser von Beetanlagen.				Wasser aus dem Fliessgraben.			Nr. 85.
	Nr. 72. Aus Schieber Nr. 1 in Malchow. 15.7.90.	Nr. 89. Aus Schieber Nr. 1 in Malchow. 1.12.90.	Nr. 58. Beetanlage 108 in Wartenberg. 15.4.90.	Nr. 63. Beetanlage 162 in Blankenburg. 16.6.90.	Nr. 90. Beetanlage 88 in Malchow. 2.12.90.	Nr. 112. Beetanlage 22 in Malchow. 17.3.91.	Nr. 64. Bei Anlagen 141–143. 16.6.90.	Nr. 98. Oberhalb Blankenburg. 15.12.90.	Nr. 99. Vor der Mündung in die Panke. 15.12.90.	Drainwasser von Wiese 25 in Malchow. 17.9.20.
Trockenrückstand	132·40	91·44	105·12	128·40	120·90	93·36	98·81	53·52	69·12	95·68
Glühverlust desselben	30·96	26·40	12·80	18·72	11·20	11·52	13·44	5·84	10·48	8·88
Glührückstand	101·44	65·04	92·32	109·68	109·76	81·84	85·36	47·68	58·64	86·80
Uebermangans. Kali erford.	43·29	39·85	2·12	4·55	2·50	2·69	5·34	2·59	3·07	3·16
Ammoniak }	9·53	12·48	0·16 } 0·22	1·44 } 1·60	0·03 } 0·06	0·06 } 0·09	0·12 } 0·18	0·32 } 0·37	0·32 } 0·36	0·48 } 0·55
Organ. gebund. Ammoniak }			0·06	0·16	0·03	0·03	0·06	0·05	0·04	0·07
Salpetrige Säure	0	0	0·38	0·99	0	Minimale Spur.	0·57	0·29	0·36	0·44
Salpetersäure	0	0	8·58	6·25	9·57	17·13	4·59	2·10	2·84	4·34
Phosphorsäure	2·12	3·775	0·128	Spur	Spur	0·24	0·176	0·13	0·16	0·15
Schwefelsäure	18·56	4·404	8·27	—	—	—	—	—	—	11·43
Chlor	24·40	21·06	19·05	23·84	24·14	16·75	19·66	7·71	11·17	27·07
Kali	6·08	6·12	1·34	—	—	—	—	—	—	2·32
Natron	23·06	20·69	15·66	—	—	—	—	—	—	23·70
Keime in 1 Cubikcentim.	—	—	1,040	870	2,850	34,200	2,450	36,400	16,820	702

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Die in früheren Jahren verbreitete, irrthümliche Ansicht, dass die Drainwässer auf die öffentlichen Flussläufe, welchen sie zugeführt werden, insofern einen nachtheiligen Einfluss auszuüben geeignet seien, als denselben eine Verminderung bezw. Erkrankung und ein Absterben der Fische zugeschrieben wurde, ist augenfälliger Weise dadurch widerlegt worden, dass auf einzelnen Rieselgütern Fischteiche angelegt wurden, deren Wasserversorgung lediglich durch Drainwasser erfolgte. In diesen Teichen wurden demnächst Bachforellen, Zander, Regenbogenforellen und Karpfen gezüchtet, welche ebenso wie deren Brut vorzüglich gediehen sind und sich in staunenswerther Weise vermehrt haben.

Aus unserem letzten, das Jahr 1. April 1889–90 umfassenden Verwaltungsberichte ist zu ersehen, dass auf den Aeckern der vorgedachten 4 Gütercomplexe gewonnen wurden :—an Oelfrüchten : Winterraps, Sommerraps, Winterrübsen, Senf, Kümmel ; an Halmfrüchten : Winter- und Sommer-Weizen, Winter- und Sommer-Roggen, Gerste, Hafer ; an Hackfrüchten : Runkelrüben, Möhren, Kohl, ferner Hanf ; und dass von unseren Gutsverwaltungen 2,749 ha. selbst bewirthschaftet wurden, während 900 ha. verpachtet waren und 809 ha. theils als vorübergehend, theils als dauernd ertraglose Liegenschaften wie auch als Deputatland keine Einnahmen brachten.

Auch an eine grössere Anzahl von Privatbesitzern, deren Grundstücke den Rieselfeldern benachbart liegen, wird durch besondere Anschlussleitungen, welche jene Besitzer auf eigene Kosten den diesseitigen Kanalisationsleitungen haben anschliessen lassen, zur Berieselung ihrer Ländereien Sewage aus den diesseitigen Leitungen gegen Entgelt abgegeben. Die in dieser Beziehung an unsere Verwaltung gestellten Anträge auf Abgabe von Rieselwasser sind indess schon so zahlreich geworden, dass wir, um nicht eventuell selbst an Wassermangel auf unseren Rieselfeldern leiden zu müssen, denselben in weiterem Umfange, als bisher geschehen, nicht mehr zu entsprechen beabsichtigen.

Die Rieselwiesen, welche eine Gesammtfläche von 766 ha. ausmachen, liefern jährlich einen fünf- bis sechsfachen Schnitt. Das gewonnene Gras und Heu ist sehr begehrt und trotz der reichen Ernte nicht in ausreichender Menge vorhanden, um allen Nachfragen entsprechen zu können.

Ueberhaupt werden die Erzeugnisse unserer Rieselfelder mit Vorliebe gekauft ; insbesondere decken die Bewohner der benachbarten Ortschaften ihren Bedarf an Viehfutter, wie Gras, Heu, Runkelrüben, Möhren u. s. w. fast ausschliesslich aus den Producten der Rieselgüter, da sie mit Rücksicht auf die Nähe der letzteren und deren reiche Erträge zum grossen Theil die Bestellung ihrer eigenen Ländereien mit Futterpflanzen eingestellt haben.

Ausser den erwähnten 4 Gütercomplexen besitzt die Stadtgemeinde Berlin noch mehrere zu Rieselzwecken bestimmte Güter, die aber erst zu einem kleinen Theil dem Rieselbetriebe dienen, zu einem weiteren Theile in der Aptirung und Drainirung begriffen sind und mit dem Rest nach den gemeinhin üblichen landwirthschaftlichen Grundsätzen bewirthschaftet werden. Dieser Grundbesitz umfasst ein Areal von rund

3,519 ha., so dass die gesammten, theils bereits als Rieselfelder eingerichteten, theils zu solchen bestimmten Ländereien eine Gesammtfläche von 7,978 ha. umfassen.

Die Wege und Alleen auf den Rieselfeldern sind mit Obstbäumen aller Art, welche in unserem Klima gedeihen, bepflanzt und ergeben reiche Ernte. Das gewonnene Obst ist sehr begehrt und liefert hohe Erträge. Die Zahl dieser Obstbäume beträgt rund 72,000. Ausserdem befinden sich noch in den auf den Rieselgütern angelegten Baumschulen etwa 150,000 Stück ein- und mehrjähriger Obstbäume. In den verschiedensten Gartenbau-Ausstellungen, welche mit den Erzeugnissen aus den Baumschulen und gärtnerischen Anlagen der Rieselgüter beschickt wurden, sind diesen Erzeugnissen erste und zweite Preise zuerkannt worden.

Von den 4 im vollständigen Rieselbetriebe befindlichen Gütercomplexen kosten einschliesslich der Ankaufspreise für den Grunderwerb, der Aptirung, Planirung und Drainirung:—

1. die Güter Osdorf, Friederikenhof und Heinersdorf rund 4,280,000 M., welche im Jahre 1890–91 einen Ueberschuss von rund 17,500 M. oder eine Verzinsung von 0·049 %;
2. die Güter Gross- und Kleinbeeren, Schenkendorf und Sputendorf rund 2,400,000 M., welche in demselben Jahre einen Ueberschuss von rund 61,500 M. oder eine Verzinsung von 2·56 %;
3. die Güter Falkenberg und Bürknersfelde mit den Hohen-Schönhausener und Marzahner Ländereien rund 3,700,000 M., welche in demselben Jahre einen Ueberschuss von rund 121,800 M. oder eine Verzinsung von 3·29 %;
4. die Güter Malchow, Wartenberg und Blankenburg rund 5,805,000 M., welche in demselben Jahre einen Ueberschuss von rund 134,800 M. oder eine Verzinsung von 2·32 % erzielt haben.

Der Gesundheitszustand der Bevölkerung auf den Rieselgütern ist ein durchaus befriedigender. Die Zahl der Erkrankungen ist verhältnissmässig keine grössere als in den Städten oder auf dem Lande. Jeder einzelne Krankheitsfall wird mittels einer besonderen, von den auf den Rieselgütern angestellten Aerzten ausgestellten Zählkarte durch den bekannten Geheimen Medicinal-Rath, Professor Dr. Virchow, kontrollirt. Es ist nach diesen Untersuchungen festgestellt, dass die vorgekommenen Erkrankungen mit dem Rieselbetrieb in keinerlei Zusammenhang stehen und auch nicht durch denselben hervorgerufen sind. Seit einigen Jahren sind im Gegentheil auf den Rieselfeldern 2 Reconvalescenten-Stationen, die eine mit 60 Betten für männliche, die andere mit 70 Betten für weibliche, nach überstandener Krankheit der Erholung bedürftige Personen eingerichtet, welche sich des regsten Zuspruchs erfreuen und zu jeder Jahreszeit durchweg voll belegt sind. Des Ferneren ist eine Wöchnerinnen-Station für 60 Wöchnerinnen und deren neugeborene Kinder auf einem Rieselfelde im Bau begriffen und gleichfalls eine weitere Station für tuberkulöse Personen beiderlei Geschlechts.

Wednesday, 12th August 1891.

The Chair was occupied successively by
The President, Sir John Coode, K.C.M.G.,
and
Mr. A. R. Binnie, Memb. Inst. C.E.

Water Supply.

BY

Alex. R. Binnie, Memb. Inst. C.E., Engineer-in-Chief, London County Council.

In the forefront of our inquiries on the subject of a good water-supply it cannot be denied that, however obtained and however treated from an engineering point of view, we must, in the first instance, secure a water of good quality and unimpeachable purity.

At first sight this may appear almost a truism, but, unfortunately, we do not find it to be either universally admitted or always observed in practice. For this we have to look to the great and almost general result of our modern modes of life and civilization, which tends more and more to aggregate our population towards large centres of wealth and industry, and these, we observe, are generally situated on the banks of important rivers or in river valleys not far distant from tributary streams. Not only are thickly inhabited areas in themselves improper sources of water-supply, but they are, also, directly the cause of pollution to the streams and rivers which flow through them. Consequently we find many of the large towns of Great Britain which are governed by Municipal Corporations, such as Glasgow, Edinburgh, Lancaster, Manchester, Liverpool, Halifax, Bradford, Leeds, Belfast, Dublin, and many others, resorting at great expense to uncultivated and almost uninhabited mountain tracts, and bringing the water from great distances so as to obtain a pure and uncontaminated supply.

When, therefore, we occasionally see large towns and cities which have not considered it necessary to take these precautions or to incur the consequent expense, but still continue to drink the water of rivers largely polluted by the more or less clarified sewage and the manure of populous areas, we are led to ask ourselves the question whether the large expenditure of capital that has been incurred in certain cases to obtain a pure water-supply has not been an entire waste of our resources.

There can be little doubt that human beings can, for a considerable time, drink with impunity water largely contaminated with the excreta, both solid and fluid, of healthy persons; and that they are able to do so with impunity, and without loathing and disgust, appears to be due to ignorance and apathy on the part of the water consumers, and to the power which rivers possess of apparently destroying and veiling the more gross and palpable polluting substances. There are some persons, no doubt, who teach that running water has the power of entirely destroying sewage and other polluting matter which may pass into it; but there are few, let us hope, who would say that we can, with safety, drink water which has been polluted with the excreta of persons suffering from cholera, typhoid, small-pox, and similar diseases; and yet this is practically the position taken up by those who advocate, unreservedly, the propriety of deriving supplies of drinking water from rivers on the banks of which, at no great distance, are situated large towns, for sooner or later we must expect epidemics to arise even under the most careful management.

Of two facts we may feel quite confident, first, that water subject to pollution is a very potent factor in the spread of disease; and second, that there is perhaps no better mode of introducing into the human system any substance which it can absorb than by drinking it in the form of a solution. This being the case it almost follows, as a natural consequence, that the utmost care should be taken to guard our supplies of drinking water from contamination; and yet we see persons around us who shut their eyes to observed and well known facts, and speak of the teaching of science and the experience of the world as sentiment, and who would continue to force upon a large number of their fellow creatures supplies of water contaminated with the excreta of millions of men and animals. That wells are frequent sources of death and disease, due to their contamination by house drains, is too patent to require a word of remark; and yet it required the cholera outbreak of 1849, and the death of some thousands of persons, to impress the fact on the people of London. And it appears to be forgotten that to drink river water polluted by sewage cost London in the cholera outbreaks of 1854 and 1866 the deaths of over 16,000 persons.

That people will go on for years drinking a supply contaminated by infiltration from graveyards, notwithstanding frequent warning, is proved by the outbreak of enteric fever in 1888, at Cradley, which caused 16 deaths in 113 cases.

The case of Lausen in Switzerland in 1872 proves that typhoid fever can be communicated by spring-water flowing miles underground from a neighbouring valley. The cholera outbreak in Spain in 1885 showed that, generally, the disease passed down the valleys, decimating the towns which drew their water from the rivers, but not affecting those which were independent of the rivers and had pure and uncontaminated supplies. In India the author has seen a town in which cholera had become endemic, almost entirely freed from that dire disease simply by giving up the water-supply derived from a populated drainage area and resorting to a purer and uncontaminated source. And the outbreak, last year, of enteric fever in the districts of Stockton and Middlesborough and Darlington, which derive their water-supply from the River Tees, proves that the germs of that disease are not destroyed by filtration or in their passage for over 13 miles down that river from Barnard Castle.

All these are cases in which chemical science is of little assistance, as it is powerless to detect the germs of disease; it can tell us of the presence of organic matter, but, without a careful inquiry into the previous life-history of the water, it cannot pronounce that, under all circumstances, it is a safe and pure drinking water.

Nor from the experience of Valencia in 1885, and of Stockton and Middlesborough, can we place much dependence on sand filtration as an effectual preventative of disease; sand filtration may arrest the living germs, but is unable, apparently, to stop the passage of the minute spores from which they spring. The precipitation and clarification of sewage effluent by chemical agency, also, can hardly be relied upon, as it merely abstracts about one-fifth of the more solid impurity, leaving four-fifths of the dissolved organic matter to flow off into the river.

What then are we to expect from the continuance of supplies to large cities from sources so polluted, but that such cities may go on for years, perhaps, boasting of the chemical purity of their water, and their low death-rate, forgetting that the constitutions of their water consumers are being gradually prepared, by continually drinking small quantities of diluted sewage, to receive the germs of some violent epidemic which sooner or later will visit the sources of supply; and then will follow such an outbreak of death and disease as will cause consternation throughout the land.

De la Distribution dans les Villes de deux eaux de qualite différente par des canalisations distinctes.

PAR

M. Bechmann, Ingénieur en Chef des Ponts et Chaussées chargé du Service de l'Assainissement de Paris, Professeur à l'Ecole Nationale des Ponts et Chaussées.

Depuis quelques années un certain nombre d'hygiénistes, frappés de la difficulté qu'on éprouve souvent à procurer aux habitants des villes l'eau pure et salubre en quantité suffisante, préconisent le *dédoublement des distributions d'eau.* Pour vaincre cette difficulté ou plutôt pour la tourner, ils recommandent l'établissement dans chaque agglomération urbaine de *deux canalisations entièrement distinctes,* de manière à porter en tous les points d'une part *l'eau potable* destinée aux usages qui la mettent en contact intime avec les parties les plus délicates de l'organisme humain, d'autre part l'eau affectée à tous les emplois où la salubrité n'est pas en cause ou ne l'est pas au même degré et qui peut être dès lors de *qualité inférieure.*

Le système est assurément ingénieux, et sans nul doute il fournit une solution rationnelle du problème. Aussi l'idée a-t-elle fait son chemin et trouvé des partisans dans tous les pays. Nous en avons la preuve dans le programme même de la viie Section du Congrès international d'Hygiène de cette année, puisqu'il porte au nombre des questions à l'ordre du jour la "*séparation de l'eau potable et de celle destinée à d'autres usages.*" Mais faut-il voir dans la double canalisation une solution générale, applicable à tous les cas ? Constitue-t-elle le type unique des distributions d'eau conformes aux règles de l'hygiène ? C'est ce que je me propose d'examiner.

Cette division, introduite systématiquement dans le service d'eau d'une ville, ce dédoublement complet de la distribution d'eau, n'est pas précisément chose nouvelle. L'illustre Belgrand, appelé en 1854 à diriger le Service des Eaux et Egouts de Paris, en a fait dès cette époque la base de ses projets pour l'alimentation normale de cette ville. Malgré les objections de diverse nature que cette innovation soulevait alors, il a su en faire triompher le principe ; et, sous son impulsion, une première application a été bientôt réalisée sur une échelle grandiose dans la capitale de la France.

Or, quelque grand succès qu'ait obtenu cette belle application, quel qu'en ait été le retentissement, elle ne provoqua point d'imitations immédiates ; et, en 1875, Belgrand pouvait encore écrire (*) ; " Paris " est la seule ville du monde qui ait adopté, pour sa distribution d'eau, " une *double canalisation*, destinée à séparer le *service public* du " *service privé.*"

C'est plus tard, et par l'effet de cette évolution si marquée de l'opinion publique en faveur des progrès de l'hygiène, que l'exemple parti de Paris est venu à porter ses fruits, que le principe de la double canalisation, désormais connu et apprécié, a trouvé des partisans convaincus, que d'autres applications ont été tentées et n'ont pas tardé à se multiplier, au point qu'en Allemagne les expressions *trinkwasser*, eau à boire, eau de boisson, et *nutzwasser*, eau industrielle ou d'usage ordinaire, sont devenues maintenant usuelles dans le langage de la technique courante.

Comme il arrive toujours, des préventions d'abord excessives ont fait place finalement à un enthousiasme exagéré ; les avantages du dédoublement des distributions d'eau, niés ou contestés à l'origine, ont tout à coup paru si évidents que, pour certaines personnes, il n'est pas de procédé meilleur ou même équivalent pour l'alimentation des villes. Plus d'un spécialiste en est venu à proclamer, au nom de l'hygiène et comme un nouvel article de foi, que la *double canalisation* est le mode le plus satisfaisant de distribution d'eau dans les villes, et qu'on doit s'efforcer de le généraliser, de le mettre en œuvre toutes les fois qu'on le peut.

Je pense qu'il ne faut pas aller jusque là ; et, en entrant dans quelques développements, je vais essayer de justifier mon appréciation, de montrer dans quelle mesure il convient de se tenir. Il m'a semblé

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* Historique du Service des Eaux depuis l'année 1854. Note à M. le Préfet de la Seine. Dunod, 1875.

que j'avais d'autant plus qualité pour traiter la question devant le Congrès que d'une part j'y représente la ville où ce mode de distribution a été pour la première fois systématiquement adopté et a donné lieu à l'application la plus heureuse et la plus considérable, et que d'autre part, ayant eu moi-même à diriger dans cette ville le service des eaux, j'ai pu me rendre compte personnellement par une expérience directe de sa valeur réelle dans la pratique.

La *double canalisation* présente *deux avantages* certains :

1°. *Réduction au minimum de la quantité d'eau pure et salubre* nécessaire pour répondre aux besoins de la population ;

2°. *Amélioration du service aux étages des maisons*, rendu indépendant de celui de la rue.

De ces deux avantages le second est particulièrement sensible et précieux dans une ville comme Paris, où le *service public* est très développé et les constructions fort élevées ; avec une distribution à *réseau unique*, l'ouverture simultanée des orifices à gros débit répartis en grand nombre sur la voie publique, ferait tomber à certaines heures la pression tellement bas que l'eau n'arriverait plus aux étages des maisons.

Mais c'est le premier qui est le plus souvent recherché parce que cet énorme développement du service de la rue, qui est la caractéristique de la distribution d'eau de Paris, est encore une exception pour ainsi dire unique. La *séparation des deux services* permet surtout le départ de deux ordres de besoins très différents et donne le moyen de limiter strictement la consommation de l'eau potable à ceux d'entre eux qui la réclament impérieusement. Dès lors on peut réduire considérablement le volume d'eau potable qu'il faut se procurer pour une ville donnée et par là même tourner les difficultés parfois très graves que présente le problème de l'alimentation de cette ville, ou réaliser une solution qui lui procure une économie importante.

Je n'ai garde de contester ces avantages qui sont assurément très réels ; je les apprécie hautement au contraire ; mais, quel qu'en soit le prix, ils ne vont pas jusqu'à m'aveugler au point de ne pas apercevoir d'autre part les *inconvénients* inhérents au *système de la double canalisation*, qui dans certains cas sont tels qu'ils compensent et au-delà ces avantages.

On ne peut nier en effet que le *dédoublement* de la distribution, l'obligation de poser deux conduites au lieu d'une dans chaque rue, de créer deux réseaux complets avec leurs accessoires, robinets, regards, ventouses, décharges, etc. ne soit une *complication* sérieuse. En doublant le développement des conduites, en augmentant de beaucoup le nombre des appareils de distribution, de contrôle et de sûreté, on accroît les difficultés de l'installation première, et surtout on crée pour l'exploitation des sujétions considérables, car les erreurs, les confusions, les fausses manœuvres, toujours possibles, appellent une surveillance plus minutieuse. L'organisation devient plus complexe, implique une direction plus attentive et plus exercée. De sorte que si l'on trouve des facilités particulières au point de vue de l'alimentation, par contre on est contraint d'admettre dans la distribution des dispositions qui peuvent aisément faire perdre le bénéfice qu'on avait cru obtenir.

Ces dispositions plus compliquées ne vont pas d'ailleurs sans surcroît de dépenses. Il en coûtera plus assurément pour distribuer une même quantité d'eau au moyen de deux conduites qu'avec une seule. Cela se conçoit sans peine, et c'est d'autant plus vrai qu'il y a une limite inférieure au-dessous de laquelle on ne saurait descendre dans la fixation du diamètre des conduites qui font le service courant. Toute sujétion, toute exigence nouvelle dans l'exploitation implique aussi un personnel plus nombreux ou plus exercé et des frais plus considérables. Et il peut fort bien arriver aussi que les économies à réaliser sur l'alimentation par ce dédoublement du service soient absorbées et au-delà par les augmentations correspondantes de dépenses dans la distribution, surtout si l'on tient compte de la capitalisation des frais annuels.

Enfin, et par-dessus tout, il faut signaler un inconvénient très grave du dédoublement de la distribution, c'est la *confusion* possible entre *deux eaux d'inégale qualité.* Il n'est pas douteux qu'au point de vue de l'hygiène, et s'il n'est pas pris de précautions spéciales pour y parer, ce ne soit une objection très sérieuse. Cette considération est de nature à fixer plus particulièrement l'attention du Congrès. Partout, en effet, où l'on mettra simultanément les deux eaux différentes à la portée du consommateur, quelle garantie a-t-on qu'il saura toujours faire un emploi judicieux de l'une ou de l'autre suivant le cas ? Et, si l'une d'elles est nuisible ou tout au moins suspecte, n'y a-t-il pas là un danger très grand, un manque absolu de sécurité ? Prétendre le contraire serait se faire des *illusions* contre lesquelles s'élevait avec force et très justement, à la date du 20 Décembre 1889, le savant Directeur de la Revue d'Hygiène*, M. le Docteur Vallin. S'imaginer qu'il serait bon de placer sur chaque évier, dans les habitations, deux robinets, un large et à grand débit fournissant *l'eau de qualité inférieure* pour la plus grande partie des usages, et l'autre tout petit délivrant *l'eau potable* presque goutte à goutte, c'est bien mal connaître la nature humaine. " Peut-on croire que dans la cuisine par exemple, disait " M. Vallin, les domestiques auront le soin de prendre à l'un des robinets " l'eau nécessaire aux lavages et à l'autre l'eau destinée à remplir les " carafes, à préparer les mets ? "† Rien ne garantira que, pour gagner du temps, on ne puisera pas bien souvent au gros robinet de préférence au petit. C'est aussi méconnaître les enseignements de la pratique ; " dans les casernes, dit encore M. Vallin, quelque soin qu'on prenne " d'inscrire en grosses lettres au-dessus d'un robinet d'eau de source : " *eau bonne à boire*, et au-dessus des robinets ou tuyaux desservant les " puits : *eau dangereuse à boire*, on voit constamment les soldats gas- " piller indistinctement la première pour les usages externes et boire la " seconde, surtout si celle-ci est plus fraîche que l'autre de quelques " degrés " ;‡ et cette observation est confirmée par M. Letulle qui nous apprend que, " malgré l'existence d'une *double canalisation* dans les

* Paris. Masson, éditeur.

† Revue d'hygiène, 20 Décembre 1889, page 1053.

‡ Revue d'hygiène, 20 Décembre 1889, page 1052.

" hôpitaux de Paris, les serviteurs puisent indifféremment au robinet " *d'eau de rivière* et au robinet *d'eau de source*.*"

Ainsi donc un système de distribution qui met deux eaux, dont une de qualité médiocre, à la portée des consommateurs, ne présente pas les garanties voulues au point de vue de la santé publique. N'en ressort-il pas à l'évidence cette conclusion, que j'énonçais déjà le 27 Novembre 1889 devant la Société de Médecine publique et d'hygiène professionnelle, à savoir que "*l'idéal d'une distribution d'eau c'est* " *l'alimentation unique*, avec un seul réseau de conduites, fournissant " partout en abondance une eau de bonne qualité, pure, salubre, à " l'abri de tout soupçon; de la sorte, en quelque point qu'on la puise, " on n'a pas de crainte à concevoir, on peut la consommer sans hésita- " tion et sans arrière pensée."† Et je crois pouvoir répéter ici ce que j'écrivais en 1888 : "Malgré la multiplicité des besoins et la diversité " des conditions parfois contradictoires qui s'imposent lors de l'éta- " blissement d'une distribution d'eau, c'est le système de *l'alimentation* " *unique* qui doit être ordinairement préféré."‡

Je n'entends nullement par là, je m'empresse de le déclarer condamner le système de la *double canalisation*. Mais je veux le restreindre à son vrai rôle, le ramener à ce qu'il doi être, c'est-à-dire un *expédient*, souvent fort utile, hautement recommandable à défaut de solution meilleure et capable de rendre dans certains cas de précieux services. J'ajouterai qu'il convient plutôt aux grandes villes où l'alimentation soulève des problèmes parfois très ardus et provoque des dépenses énormes, sur lesquelles il permet souvent de faire des économies importantes; tandis que, dans les petites villes, où la simplicité la plus grande, la rusticité des installations doit être la règle, il y a lieu de préférer la *distribution unique* parce que les besoins y sont plus faciles à satisfaire, parce que surtout on n'y aura jamais la garantie d'une organisation bien agencée, d'une administration sévère, intelligente et exercée, telle qu'on peut l'obtenir dans les grandes cités. Excellente à Paris où il serait absurde à coup sûr, pour l'éviter, d'aller chercher l'eau d'alimentation dans le lac de Genève ou celui de Neuchâtel, très recommandable encore dans les villes de premier et de deuxième ordre où "l'on est obligé de recourir à plusieurs sources " d'alimentation parce que aucune ne répondrait complètement à tous " les besoins, dans celles déjà partiellement desservies où il est devenu " nécessaire d'entreprendre des travaux complémentaires, dans celles " où les eaux qu'il est le plus facile de se procurer sont de qualité " inférieure et où l'eau pure ne peut être obtenue qu'à un prix élevé,"§ la double distribution devient très médiocre dans les villes de moindre importance, absolument irrationnelle et détestable dans les petites localités "quand on ne rencontre pas de difficultés extraordinaires

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* Revue d'hygiène, 20 Décembre 1889, page 1053.

† Revue d'hygiène, 20 Décembre 1889, page 1058.

‡ Bechmann, Salubrité urbaine, Distributions d'eau, Assainissement. Paris 1888. Baudry, éditeur. Page 24.

§ Salubrité urbaine, Distributions d'eau, etc. Page 24.

" pour y fournir en quantité suffisante de l'eau de qualité acceptable, " ce qui est le cas le plus ordinaire."* Le choix entre les deux systèmes doit être "une question d'espèce: dans chaque cas, suivant " les circonstances locales et les conditions particulières, ce n'est " qu'après discussion des diverses solutions en présence que l'on peut " prendre la meilleure détermination."†

Enfin, dans les grandes villes mêmes, on ne doit pas perdre de vue le *danger d'une confusion possible* entre les deux eaux. En effet, s'il n'y a aucun inconvénient à laver les ruisseaux et les cours, arroser les rues et les jardins, alimenter les chaudières, etc., avec une eau qui, sans être insalubre, est impropre à la boisson, il faut empêcher qu'elle soit accessible aux habitants, si l'on veut avoir des garanties suffisantes, une sécurité complète au point de vue de la salubrité publique, et ne pas s'exposer à une *suspicion* constante, irrémédiable, qui péserait d'une manière fâcheuse sur la distribution tout entière. On n'y saurait parvenir qu'en *interdisant l'introduction de l'eau non potable dans les logements privés.* La double canalisation doit être limitée à la rue, ne pas pénétrer dans la maison. "Il convient, disions-nous déjà " en 1888, de ne délivrer dans les habitations qu'une seule nature " d'eau, afin d'éviter des confusions inévitables et fâcheuses pour les " usages domestiques; comment empêcher en effet d'une manière " efficace l'emploi de l'une des eaux pour la boisson si elles sont toutes " deux à la portée de la main ? "‡

Le rôle de *l'eau de seconde qualité* sera encore assez grand si on a charge d'assurer le *service public*, qui absorbe à Paris plus de la moitié de la consommation totale, et le *service industriel*, extrêmement développé dans certaines régions. On pourra d'ailleurs, moyennant des précautions particulières, l'introduire en même temps que l'eau potable dans quelques grands établissements, où la canalisation sera établie à cet effet dans des conditions spéciales et la surveillance organisée par une direction ferme et sévère de manière à donner toutes garanties. Encore conviendra-t-il, pour que la sécurité y soit absolue, de donner aux conduites et aux orifices fournissant l'eau non potable un aspect distinct qui les signale à l'attention générale et prévienne les erreurs, et des formes telles qu'il soit difficile d'y puiser l'eau pour la boisson. "A Paris on a pu sans inconvénient réel pousser parfois " jusque dans les maisons la *double canalisation*, et il est beaucoup " d'immeubles pourvus à la fois de *l'eau de source* et de *l'eau de* " *rivière*, sans que la confusion y soit possible; grâce à la *différence* " *de pression* des deux services, l'une des deux eaux se trouve " forcément réservée aux usages des écuries, remises, cours, etc., et " l'autre, atteignant seule les étages supérieurs, dessert nécessairement " les cuisines, cabinets de toilette, etc."§ Mais il faut considérer ces cas spéciaux comme des *exceptions*, éviter de les multiplier, et s'écarter

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* Bechmann, Salubrité urbaine, Distributions d'eau, etc. Page 24.

† Bechmann, Salubrité urbaine, Distributions d'eau, etc. Page 25.

‡ Bechmann, Salubrité urbaine, Distributions d'eau, etc. Pages 135.

§ Bechmann, Salubrité urbaine, Distributions d'eau, etc. Pages 135 et 136.

le moins possible de la *règle* qui proscrit le dédoublement de la canalisation intérieure dans les habitations.

Nous pensons que les considérations qui précèdent justifient amplement les conclusions que nous proposons de soumettre au vote du Congrès et qui seraient formulées comme suit :—

I.—*Pour le service d'eau d'une ville l'idéal est la distribution unique d'eau potable affectée à tous les usages.*

II.—*Lorsque des circonstances particulières obligent à recourir à l'expédient d'une distribution double fournissant deux eaux de nature différente, dont une seule est potable, par des canalisations distinctes, il faut éviter d'étendre le dédoublement de la canalisation dans les logements privés où l'eau potable seule doit être mise à la portée des consommateurs.*

The Separate Water Supplies for Domestic and for Sanitary Purposes at Southampton.

BY

Wm. Matthews, Mem. Inst. C.E., F.G.S.

Until 1852 the town of Southampton depended for its water supply upon the surface drainage from the Common and adjacent lands, which was collected and stored in two reservoirs situated on the Common, at a level of about 60 feet above the town, and holding together 5,000,000 gallons.

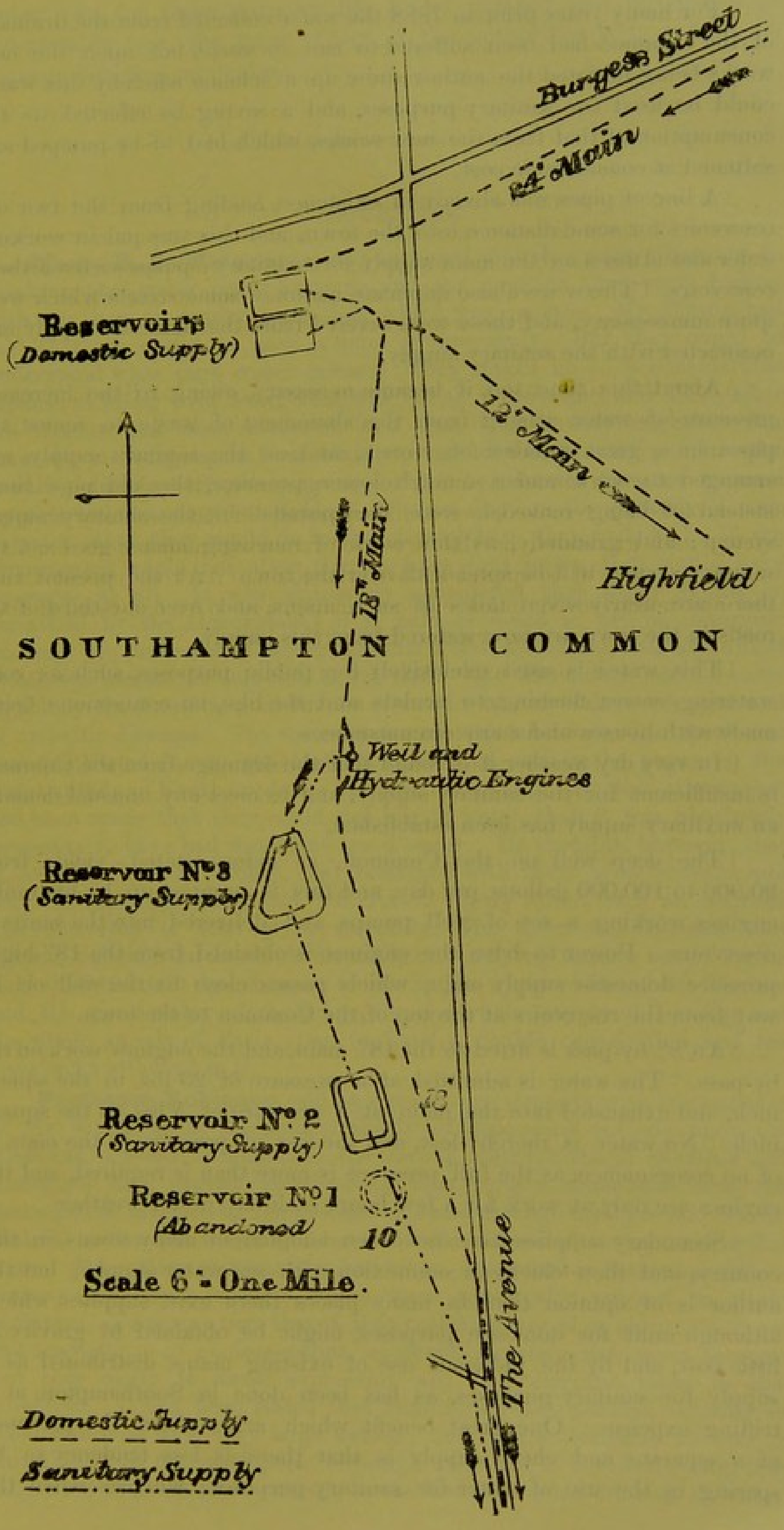
A well and boring was also sunk near the upper of these reservoirs, with the object of obtaining water from the chalk. The scheme was, however, a complete failure, and the boring was abandoned at a depth of 1,317 feet, after having involved an expenditure of over 20,000*l.*, and yielded less than 100,000 gallons per day of water of indifferent quality.

A supply pumped from the River Itchen was introduced in 1852, and remained in use until 1888, when new works were established, drawing a supply from wells sunk in the chalk, eight miles to the north of Southampton.

The water from this source is abundant and of great purity, but somewhat hard, and to remove this hardness a softening process has been adopted with great success, the working expenses being less than $\frac{1}{4}$*d.* per 1,000 gallons.

This water is delivered partly direct to the town and partly into reservoirs situated at the top of the Common, 160 feet above the town, and holding 5,000,000 gallons.

The foregoing constitutes the domestic supply, and is distributed throughout the town in the usual manner.


Burgess Street
24" Main
Reservoirs
(Domestic Supply)
12" Main
18" Main
Highfield
SOUTHAMPTON COMMON
Well and
Hydraulic Engines
Reservoir No. 3
(Sanitary Supply)
Reservoir No. 2
(Sanitary Supply)
Reservoir No. 1
(Abandoned)
10"
Scale 6" = One Mile.
The Avenue
Domestic Supply
Sanitary Supply

For many years prior to 1888 the water collected from the drainage of the Common had been suffered to run to waste, but upon the new works being initiated the author drew up a scheme whereby this water could be used for sanitary purposes, and a saving be effected in the consumption of that from the new works, which had to be pumped and softened at considerable cost.

A line of pipes was already in existence, leading from the two old reservoirs for some distance into the town, and this was put in working order and utilised as the main supply for 'sanitary' purposes from these reservoirs. There were also duplicate mains in some streets which were quite unnecessary, and these were severed from the domestic supply and connected with the sanitary supply.

About this time, too, it became necessary, owing to the increased pressure of water arising from the abatement of waste, to renew the pipes in a great number of streets, and as the sanitary supply was arranged to work under a much lower pressure, the old pipe lines, instead of being removed, were incorporated in the sanitary supply system; and gradually, as this work of renewing mains goes on, the sanitary system will be spread all over the town. At the present time there are nearly seven miles of such mains, and over one-third of the roads in the town are now watered from this supply.

This water is used exclusively for public purposes, such as road watering, sewer flushing, to urinals and the like, no connexions being made with houses under any circumstances.

In very dry weather it is found that the drainage from the Common is insufficient for the sanitary supply, and to meet any unusual demand an auxiliary supply has been established.

The deep well on the Common, as before stated, yields from 90,000 to 100,000 gallons per day, and this is pumped up by hydraulic engines working a set of well pumps and delivered into the sanitary reservoirs. Power to drive the engines is obtained from the 18″ high-pressure domestic supply main, which passes close to the well on its way from the reservoirs at the top of the Common to the town.

An 8″ by-pass is fitted to the 18″ main, and the engines work on the by-pass. The water is admitted at a pressure of 20 lbs. to the square inch, and exhausted into the main at a pressure of 5 lbs. to the square inch. No water is thereby lost, and the loss of pressure in the main is of no consequence, as the full pressure is more than is required, and the engines are only at work for a few hours each day in dry weather.

Secondary supplies have not been adopted in many towns in this country, and then chiefly in connexion with sea-water supply; but the author is of opinion that in many places there exist supplies which, although unfit for domestic purposes, might be obtained by gravity at little cost, and by the judicious use of existing mains distributed as a supply for sanitary purposes, as has been done in Southampton, at a trifling expense. One great benefit which arises from the presence of a separate and cheap supply is that there is less tendency to be sparing in the use of water for sanitary purposes; whereas when the water used for these purposes has to be pumped and distributed at considerable cost, the great object of the authorities is to reduce the consumption to a minimum.

DISCUSSION.

Mons. P. A. Maignen said it appeared that they were all agreed in thinking that water must be pure, and the question they were dealing with was how to render pure that which was impure. Mr. Binnie had said that one ought to have a pure water-supply. But they ought to understand what pure water meant. They might go to a considerable expense to bring to a town what was called pure water, and then, after the expense had been incurred, find that it was very impure. For example, at a congress in Brussels it was intended to fix at 30° per litre the quantity of inorganic matter, namely, lime, to be tolerated in water. Several members of the congress asked, if 30° were fixed as the quantity of lime in water, what they would do in that town where they had 35°? If the Government would not allow them to have that water, they would have no water at all. It was ultimately considered that water might be permitted by the Government if it held as much as 50° of inorganic matter. He protested, however, against water containing that amount of calcareous matter in solution being used. He had lately been greatly struck by the deleterious influence of hard water as a cause of gout and of arthritic diseases. The second point on which he desired to speak was that mentioned in the paper of M. Bechmann and in the paper on the water-supply of Southampton. It appeared to him that the assumption had been made that they could not purify water, that it was absolutely necessary to have bad water and good water. He thought, however, that if, in these days of science, they remained with their arms crossed, and declared that they would not attempt to purify water, such an attitude was unworthy of that great assembly. He, therefore, proposed that attention should be drawn to the mode of purifying impure water, for he held that it would be cheaper to purify the worst water of the Thames and the worst water of the Seine, for the whole supply of London and the whole supply of Paris, than to have a double canalisation and the drawbacks attached to it.

Professor Robinson said he agreed very strongly with the remarks of Mr. Binnie as to the undesirability of depending entirely upon the filtration of water, inasmuch as the recent observations of chemists and biologists had proved conclusively that certain organisms were not destroyed or arrested by the passage of water through sand *per se*. Nevertheless, he thought they ought not to be alarmists in what they said in that room. Many large communities had taken, and would in future take, their water-supply from sources which were practically subject to slight pollution, and it was true that if that pollution was of a nature to cause the conveyance of cholera-germs, no doubt a certain risk must be run; but they ought to avoid expressing any very alarmist views in that direction. It had been stated that running streams purified themselves. That was true to a very large extent; but it was desirable to bear in mind that, in the metropolis, although they had a low death-rate, they ought not to attribute it entirely to the fact of London drawing its water-supply from the Thames, for he believed it was still more due to the sanitary precautions, the excellent scavenging arrangements, the hygienic provisions made in the houses of the poorer classes, and all the other sanitary measures that were now so well recognised as essential. It ought not, therefore, to go abroad that the supply of water to London from the Thames was the only cause of the low death-rate. He believed that a large number of persons did exactly as he did in his own house, where cisterns had to be used, *viz.*, not to allow any water to be drunk without its being filtered. By a constant supply, one of the chief causes of mischief would be obviated. He thought the question of intermittent and constant supply deserved to be brought before the Section. It ought, in his opinion, to be made compulsory that each house should have a supply of water without having to store it in cisterns. In the houses of the well-to-do and educated classes, the mischief of storing any sort of water was well recognised, and no drinking water should be drunk without passing through a filter after coming from the cistern; but amongst the poorer classes, who form the larger number of the inhabitants of London—those who lived in the smaller houses—in spite of the precautions that were taken by inspectors of nuisances and by the excellent officials acting under the vestries, the state of things was very different, and it was impossible to over-estimate the mischief arising from the cisterns and stores of water to be found in such houses. He had referred in his paper to a subject on which he hoped th Congress would hear something from Dr. Frankland, viz., to a very interesting experiment made in America by the State Board of Health of Massachusetts. It was an interesting experiment on a very large scale, extending over a long period of time, and it showed conclusively that some bacteria absolutely passed through sand filters without any injury whatever, coming out perfectly healthy, and active for future mischief. He could confirm what Mr. Binnie had stated, to the effect that sand-filtration alone could not be relied upon for the perfect purification of water, but there were means of purifying water by using a form of filter like the iron filter of Dr. Anderson, and also several other forms of filter. At all events, there were certain compounds which appeared clearly to have the power of destroying all bacteriological life. Therefore, when engineers had to deal with the filtration of impure water, it should be remembered that the old sand filter might be improved upon. With regard to the duplicate water-supply—an impure supply for "sanitary" purposes, and a pure supply for domestic purposes—that was an ideal arrangement carried out successfully at Southampton, and was proposed many years ago by Sir Joseph Bazalgette to be applied to London, but the practical difficulties in the way caused the withdrawal of that scheme. The idea was an excellent one, and the author of one of the French papers had laid down some very good conclusions on the subject, to the effect that it was desirable, if they could, to use impure water where pure water was wasted; but he was afraid that there were practical engineering difficulties in the way of doing it on a large scale or in large towns, and he thought, therefore, from a practical point of view, that it was not capable of being carried out.

Dr. Edward Frankland said they were all agreed that amongst the conditions necessary for the maintenance of a satisfactory hygienic condition in towns, a supply of pure water was, perhaps, the most important of all. The attention of hygienists had been more and more directed of late years to water, inasmuch as the guilt of sewer-gas in the propagation of epidemic disease had been more and more diminished. The more numerous the investigations that were made into the sources of infection in such cases, the more clearly did it appear that the infectious matter was not, or only in very exceptional cases, capable of being conveyed by sewer-gas. The reason was not far to seek. The infectious matter, as they now knew, but did not formerly know, must be solid, it was a living organism, and no living organism could consist either of liquid or of gas, it must be solid; and numerous and satisfactory experiments had shown that it was with extreme difficulty that a solid, or, for that matter, a liquid, could be suspended in the gaseous atmosphere of a sewer. They might agitate sewage or any liquid in the most violent way with atmospheric air, and yet they could prove, by the most delicate tests, that none of the liquid was carried more than a foot or two from the surface. It was, however, different when there was a gas generated in the liquid. The minute gas bubbles seemed to have the effect of buoying up, like so many small balloons, the particles of liquid in which they were generated, and if there were minute solids like the spores of organisms in that liquid, it was obvious that they would be carried along with it, and in that way, no doubt, infection could be conveyed by means of the air. But unless they had very badly constructed sewers in which the sewage was undergoing active fermentation, it was impossible to conceive that such an evolution of gas as that would take place. Indeed, the result of laboratory experiments had of late been confirmed by Professor Carnelly and others, who had found that sewer-gas was much freer from suspended organisms than the ordinary atmosphere which they breathed. There was probably at that moment a thousand-fold more organisms in the air of the room in which they were assembled than in a corresponding quantity of air in the sewers beneath their feet. Their attention had accordingly been directed more and more to liquids, and especially to water, for the propagation of epidemic disease. It was pretty well known that developed bacteria were very soon killed in flowing water, and, therefore, that those developed organisms could not exist for any length of time in river water. On the other hand, the spores of bacteria were not killed by a very prolonged contact with running water; and as those spores were capable of development and were exceedingly small, they were the dangerous bodies to which they had to look. Much had been said about the purification of rivers and of water-supplies by oxidation; and he had seen many very beautiful cascades at water works by which it was sought to aërate, and consequently to purify, the water. He did not, however, believe that those attempts at purification had any important effect, at all events in removing dead organic matter in solution in the water; but they certainly could not have any effect in killing the spores of which he had spoken; and that those spores passed through sand filters the experiments just related as having been made in America conclusively showed. They also passed through very great thicknesses of porous material, such as the old moraine of a glacier. There was an experiment upon a large scale made in Switzerland, to which Mr. Binnie had alluded in his valuable paper. A case of typhoid fever occurred in a valley called the Fühler Thal, separated from another valley containing a village by the old moraine of a glacier. The water supply of the village was derived from a spring known to come from the Fühler Thal on the other side of the moraine, through its porous material. A violent outbreak of typhoid fever occurred. The cause of it was very exhaustively investigated, and the dissemination of the infective material by a patient in the neighbouring valley was clearly made out. His clothes were washed in the stream which disappeared at a swallow hole and was afterwards proved to furnish the spring from which the village in the other valley was supplied. The people who drank the water from that spring were affected by typhoid fever, while those who had other sources of supply escaped entirely. But the value of that demonstration consisted in this:—it was clearly shown that by dissolving in the brook in which the patient's clothes were washed several hundredweights of common salt, the quantity in the spring water in the other valley immediately rose very much. Then a similar quantity of flour was carefully diffused in the water of the brook, which again disappeared in the swallow hole, but did not affect in the slightest degree the clearness of the spring water which was distributed in the village; conclusively showing that a filtration which was probably much better than any artificial sand filter failed to remove the typhoid germs, although it was perfectly effective in removing the minute starch granules of the flour. He desired to confirm the statement made by Mr. Binnie that chemistry could not tell whether the water was free from zymotic poisons. It could trace the history of the water; it could tell, at all events in many cases, most conclusively whether it had previously been contaminated with sewage, and even whether that had been long ago or recently; and he did not think that even now they could rely upon bacteriology as giving decisive evidence as to whether water was infected or not; for many experiments had been made in which waters artificially infected with typhoid had been examined, and the bacteriologist had failed to find the typhoid-germ present. It was, therefore, he thought, a matter of precaution at all events, to supply towns, as far as possible, with water which had never been contaminated with sewage. As to the methods of purification, he should listen attentively to the papers about to be read to the section, but he did not know at present of any certain method of purification, except boiling the water, and that, he thought, all engineers would agree was an impracticable thing with water to be supplied to a town. M. Bechmann had given the Congress a valuable opinion about a dual supply, on which he (Dr. Frankland) should like to say a word or two. As towns grew in population it obviously became more and more impossible to supply to them the enormous volumes of pure water which they required if they were to have one supply only. He had often thought of the possibility of supplying a drinking water and a water for "sanitary" and out of door purposes, the two being kept entirely separate. He saw clearly great difficulties in the way of such a system. The most obvious solution of the difficulty would be that which appeared to have been adopted in Southampton, and it would be interesting to know what were the relative volumes of the two waters in that town. But so far as he knew, the simple method which would suggest itself to everybody, that of having a supply for the outside and another for the inside, had this great disadvantage in the way of its adoption, that the outside water was, at all events in English towns, used in such comparatively small quantities that it was hardly worth considering. If they were to supply the inside wants of a house by a pure water they might almost as well supply the whole town with it. At all events that was the case with English towns. But he was quite sure it was very different in France, where, as M. Bechmann had stated, a large quantity of outside water was used for fountains and other purposes for which in England it was not required. But if there could be some contrivance by which the water for "sanitary" and other similar purposes could be supplied to the inside of houses without the possibility of people being able to get at it for drinking, he thought that would be a great boon to large towns like London and Manchester, especially to London. How that was to be done he did not venture to suggest. It was an engineering question, but he could not think that it was impossible. They would then only require in London about one quarter or perhaps one fifth of the present supply for drinking and for dietetic purposes generally, the dietetic water being kept perfectly separate from the other, which latter might even be abstracted from the tidal reaches of the Thames.

Mr. Baldwin Latham said he did not at all dispute Mr. Binnie's facts that in India the effects produced by water-supply were not very deleterious, even when it was taken from rivers. In his paper he had given one remarkable instance where such a thing had occurred. But he believed that water supplied for domestic purposes should be of the greatest purity that it was possible to secure. He was not an advocate for taking water for the supply of towns from impure sources, but where there was no other source except that of a river, and where no serious objections had been shown to that source, it should not be discarded. It was better to have that water than none at all. It had been said that they ought not to judge of the health of London by its water-supply. That might be perfectly true, but, on the other hand, if the London water-supply was of that noxious character which so many people were so constantly preaching, surely it would be shown in the health statistics of the metropolis. What were the facts with regard to those particular diseases which were supposed to be due to impure water-supplies? The fever death-rate in London had been reduced from ·78 per thousand in 1868, to ·15 per thousand in 1890, in other words, to one fifth. No doubt that was due to progressive sanitary improvements, and also, probably, to the great improvements that had taken place in the establishments of the various water companies with regard to the supplying of much purer water than had been supplied in the previous years. So with regard to the zymotic death-rate in London, which in the last twenty years had been reduced by more than one-half. Those figures clearly showed that the water-supply could not have had any very noxious influence upon the health of the people. With regard to the facts which he had stated, as to the wonderful purifying power of water flowing down a river like the Ganges, they had been corroborated by the German Commission on Cholera, which laboured in India for a long period, Dr. Koch being one of its eminent members. It was conclusively shown that this purification in the water had taken place; and in one of the most remarkable cases they had ascribed it to the influence of long exposure to light. They had shown, by experiments, that many of the germs of disease were absolutely destroyed by such exposure. Now that exposure which took place in a river did not take place in underground water; and there was no doubt that underground waters, when once polluted, not being exposed to the beneficial influence of light, would carry the germinal matter of disease for miles underground. One instance of that had already been given. Last year he had to make, for the East Riding County Council, an investigation as to the outbreak of fever in Beverley. Beverley was supplied from a deep well in the chalk. It had been subject to repeated outbreaks of typhoid fever, and it had been shown, conclusively, by the medical officers of the Local Government Board, that these were traceable to the water-supply; but how that was brought about they had never been able clearly to demonstrate. Last year he made an examination of the district, after an outbreak of fever, and he found the whole of the sewage of a village, and the stream into which it flowed, disappearing in a swallow-hole, two miles from the works. Subsequent chemical tests, by the use of lithia, showed that in the course of a single day the whole of that sewage must have gone through the ground into the water-supply. Therefore the fact was at once established that there was a direct connexion by sewage contamination between that water-supply and the cases of typhoid which had occurred. In that case the water travelled more than two miles underground. With regard to the question of dual water-supply:—If they could so manage the dual water-supply that, as in the case of Southampton, they did not permit the two supplies to be taken into any one house, or give the opportunity of taking the dirty and cheap water with the pure and expensive water, it was all very well. Even in London they had for years had a dual supply. The New River Company supplied, from the ponds at Hampstead, water for flushing sewers and watering roads, as distinct from the domestic supply, and many other towns had also used water in that way. Many seaside towns, for example, used sea water for the purpose of watering roads and flushing sewers. So long as it was confined to the mere question of dealing with works which were under the control of the sanitary authority, there could be no objection whatever to such a supply, but the moment they gave the consumer an opportunity of taking water from either one source or the other, they introduced an element of danger into the habitations of the people.

Herr Kümmel (speaking in German) said that the best system was to deliver one quality of water, but if that was not possible, to deliver to the consumers the best water only. But besides the quality of the water, they also had to consider the quantity of water to be supplied for domestic purposes at any hour of the day or night, without interruption Those who lived in large towns at a distance from mountains were not able to procure the water from the hills. They found that the ground-water very seldom existed in sufficient quantity for delivery to the consumers, and they had therefore to take the water from its own source. In the case of river water it was found to be contaminated by many towns above their own. That may have been occasioned by sewage, or by the superficial introduction of human excreta. There had been very little alteration in the construction and working of filter-beds for the last 40 years. But they probably might be able to introduce a valuable means in future. The presence of organic matters, which was formerly the only criterion of the quality of the water in the previous state of their knowledge, was not so important as the presence of bacteria. They now know that the bacteria lived on, and destroyed, the organic matter, and they therefore concluded that the quantity of organic matter was a condition favourable to the existence of a large number of bacteria; and that a trifling quantity was the condition for a small number. They ought to try and discover, as exactly as possible, the number of bacteria in the ordinary and in the filtered water, and to compare the conditions and working of the filters with regard to their effect in diminishing that number. If possible they should, at the same time, state the different kinds of bacteria that were present. That was a very important but a very difficult matter. If all the engineers engaged in filtration would endeavour to ascertain the best way of diminishing the number of the different kinds of bacteria, and to avoid the presence of more than from 25 to 30 bacteria per cubic centimetre, even with a number of 24,400 per cubic centimetre in the river water, he was sure that they could purify the river water, polluted by domestic drainage, in such a way that they could deliver a good, potable, and safe water to their customers. But then they must not believe that they had fulfilled their duty when they had worked their filters as well as possible, leaving the rest to God and to good fortune.

Dr. William Odling said that if they took pure river water and contaminated it purposely with sewage, and attempted to oxidize that sewage by passing a current of air through it, or by some similar process, they obtained practically negative results. They saw, in a great number of cases, that there was an absence of purification; and the observation of that fact, together with the non-observation of facts of an entirely different character, had led some chemists to maintain that the self-purifying power of water was exceedingly small, that it was, in fact, a negligible quantity. The facts remained as they were, but the view had entirely altered, because it had been found that, under suitable conditions, the oxidizing power of river water upon sewage matter was simply enormous. It was not a question of a few grains or a few per-cents., but of hundreds and hundreds of tons of oxygen consumed in the destruction of the matter discharged into running water. That was a point that was admitted. That, of course, referred to dead organic matter. Next came the question of living matter, which they might speak of generally under the name of microbes. In the present state of their knowledge, it might be said that the microbes in the main existed both in their developed form and in the form of spores. In the developed form they multiplied with extraordinary rapidity. In the form of spores, so long as they continued in that form, each egg remained an egg only. Then another point had been established, that the objectionable microbes, in their fully developed state as discharged into running water, could not exist, could not multiply, and rapidly disappeared. It then only remained a question of the spores. It appeared that some could exist for a considerable length of time in river water. Some, among whom was Dr. Frankland, argued the question in this way: that no matter what the extent of dilution, now and then an individual would chance to take a spore, and would suffer for it. With regard to the chance, it was extremely small. He had made a calculation that, if so many million spores were taken into the Thames, say at Oxford, the chance of a person getting one of them at Teddington Lock would be something like the chance of getting one single spore from drinking some hundreds of gallons of water. That was a point—he thought the only one—on which some of them were at issue with Dr. Frankland, whose view was that, because a single spore put into a sterilized jelly would almost certainly develop itself, and from that would proceed an infinite multiplication of the microbe, the same thing took place in the animal body. He (Dr. Odling) contended that all the evidence went to show that that was not the fact; the animal body had a definite power of preventing the development of those objectionable microbes, and it was only when they amounted to a quantity beyond that which the animal body was capable of dealing with, that they became dangerous. For his own part, he should have no objection to taking one microbe-spore every day of his life, without any fear of having his life thereby shortened.

The President said that he was sure the members of the section would join him in congratulations to Dr. Odling on the highly interesting information he had afforded.

M. Bechmann (speaking in French) said, he only wished to offer a word or two in reply to the observations which had been made on the subject of his communication. He thought that no one had contradicted his first proposition, that the ideal distribution of water was a single distribution. It was said that it was better to purify water by filtration than to distribute two kinds of water, but that was no contradiction to the proposition he had put forth. Purification and filtration were but the means of obtaining the distribution of a single supply. In opposition to his second proposition, it had been stated that by renouncing the idea of introducing two kinds of water into the interior of houses, he too much reduced the rôle of the water supplied outside; in London, for example, the great part of the consumption was in the interior of the houses. That objection had been made by Dr. Frankland. It should be remembered, however, that in Paris a large quantity of water was required for the streets, the public fountains, and the like, for what was known as the public service; there was also a large quantity required for industrial purposes, altogether more than 130 litres per head. With regard to the introduction of a dual supply, it was only proposed to have one kind of water for the interior of a house. The amount of that water provided was 140,000,000 cubic metres for a population of 2,400,000, amounting to 60 litres, or between 13 and 14 gallons per head. That, however, was admitted to be insufficient, and works were being executed, and would probably be completed in two years, for the supply of 100,000 cubic metres more, in all 240,000,000, or 100 litres per head. That was for domestic use only, and hé thought that 20 gallons per head was a very respectable quantity, and perfectly sufficient for the service of the interior of houses.

Mr. A. R. Binnie said, with regard to the remarks that had been made on the subject of the calcareous impurities in water, he thought that the subject of hard and soft water had been pretty well discussed in this country for many years past. They were gradually arriving at the conclusion that unless the water was excessively hard—by that he meant something over 25° or 30° of hardness—the mere presence of calcareous matter in the water was not detrimental to health. On the other hand, if water was required for manufacturing purposes, the question of softness became absolutely essential. Speaking of water, it would be observed that the words he had used in the paper were, "A good supply, and a supply unimpeachable on the question of purity." A supply might be very good in the sense of chemical analysis, but might not, from his point of view, be a good and pure supply. He always disconnected the two things in his own mind, because of the fact which had been emphasised by those who were much more able to speak on the subject than himself, that chemical analysis, in its present state, was not able to tell them the whole history of the water. On the subject of duplicate supplies in towns, he thought that the matter would require considerably more investigation before the system could be applied to very large places. He could quite understand, in the case of Southampton, that the circumstance of the old pipes existing in the town lent itself to an economical introduction of a new supply. But what did they find in that particular case to be the outcome of the duplicate supply? They found that the houses were supplied in their entirety; that the interiors of the houses were supplied with potable water, water for washing, and for water closets, and that the only saving ultimately effected by the introduction of the duplicate supply in that case was for absolute "sanitary" purposes out of doors, such as flushing sewers and urinals, watering roads, and the like. So that he did not see, putting it on that limited ground, that there was much to be gained from a duplicate supply. On the other hand, looking at the expense, and to what it would cost for each house, and to the possible danger where the entire supply was of a very inferior quality, he hardly thought that the subject had been sufficiently investigated to warrant them in pronouncing any decided opinion upon it. With regard to Professor Robinson's remark about a constant supply, he thought they had all made up their minds on that subject—that the supply should be constant. He could not imagine, in the year 1891, anyone advocating an intermittent water-supply. With respect to sand-filtration, after what they had heard from their friends the chemists, they could not, as engineers, say absolutely that sand-filtration was the end of everything. Mr. Baldwin Latham and himself appeared to be very much at issue with regard to the water-supply of India. He was sorry to differ from that gentleman *in toto*. He had lived for six years in India, and nothing had impressed itself upon his mind so much as the fearful effect on the health of India produced by the drinking of water from rivers. When cholera, as it often did, broke out in the Great Hurdwar Fair, which was held near one of the main sources of the Ganges, it swept down the Gangetic valley, and decimated the people who drank the water in all directions. It was a matter of history, and it did not require him to assert the fact that cholera outbreaks in India were clearly traceable all down the Gangetic valley. They might take the case of a town in which cholera had become epidemic within the memory of man, and was never known to be absent. During the six years previous to the new works being constructed, people had died to the number of 1,264 out of a population of 84,000. They then introduced the new water-supply. The old supply was obtained from a reservoir or large tank, the water flowing into which was derived from a more or less populated drainage area. The new works were not very far distant from the town. The drainage area was perfectly pure. There was one village in the drainage area which was bought up, and the people were transferred to another district. The effect in the first six years after the introduction of that supply was to reduce the total number of deaths from cholera to 177, and of those deaths they had every reason to believe that a large proportion were imported from the districts immediately surrounding the city. There was no drainage to complicate the question. The town was undrained before, and it remained undrained to the present day.

L'Hygiène des Chemins de fer et des Voyageurs.

PAR

Le docteur Louis de Csatáry, Conseiller du Conseil général d'hygiène publique de Hongrie, Inspecteur en chef du service de Santé des Chemins de fer R. de l'Etat hongrois.

J'ai eu l'honneur de traiter la question de l'hygiène des chemins de fer et des voyageurs dans les congrès internationaux de Vienne et de Berlin.

Mes conclusions furent acceptées à Vienne à l'unanimité des voix.

La section d'hygiène du Congrès international de Berlin reconnut l'importance de mes propositions et fut d'avis qu'il sera utile de discuter les thèses spéciales dans une prochaine réunion.

Je suis très heureux de pouvoir soumettre mon ouvrage, le fruit des études et de l'expérience de 32 années, au jugement des ingénieurs et des hygiènistes de toutes les nations réunis en Angleterre, le berceau et la véritable patrie de l'application de la vapeur et des principes de l'hygiène en général.

L'hygiène des voyageurs est en relation directe avec celle des chemins de fer en général; le voyageur ne pourra conserver sa santé si les institutions des grandes voies de circulation ne sont pas conformes aux principes reconnus de l'hygiène.

Ces grandes voies sont représentées sur la terre ferme par les chemins de fer et les tramways.

Le Ministre du Commerce hongrois M. de Baross introduisant le tarif des zones, a augmenté le nombre des voyageurs dans des proportions gigantesques; son œuvre philanthropique est un des plus utiles bienfaits que l'on puisse rendre à l'humanité; le prix minime des voyages les plus éloignés donne au plus pauvre la possibilité de changer son domicile; ce penny système des voyages est aussi de grande importance pour l'avancement des sciences, des arts et de l'industrie; il est facile de prévoir que ce système bienfaisant à toute l'humanité sera adopté tôt ou tard par toutes les nations civilisées.

Mais avec le nombre croissant des voyageurs il est nécessaire de subvenir aux exigences de leur santé et de leur sûreté en voyage; il faudra prendre des mesures utiles pour protéger non seulement les voyageurs, mais aussi le personnel de service contre les influences nuisibles de la locomotion rapide sur les voies ferrées.

Les mesures à prendre se rapportent :—

1. Aux conditions hygiéniques des bâtiments et des moyens de transport.
2. Aux moyens de secours et de sauvetage en cas d'accidents et de maladie en temps de paix comme en temps de guerre.
3. Aux conditions hygiéniques du service du personnel employé.
4. À l'emploi d'un nombre suffisant de médecins pour le secours des employés et des voyageurs.

I.—Bâtiments et moyens de transport.

Tout bâtiment doit être construit selon les règles hygiéniques.

Il est donc nécessaire que l'inspection hygiénique des bâtiments et des gares soit faite par le médecin expert qui doit prendre part à la commission technique déléguée lors de l'enquête d'exploitation pour examiner les chemins de fer avant leur ouverture.

À cette occasion le chef du service de santé est obligé d'examiner les conditions hygiéniques des bâtiments de toute espèce, des gares et des eaux potables.

Il est absolument nécessaire que l'emplacement des gares soit assez large; dans le cas contraire le personnel de service est exposé aux plus grands dangers ; dans les gares étroites il y a toujours beaucoup d'accidents causant la mort et les graves blessures des employés.

L'encombrement des employés dans les bureaux et des ouvriers dans les usines est nuisible à la santé ; tous ces locaux doivent être spacieux et bien aérés.

Il serait utile de soumettre les plans de construction à l'avis du chef du service de santé pour éviter des fautes commises contre les règles de l'hygiène.

La construction des wagons doit présenter au voyageur la sûreté et le confort sans aucune distinction des différentes classes.

Les places ne pourront pas être étroites, car en ce cas elles sont nuisibles, surtout aux voyageurs de longue route obligés de rester longtemps dans une position incommode.

Il est contraire aux principes de l'hygiène de faire distinction des sièges selon les classes des voitures, car le voyageur de troisième classe a besoin de place suffisante aussi bien que celui qui, plus favorisé par le sort, peut voyager en seconde ou en première classe.

L'utilisation des places est parfaitement juste et le grand nombre de voyageurs la rend inévitable, mais d'autre part il est aussi nécessaire de subvenir aux besoins du public.

La ventilation, l'éclairage et le chauffage des voitures exigent aussi des notions hygiéniques.

La ventilation peut se faire sans aucune difficulté par l'abaissement des fenêtres ; on peut aussi écarter les fenêtres de leurs châssis pour éviter tout courant d'air, comme j'ai introduit cette méthode dans la voiture de sauvetage, construite selon mes plans, et exposée à la grande exposition d'hygiène de Berlin de 1883.

Chaque voiture doit être ventilée par l'ouverture de toutes les fenêtres cinq minutes avant la réception des voyageurs.

Tout voyageur a fait l'expérience des désagréments causés par le défaut de la ventilation en entrant dans une voiture chauffée artificiellement ou en été par le soleil.

Le chauffage des voitures est soumis à de grandes difficultés et jusqu'à présent nous ne connoissons pas une méthode parfaite.

Les appareils de circulation à air chaud, à vapeur ou à eau chaude ne permettent pas de tempérer convenablement les degrés de chaleur et sont souvent la cause d'odeurs désagréables.

D'autre part les voyageurs n'ont pas l'habitude de se pourvoir avec des habits assez chauds, même en hiver, car ils croient avec raison que ce n'est pas nécessaire dans les voitures chauffées ; en abandonnant la voiture ils se refroidissent très-facilement et sont exposés à de graves maladies.

Selon mon expérience l'unique méthode par laquelle la chaleur peut être maintenue et tempérée consiste dans l'application de fourneaux.

L'éclairage doit être assez fort pour que le voyageur puisse lire sans aucune difficulté, ce qu'on ne trouve pas en général dans la plus grande partie des voitures en usage ; la lumière insuffisante gâte les yeux des liseurs.

Il serait nécessaire selon les exigences de l'hygiène d'employer partout l'électricité pour l'éclairage suffisant des voitures.

Il est aussi de grande importance que la construction des wagons amoindrisse par sa résistance les suites des accidents, et surtout que les voyageurs puissent se sauver assez vite des dangers prévus.

Dans ce but les portes des wagons doivent être facilement accessibles et faciles à ouvrir.

On a introduit depuis quelques années des wagons avec des couloirs latéraux, munis seulement de deux portes aux extrémités des couloirs; ces wagons représentent les plus grands dangers en cas d'accident, car il est impossible d'atteindre par le couloir étroit les portes pour se sauver et même il est très-difficile de circuler, d'entrer ou de sortir de ces couloirs même quand il n'y a pas de danger.

La plus grande propreté doit être maintenue dans tous les wagons, les réservoirs doivent contenir en été comme en hiver une quantité suffisante d'eau fraîche

En hiver il faut introduire dans ces réservoirs de la vapeur chaude pour empêcher que l'eau gèle.

L'introduction des wagons-lits est un grand bienfait pour les voyageurs, mais il est à désirer, pour des raisons hygiéniques, que les couloirs latéraux soient plus larges, que l'on n'applique pas les lits l'un au-dessus de l'autre, et que les cabinets de toilette soient partout séparés des closets.

Les wagons employés sur les tramways doivent être construits selon les mêmes règles de l'hygiène; il faut surtout éviter l'encombrement des voyageurs qui favorise l'indécence et tend à propager les maladies contagieuses.

Pour cette raison il ne faudra pas imiter l'institution des tramways de Vienne et de Budapest; dans ces capitales on remplit les wagons de voyageurs sans le moindre égard aux places existantes; il faudra donc partout maintenir le principe de ne pas admettre dans les wagons de tramways plus de voyageurs qu'il n'y a de sièges.

II.—Moyens de sauvetage.

Chaque administration des chemins de fer est obligée de rendre possible que les voyageurs et les employés blessés ou malades puissent être pansés, transportés et secourus sans aucun délai.

Il faut aussi prendre les mesures nécessaires pour le transport de ceux qui souffrent de maladies contagieuses et éviter les dangers auxquels les autres voyageurs sains pourraient être exposés.

Maintenant on opère le transport des malades contagieux dans des coupés séparés, soumis à la désinfection.

Je suis d'avis que ni la séparation, ni la désinfection ne sont suffisantes pour sauvegarder les voyageurs de l'infection.

Pour éviter ce grand danger, j'ai fait construire en 1881 une voiture spéciale pour le transport des malades et des blessés qui fut visitée dans tous ses détails à l'occasion de l'exposition générale d'hygiène de Berlin par les Professeurs Billroth, Langenbeck, et Esmarch, et reçut le grand diplome d'honneur.

Les principes dominants de la construction de cette voiture sont les suivants :—

(*a.*) Double usage des lits mobiles placés dans les wagons, comme civière et comme gîte du malade ; on peut enlever le lit avec la plus grande facilité.

(*b.*) Il est possible d'installer le malade ou le blessé dans son propre lit transporté dans le wagon.

(*c.*) La désinfection complète des lits transportables s'opère sans la moindre difficulté.

(*d.*) La voiture de sauvetage est pourvue de tous les instruments et objets de pansement nécessaires, de glace, d'eau chaude et froide, de médicaments ; dirigé au lieu d'accident, le wagon peut être utilisé même lorsque le nombre des blessés est grand.

Les chemins de fer de l'État hongrois emploient ces voitures pour le transport des malades et des blessés et il est dans l'intérêt de la santé des voyageurs que des voitures spéciales existent partout pour le transport des malades et des blessés. (La description et les plans du wagon sont joints, p. 128.)

Des civières et des boîtes de secours doivent être présentes à chaque station, et chaque train doit être muni d'un petit étui à pansement contenant aussi quelques médicaments nécessaires.

Il est inutile de placer de grandes boîtes de secours dans le train, car les objets contenus sont gâtés malgré la meilleure fermeture par l'ébranlement continuel.

Chaque station doit être pourvue d'un reservoir à glace.

Le personnel des chemins de fer doit recevoir des instructions suffisantes en tout ce qui concerne le sauvetage, et les premiers secours à donner aux blessés ou aux malades.

Les médecins des chemins de fer sont obligés de donner ces instructions au personnel et de surveiller continuellement le bon état de tous les appareils de sauvetage.

III.—Conditions hygiéniques du Service des chemins de fer.

Dans l'intérêt des voyageurs comme dans celui des employés le principe est à maintenir que le service se fasse sans danger pour la santé des employés et sans le surménage du personnel, par lequel la sûreté des voyageurs serait menacée au plus haut degré.

La longue durée continuelle du service devient la cause de maladies corporelles et même d'aliénations mentales.

Il faut donc que chaque administration de chemin de fer soit obligée d'avoir un nombre suffisant d'employés, de manière que leur santé ne soit pas compromise par le surménage qui peut aussi devenir fatal aux voyageurs.

C'est surtout le personnel du trafic et des trains qui ne doit pas être exposé aux conséquences funestes de la lassitude, car c'est la grande fatigue par laquelle une grande partie des accidents est causée.

Il faut sauvegarder le personnel contre les intempéries du temps et les pourvoir des vêtements correspondants aux saisons ; tout vêtement qui empêche le libre mouvement est dangereux, et ce sont surtout les longues pélisses ou redingotes qui sont devenues la cause de fâcheux accidents.

Les yeux doivent être gardés par des lunettes à verres foncés contre l'éclat des champs de neige.

Il est aussi nécessaire que chaque employé jouisse annuellement d'un congé de quinze jours.

IV.—Le Service de Santé.

Il faut employer pour le service de santé des médicins prêts à chaque moment à secourir les malades et les blessés du personnel et en cas d'accidents les voyageurs.

Les médecins ont aussi l'obligation de visiter les employés concernant leur aptitude pour le service, la mise en retraite, les cas de simulation, etc. ; ils enseignent au personnel les éléments des premiers secours et ils rédigent la statistique médicale.

Les médecins des chemins de fer ne s'occupent donc pas exclusivement du traitement des malades, mais ils fonctionnent aussi comme les organes de contrôle des directions.

Il serait donc dans l'intérêt des administrations de donner à leurs médecins les mêmes avantages qu'aux autres employés.

Mais la plus grande partie des administrations ne suit point ce principe.

Le médecin des chemins de fer a une position indécise.

Il est regardé en véritable employé quand on l'oblige de rendre des services, mais dès qu'il est question de lui faire les avantages des employés comme bénéfice fixe, droit de retraite, etc., sa situation change et il appartient aux organes amovibles et privés des droits des employés.

Cette position éphémère des médecins des chemins de fer ne sert point à l'avantage du service de santé.

Il est donc dans l'intérêt non seulement des médecins, mais aussi dans celui du personnel, de donner aux médecins la même position qu'aux autres employés, avec le droit d'avancement et de retraite.

Le service médical est souvent rendu difficile par le manque des moyens de transport ; il serait donc utile de pourvoir chaque médecin employé d'une draisine ou d'un vélocipède.

Il est aussi avantageux de mettre une petite pharmacie manuelle à la disposition des médecins, comme c'est introduit auprès des chemins de fer de l'État hongrois avec le meilleur succès.

La direction et le contrôle du service de santé exige un médecin expérimenté qui soit dans la même position que les chefs des autres services.

Conclusions.

I.—Il est nécessaire que les plans de construction des bâtiments et des voitures soient jugés au point de vue hygiénique par le chef de service de santé qui devra aussi prendre part à l'enquête d'exploitation.

II.—Il faut que la construction des voitures soit telle qu'elle n'empêche pas les voyageurs de se sauver en cas d'accidents ; par conséquent : pas de couloirs latéraux étroits, mais des portes facilement accessibles et s'ouvrant sans difficulté.

III.—Les sièges des voitures doivent être également larges et commodes dans toutes les classes.

IV.—Il sera nécessaire de transformer et d'améliorer le chauffage et l'éclairage des voitures.

V.—Il ne sera pas permis de laisser entrer dans les voitures des tramways plus de voyageurs qu'il n'y a de sièges.

VI.—Il faut construire et mettre à la disposition du public des voitures spéciales pour le transport des malades et principalement de ceux qui sont atteints de maladies contagieuses.

VII.—Il faut que chaque station soit pourvue d'une boite à secours, d'un brancard et d'un réservoir à glace, et chaque train d'un petit étai à pansement.

VIII.—Il faudra éviter soigneusement le surménage du personnel et surtout des employés du trafic; par conséquent il faudra les nommer en nombre suffisant; il sera utile de donner à chaque employé pour la restauration de ses forces sur sa demande annuellement un congé de 15 jours.

IX.—Les affaires de santé doivent être dirigées par un médecin hygiéniste expérimenté en qualité de directeur de service.

X.—Les médecins des chemins de fer doivent jouir des droits des autres fonctionnaires, notamment du droit d'avancement et de retraite.

Si les directions des chemins de fer suivent ces principes proposés, elles auront tout fait pour le bien-être de leur personnel et des voyageurs.

Mais le voyageur doit aussi pourvoir aux exigences de sa santé et connaître les influences fâcheuses auxquelles il peut être exposé, surtout pendant la durée d'un long voyage.

Le voyage en chemin de fer est le plus sûr parmi tous les autres moyens de locomotion; selon les résultats d'une statistique rigoureuse des dernières dix années il y a eu dans la monarchie austro-hongroise et dans l'empire allemand un cas de mort sur 15 millions et un cas de blessure sur 4 millions de voyageurs en chemin de fer.

Le voyage comme tel est incontestablement utile à la santé si son mode et ses conditions correspondent à l'individualité du voyageur.

On a beaucoup parlé et écrit sur les maladies spéciales auxquelles les employés des chemins de fer et les voyageurs seraient exposés.

D'après l'expérience et les études de 32 années je suis en état d'affirmer que ces maladies spéciales, c'est-à-dire, causées par les voyages en chemin de fer, n'existent pas.

Il est incontestable que le surménage physique et intellectuel, le manque du sommeil, la position inusitée et incommode du corps peuvent devenir les causes des maladies des voyageurs, mais si les administrations suivent les principes établis en ce qui concerne les places des voitures et le travail des employés, et si les voyageurs ne commettent pas de fautes hygiéniques, on évitera facilement toute cause de maladie.

On ne peut nullement fixer en général les prescriptions valables sans aucune exception pour les voyageurs, car il y a grande différence entre le voyageur qui fait le voyage pour son plaisir et celui qui est obligé de voyager; j'essayerai pourtant de donner aux voyageurs quelques conseils qui pourraient leur être utiles :—

1. Il ne faut pas voyager en état malade ou indisposé sans avoir consulté le médecin; il faudra agir de même si l'on devient malade pendant le voyage.

2. Le voyage pendant la nuit est à éviter autant que possible; la nuit est le temps naturel du repos et le sommeil dans les wagons n'est pas réparateur à cause de l'ébranlement continuel; si néanmoins on est forcé de voyager pendant la nuit, il sera utile de se servir des wagons-lits; en tout cas il faudra se débarrasser des vêtements et des corsages étroits, et remplacer les bottes ou souliers par des pantoufles commodes, ne serrant point les pieds.

3. Il ne faut pas voyager trop longtemps continuellement; 8–10 heures de voyage en train de vitesse suffisent; la plus longue durée est une cause de lassitude pour la plupart des voyageurs.

4. Pendant le voyage il faudra observer la plus grande tempérance en collations et boissons, si non, on sera exposé à de graves inconvénients.

Il sera aussi utile d'être en possession de quelques comestibles surtout dans les trains qui n'ont pas de wagons restaurants, car le temps destiné au dîner est en général très-court et rarement suffisant pour qu'il puisse être pris avec le confort désirable.

5. Le vêtement doit être léger et accommodé à la saison du voyage.

C'est une grande faute de ne pas se munir en hiver de vêtements chauds, croyant que les voitures sont assez chauffées; il est vrai que l'on a rarement besoin du manteau dans la voiture même, mais il est d'autant plus nécessaire en sortant, quand on est exposé à toutes les rigueurs de l'atmosphère.

Les dames devront se passer de longues robes pendant le voyage, car elles pourront devenir la cause d'accidents funestes, en empêchant le libre mouvement en entrant dans la voiture et aussi en sortant.

6. Si l'on voyage longtemps, 10–15 heures, il faut donner de temps en temps une position horizontale aux extrémités inférieures; si les pieds sont toujours pendants, il en résultera l'enflure œdème.

7. Il ne faut pas lire continuellement, surtout dans les trains de vitesse; la lecture devient très-nuisible aux yeux, si on ne leur donne pas du repos de 10–15 minutes; l'éclairage artificiel n'est convenable à la lecture que s'il est parfaitement suffisant; le crépuscule dominant dans la plupart des wagons gâte les yeux du liseur, et en général il ne faudra pas s'occuper de lecture si elle cause le moindre désagrément aux yeux.

Il faudra aussi préserver les yeux contre les étincelles à l'aide de lunettes simples et contre l'éblouissement causé par les neiges à l'aide de lunettes de teinte foncée.

8. Il faut bien se garder d'entrer dans un train ou de sortir d'un train qui est en mouvement même assez lent, car une secousse imprévue peut devenir facilement la cause de la mort de celui qui enfreint les règlements.

Description de la voiture d'ambulance des Chemins de fer R. de l'État hongrois.

Cette voiture, destinée au transport des malades et des blessés, est posée sur un châssis entièrement en fer, à deux essieux, distants entre eux de 6 mètres. Les dimensions de la caisse et les autres parties extérieures sont analogues à celles des anciennes voitures à intercommunication.

Cette voiture est munie à l'une de ses extrémités seulement et des deux côtés de la voiture, de marchepieds donnant accès à une plateforme fermée ; le soufflet d'intercommunication de ce côté peut être adapté à la paroi frontale de cette plateforme, tandis qu'à l'autre extrémité de la voiture le soufflet d'intercommunication est adapté directement à la portière de la paroi frontale de la caisse même.

Dimensions principales de la voiture :—

	m.
Longueur totale mesurée entre l'aplomb de buttoirs tampons	11,060
Longueur de la plateforme	0,750
Largeur de la plateforme	1,910
Longueur de la caisse	9,080
Largeur de la caisse	3,120
Hauteur de la caisse	2,465

Les installations intérieures de la voiture sont les suivantes :

De la plateforme on pénètre, par une portière à deux battants, dans une salle partagée dans sa longueur en 4 compartiments dont 3 de 2^{m}, 100 et un de 0^{m}, 660 de largeur, séparés entre eux par des parois à hauteur d'appui.

Dans chacun des 3 premiers compartiments sont placés à droite et à gauche, près des fenêtres, deux lits-civières du système Eckermann, soit en tout 6 lits pour les malades et les blessés.

Les compartiments peuvent être clôturés par des rideaux fixés au-dessus des parois de séparation.

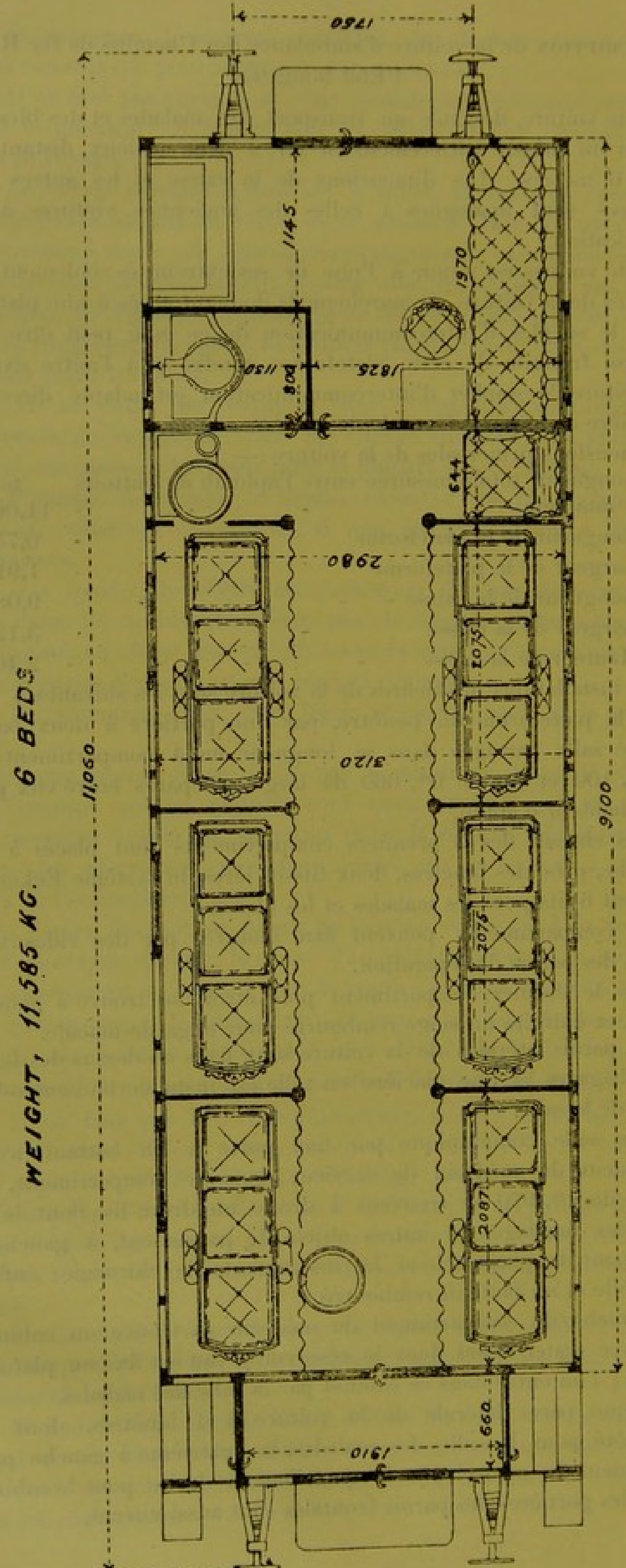
Dans le dernier compartiment plus étroit se trouve à gauche un fourneau, et à droite un siège rembourré pour le garde-malade.

Aux parois latérales de la voiture sont fixés au-dessus des fenêtres des portebagages et une glacière en toile est installée en contre-bas du plancher de la salle.

Cette salle communique par une porte à un battant avec le compartiment du médecin de service ; dans ce compartiment, d'une longueur de 1^{m}, 970 se trouvent à droite un divan-lit, dont le tiroir contient les bandages et autres objets de pansement, à gauche une armoire pour la pharmacie et les instruments de chirurgie ; enfin une table mobile et un fauteuil rembourré.

A gauche du compartiment du médecin se trouve un cabinet de toilette avec water-closet dont le réservoir-à-eau est fixé au plafond de la voiture ; l'on entre dans ce cabinet par la salle des malades.

Chaque paroi latérale de la voiture a 4 fenêtres, dont 3 de chaque côté pour la salle des malades, la quatrième à gauche pour le compartiment du médecin, et la quatrième à droite pour le cabinet de toilette ; les portières des parois frontales sont aussi vitrées.


1760
1145
1970
1150
804
1825
644
2980
2075
3120
11,060
9100
2076
2087
660
1910
WEIGHT, 11,585 KG. 6 BEDS.

La salle est éclairée la nuit par 3 lampes à huile du type règlementaire, fixées au plafond, et le compartiment du médecin par deux lampes à huile fixées l'une au plafond et l' autre à la paroi.

La ventilation se fait par des glissières à jour placées au-dessus des fenêtres et par deux ventilateurs-aspirateurs appliqués au plafond.

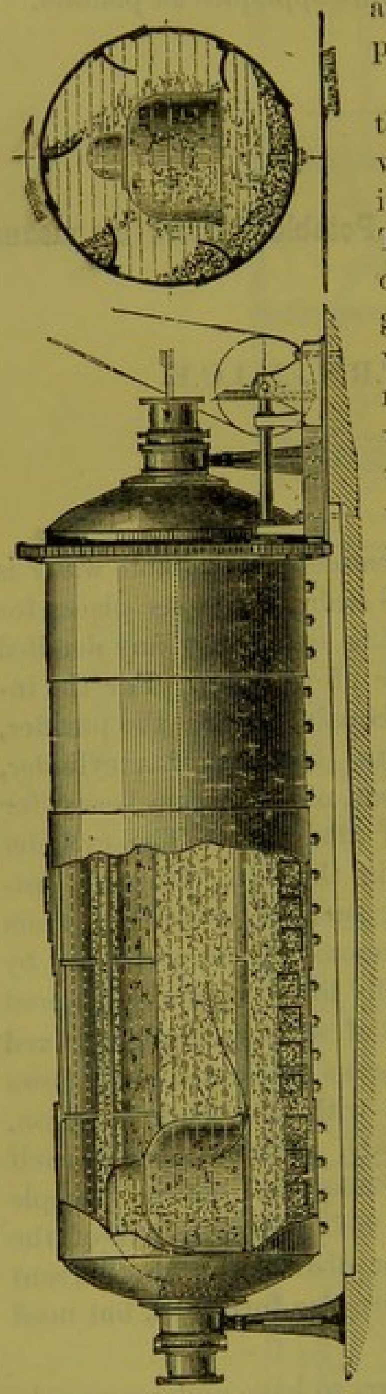
The Revolving Purifier for Treatment of Potable Waters by means of Metallic Iron.

BY

WILLIAM ANDERSON, D.C.L., F.R.S., M.I.C.E.

Since the revolving purifier for the treatment of potable water is no novelty, but has been at work on a large scale at various places for some six or seven years, it is not proposed to enter into any detailed description of the apparatus, or of its mode of working. For the information, however, of those who are not acquainted with the purifier, a short account is necessary. The apparatus consists of a cylinder, supported horizontally on two hollow trunnions, of which one serves for the entrance and the other for the exit of the water. The cylinder contains a certain quantity of metallic iron, in the form either of cast-iron borings, or, preferably, of scrap iron, such as punchings from boiler plates. The cylinder is kept in continuous but slow rotation by any suitable means, the iron being continually lifted up and showered down through the passing water by a series of shelves or scoops fixed inside the shell of the cylinder. By this means the water, as it flows through, is brought thoroughly into contact with the charge of iron, which, in addition, by its constant motion and rubbing against itself and the sides of the cylinder, is kept always clean and active. Simple contrivances for preventing the iron from being carried out of the cylinder or piled up at the outlet end, and for distributing the current of water over the whole area of the cylinder are also furnished, but need not be described.

The water as it leaves the cylinder appears to have undergone only one change of any importance, viz., a quantity of iron, ranging from one-tenth to one-fifth of a grain to the gallon has been taken up, and to get rid of this the water has to be aerated either by blowing in air, or by merely allowing it to flow along a shallow open trough; in both cases repose in a settling reservoir is necessary. After a few hours—from two to six in most cases, much less in some—the greater part of the iron will have subsided to the bottom of the settling tank, usually as loose flakes of iron peroxide associated with organic matter and other impurities, and the water is then ready for filtration. In most cases a rapid passage through a shallow layer of sand is all that is required to separate the iron, which remains as a fine layer on the surface of the sand, while the water issues from the filter free from iron, greatly ameliorated as regards organic matter, and practically deprived of microbes.



The revolving purifier was invented by the author in 1884–5, to meet the difficulties which arose in the working of the "spongy-iron" filters at the Antwerp waterworks. These filters which consisted of a mixture of "spongy iron" and gravel, choked up gradually and became almost inactive, after working for three years very satisfactorily as regards the purification of the water. They were replaced by the revolving purifiers, which have been in operation there ever since with most satisfactory results. It is not necessary in this paper to repeat the numerous details of working results at Antwerp, as they have already been made public, but it is proposed to lay before the members of the Congress results obtained on the practical scale at other places during the past year.

Boulogne-sur-Seine.—A purifier with a 6-inch inlet pipe capable of dealing with 200,000 gallons of water daily, was erected last summer at the pumping station of the Compagnie Générale des Eaux at Boulogne-sur-Seine. It was furnished complete with filter beds, and having worked during the autumn of 1890 remains still in operation. Very exhaustive trials and analyses were made by the Compagnie Générale des Eaux to test the system, principally with respect to the removal of bacteria, and of organic matter as estimated by permanganate of potash. The results obtained are thoroughly satisfactory, especially as regards bacteria. The numbers determined in the autumn of 1890 are interesting, as illustrating the experimental stage of the working of the plant. During the first two periods of working, for which the average percentage reduction of organic matter is given, the charge of iron in the revolving purifier, originally rather deficient, was further reduced by solution; during the third period the charge was made up to its full weight, and kept constant by periodical additions of iron.

Average percentage reductions of organic matter estimated by permanganate of potash.

1st Period.	2nd Period.	3rd Period.
42 per cent.	40 per cent.	66 per cent.

The number of microbes was on the average reduced to 50 per cubic centimetre in all three periods.

The experiments with this purifier were stopped about Christmas last, and the Compagnie Générale des Eaux ordered plant for dealing with the entire supply from these waterworks; but to obtain additional evidence of the efficacy of the system, the 6-inch machine was started again in May of this year, and the first few sets of analyses gave the results represented in the Table, which show a very constant and high co-efficient of purification in very varying conditions of the river, the lowest improvement, 36 per cent., occurring the day after a heavy rainstorm which washed some rubbish into the filters.

Date.	Organic Matter (expressed in milligrams of Oxygen per litre).			Microbes.*	
	Seine.	Purified.	Improvement °/ₒ.	Seine.	Purified.
May 20 - -	3·44	1·14	67	830	85
„ 22 - -	2·24	1·60	36	2,500	72
„ 25 - -	3·04	0·96	69	7,200	65
„ 27 - -	3·60	1·04	71	3,840	33
„ 29 - -	3·12	1·04	67	6,420	48
June 1 - -	3·52	0·88	75	—	—
„ 3 - -	4·72	0·88	82	4,500	36
„ 5 - -	4·88	1·04	79	1,600	50
„ 8 - -	3·60	1·20	67	5,800	22
„ 10 - -	2·88	1·20	59	L.	24
„ 12 - -	3·68	1·28	65	L.	10
„ 15 - -	3·52	1·04	71	—	—
„ 19 - -	3·68	1·44	61	—	—
„ 22 - -	2·08	1·28	39	L.	35
„ 24 - -	2·24	1·20	47	L.	L.
„ 26 - -	2·96	1·12	62	L.	8
July 3 - -	3·12	1·20	62	—	—
„ 6 - -	3·76	1·28	66	—	—
General Means - -	—	—	63	4,086	40

The analyses show that the satisfactory results obtained during the thir period in the autumn can be considered as normal under any circumstances, and that the Compagnie Générale des Eaux may look forward with confidence to supplying a good potable water from this pumping station as soon as the permanent plant has been set to work.

It has been asserted by critics of the author's system that the quantity of free oxygen dissolved in water is seriously diminished by treatment

* The number of microbes here given must be considered as no more than a rough estimate, because the colonies were observed for only six days instead of for fifteen—the usual period of experiment. The principal object of the numerous trials and analyses made was to ascertain the reduction of organic matter.

with iron—it has even been boldly stated that the water is entirely and permanently deprived of its dissolved oxygen—and that in consequence the purified water has a flat and vapid taste. As a matter of fact, seeing that a thorough aeration of the water on leaving the purifier is essential for the complete conversion of the ferrous salts into the ferric form, and is always provided for, the free oxygen, even if it were diminished in the purifier, is immediately replaced, so that the quantity contained undergoes no very great diminution.

M. Regnard, chemist to the Compagnie Générale des Eaux, reports that at Boulogne-sur-Seine the diminution of dissolved oxygen is very trifling. It some cases it has even been found that the quantity is increased after treatment.

In order to show that the purifier system is really superior to simple sand filtration, careful comparisons of the relative efficiency of the two systems have been made in many places, sometimes using the same filters with and without the purifiers, sometimes using precisely similar filters simultaneously under identical conditions. The figures already quoted for Boulogne-sur-Seine are of themselves a sufficient proof of the efficacy of the purifier system, the percentage reduction of about 40 per cent. when the machine was working under not quite satisfactory conditions, rising to 60 per cent. when these conditions were improved. To supplement this, the following figures may be quoted:—

At Agra a machine was erected capable of dealing with 50,000 gallons a day. Mr. A. J. Hughes, M.Inst.C.E., Supervising Engineer, Municipal Works, N.W.P. and Oudh, India, reported that the reduction of organic matter by simple sand filtration, at a speed of 24 gallons per square foot (per 24 hours), was 57 per cent., and that the reduction of organic matter by the revolving purifier system, filtering at a speed of 35 gallons, was 64 per cent., *i.e.*, 12 per cent. better results at 50 per cent. higher speed of filtration. In consequence of this experiment, purifiers have been erected to purify the whole supply for Agra. They have been at work now about six months, and are giving most splendid results, but unfortunately the figures have not arrived in time for insertion in this paper. Mr. Hughes has, however, stated that the albumenoid ammonia is reduced from 0·13 to 0·02 parts per million.

At Monte Video are three machines capable of treating 1,250,000 gallons daily. The reduction of organic matter by simple sand filtration, deduced from the average of fourteen analyses extending over a month, is 30 per cent.; reduction of organic matter by revolving purifier system, average of 13 analyses, extending over the same period, 47 per cent.

In these cases the same filters were used with and without the purifiers, which, if anything, favoured the simple sand filtration.

At Molesey Lock there is an experiment on a practical scale, consisting of a machine capable of dealing with about 6,000 gallons daily. It is at work purifying Thames water on the Lock Island. There are two similar filters, one reserved for simple sand filtration, the other for filtration after treatment with iron in the purifier. Average results obtained during the autumn of 1890:—

——	Thames.	Filtered.	Purified and Filtered.
Mean albumenoid ammonia (parts per million)	0·087	0·049	0·039
Mean total organic matter (Kubel & Tiemann process; gram. per litre) - - -	0·047	0·037	0·031
Mean reduction per cent. albumenoid ammonia	—	44 per cent.	55 per cent.
„ „ total organic matter -	—	20 „	33 „
Mean total reduction - - -	—	32 „	44 „

The system was worked under different conditions, some of which gave better purifications than others, but all results for the autumn of 1890 are included in the above means.

In conclusion, it may be stated again that the results quoted in the paper and the figures given have not been obtained by small laboratory experiments, but from installations, some of a very large size, working continuously under practical conditions; and, with the exception of Agra, all have been obtained during the last twelve months, and may be regarded as corroborative evidence on the points demonstrated by previous analyses and experiments at Antwerp and elsewhere. The quotation of favourable isolated cases has been avoided, and the average results derived from series of experiments have been given wherever such existed.

The Purification of Water by Rapid Filtration.

BY

Philip S. Wales, Medical Director, U.S. Navy.

The purification of water is a subject of great interest and importance, as well from a hygienic as from an industrial point of view. As the varied sources from which water is drawn for domestic use are liable, from either natural or artificial causes, to pollution deleterious to health and favourable to the dissemination of disease, its purity becomes a question of paramount importance.

The simple process of purification by boiling the water alone or with some astringent substance has been in vogue among the Chinese and other Orientals from a remote period. Distillation is also often used on a small scale, especially on board ship, and notably on the coast of Peru, where the water is impregnated with sodium nitrate. Filtration is also a common method employed in the household by the aid of the numerous forms of domestic filters, made of various porous substances, sand, stone, charcoal, sponge, &c.

The purification of large quantities of water for domestic and industrial purposes can only be effected by large filter beds or by specially devised machines, and it is the intention of this paper to dwell alone upon the latter method, the characteristic feature of which is to cause the water to pass rapidly through the filter bed under pressure. This system is the one making the most rapid strides in the United States, and is now the subject of investigation at the Museum of Hygiene, Washington, D.C.

The filtering machines are constructed of iron cylinders which are placed upright in the smaller sizes and horizontally in the larger.

The dimensions of the cylinders vary in diameter and length, according to the amount of work they are intended to accomplish, that is to say, according to the quantity of water required and the amount of foreign matter in it.

It is found best in practice to restrict the diameter within 10 feet, as the difficulty in washing increases rapidly with the area of the sand bed. The length ranges up to 25 feet. The pipes connect with the cylinders in such a way that the water is let in upon the sand, through which it filters to the outlet.

After the filter bed becomes embarrassed with the accumulated foreign matter, the current of water is by special contrivance reversed, so that it is passed from below upwards and washes out the impurities held in the sand, which are mostly confined to the surface, or at most to the upper two or three inches, of the filter bed. The "wash" water flows, at the end of the operation, very nearly as pure as the filtered water itself.

This is the general principle involved in the construction of the filtering machines. In some of them the cleansing is greatly facilitated by a stirrer or agitator mounted in the axis of the cylinder.

The time required for cleansing a filter will depend upon the condition of the water: if very muddy, or at its worst, as after a rain, about one hour; in ordinary conditions, half that time.

The cylinders are sometimes connected with pipes in such a way that any one of a system of cylinders may be washed with filtered water flowing from its nearest neighbour, or from one further removed in the line.

There are two principle types under which these machines may be classed. In the first, nothing but sand, or sand and charcoal is used as a filtering material; in the second, besides a filtering bed of these materials, the water is treated with alum, or sulphate of aluminium in definite doses, by a special contrivance before it reaches the bed. When the sand is alone employed, water, carrying heavy proportions of fine silt or suspended organic matter, is not entirely clarified as it is when this proportion is smaller. In such cases the alum gives most excellent results by massing the fine particles into such magnitudes that they are obstructed in the interstices of the sand.

If the alum is properly dosed, most of it will be caught in the filter bed; but if, on the other hand, an excess is introduced into the water, the amount in excess in solution will pass through the filter undecomposed, and the water will be correspondingly impregnated.

As this enables the filtration to be done more thoroughly, the filter necessarily becomes sooner clogged, and needs more frequent washing.

An idea of the amount of work which these filters may be called upon to perform may be conveyed by considering that some of the muddy, rapid rivers of the western section of the United States may, under the most unfavourable circumstances, carry as much as an ounce of fine mud to the gallon mixed with a variety of vegetable organisms.

The clarification of such water, if taken direct from the river, would embarrass the filter too much for successful rapid filtration; indeed, water containing a quarter of an ounce of foreign matter to the gallon, is a severe test for a filter.

In the first example, a filter discharging 250 gals. per minute would be charged with 15½ lbs. of solid matter in the same time; so that the thickness of the "blanket" of mud on the filter surface would soon arrest the flow of water.

In the experiments carried on at the Museum of Hygiene, it was found that it is the "blanket," or sedimentary layer which first forms on the top of the sand, which diminishes the flow of water long before the bed is penetrated to any extent. This phenomenon was carefully studied with the aid of a glass model.

It sometimes occurred in the small machines of the capacity of 10 gals. per minute, stopped by this surface deposit, that the flow was renewed to its full capacity by jarring the bed by a sharp quick blow upon the cylinder which dislodged this surface stratum.

If the water is heavily charged with solid matter it will be necessary, for efficient results, to get rid of the larger portion by sedimentation before passing it into the filter.

Alum greatly assists in clarifying heavily charged water. Now, as to the quantity of alum needed to clear up the water, it was shown that a half grain to the gallon will, on the average, answer for this purpose.

During the year 1890 there was used at Atlanta, Ga., waterworks 92,390 lbs. of alum, equal to 532,166,400 grains; $253\frac{12}{100}$ lbs. per day, equal to 1,457,971 grains; 617 grains of alum to 1,000 gals., or $\frac{617}{1000}$ grains per gallon.

In rapid filtration one square foot of filtering surface to three gallons per minute is usually allowed. A filter may be instanced with two cylinders, each five feet in diameter and 12 feet long with a stirring shaft for agitating the sand. Each shell has a filtering capacity of 259,200 per diem. The pipes in a system of such cylinders are so connected that the washing can be done with filtered water, and any one cylinder may be washed by any other. In other types of filters the washing is done with unfiltered water.

The sand is kept from washing out of the cylinders by various devices. In the "Loomis" by a simple perforated plate; in the "Duplex" by an ingeniously constructed perforated plate, into the perforations of which pins move, both to hold back the sand and to prevent clogging; in the "Hyatt," by shot or wires; and in the "Bowden," by perforated nozzles. All of these devices are found to work efficiently.

The space occupied by filters constructed upon the principle of those in question would, of course, vary with their capacity. On an average, a plant capable of filtering 1,000,000 gals. per diem, would occupy an area of about 25 feet by 30 feet, and 16 feet vertically. The cost of such a plant is between 8,000 dollars and 10,000 dollars. The expense of maintenance depends considerably upon the solid matter contained in the water. According to the report of the water commissioners of Atlanta, Ga., for the year 1889, the annual cost of maintenance of the filter plant (capacity 3,000,000 gals. per day), was 2,093·39 dollars.

This system of rapid filtration is successfully pursued at many places in the United States, among others at—

Oakland, Cal.,	capacity for	24 hours	-	4,000,000 gallons.
Atlanta, Ga.	"	"	-	3,000,000 "
Long-Branch, N.Y.	"	"	-	2,000,000 "
Ottumwa, Iowa	"	"	-	1,500,000 "
Athol, Mass.	"	"	-	1,000,000 "

Indeed there is no limit to the quantity of water that can be filtered by these machines; plans and propositions having been submitted to the City of Allegheny, Pa., for a filter plant with a capacity of 30,000,000 gals. per day.

In many industrial pursuits the water at hand is unfit for the manufacture of certain special products, and has, therefore, to be improved and adapted to the purpose by filtration.

In sugar refining the water is often so impure that it requires filtration to adapt it to this purpose.

At the Museum of Hygiene at Washington, D.C., four of the best types of house filtering-machines have been used for experimental purposes, the Duplex, Loomis, Hyatt, and Bowden. The Duplex filter consists of three cylinders, two charged with sand, the third with charcoal. The area of filtering surface is 1½ square feet, and the depth of the bed 2 feet 5 inches. The flow is rated at five gallons per minute.

After running for a time it becomes necessary to cleanse the filter; a valve is moved to either the right or left, by which motion one or the other of two pipes will be in communication with a pipe connected with the sewer for conveying away the impurities from the sand cylinders during the process of washing. This pipe, before entering the sewer, has inserted in it an ordinary ball trap with a glass cup, which exhibits the condition of the water coming from the filter during the operation of cleansing, and admits of determining the moment when the filter is sufficiently cleansed.

After the water has been running this way for a few minutes, the sand will become loosened in the cylinder, and a shaft with radial arms attached can then readily be turned for the purpose of thoroughly stirring up the sand and removing any adhering particles of dirt to be carried out with the cleansing water. By returning the valves to their original position the process of filtration will be continued.

If at any time it is desired to aërate the charcoal by a somewhat similar arrangement, the water can be removed from the charcoal and air will take its place, when the coal, having become sufficiently aërated, the filtering process can be continued as before.

Aëration can be effected, if desired, during the time the sand is being washed in the sand cylinders. If for any reason it be found necessary to take out the charcoal, it can be readily done by simply removing the bonnet from the cylinder, and scooping the charcoal out, as it is not packed but lies loosely in the cylinder.

When it is desirable to use alum the slightest trace of it is introduced into the water as it passes in.

The "Loomis" and "Hyatt" house filters are single cylinder machines.

An alum tank can be connected with the main inlet pipe at a convenient point, to dose the water as required; a small valve at the top of the alum tank controlling the alum supply.

The "Bowden" filter is a doubled-chambered cylinder, one above the other, filled with sand, so arranged that the filtered water from one can be used to wash out the other; and, after washing, both chambers are used for filtration. An alum chamber is attached which can be used when required.

The question will now naturally be asked, what effect has filtration on the purification of water from a chemical and biological standpoint?

In this paper we cannot discuss it at length (the final report of our investigations will do this), so we purposely omit all tabulated records, and give briefly some of the results we have obtained, which are of positive value. The albumenoid ammonia is reduced on an average by about 69¼ per cent.; this is the average of the four filters, and shows that filtration has a marked effect in removing organic matter.

The free ammonia is frequently increased; this of course, is readily understood by the breaking up of the albumenoid ammonia. When ammonium alum is used as a coagulant, this is markedly the case, and should be borne in mind when estimating the value of a filter.

The nitrites and nitrates are occasionally reduced, and in some cases increased, but in rapid filtration an increase would not be expected, as very little time is allowed for oxidation to take place in the organic matter. The chlorine is not appreciably effected, but the amount in the water we have been working on is so small (1·7) that more extended investigations are required to determine the question.

The hardness is reduced about 1 per cent., but our observations were made on the Potomac water, which is very soft (67 parts per million). With waters of a higher degree of hardness, filtration might make a greater reduction. The suspended matter is reduced 50 per cent.; the Potomac, when turbid, carries a large amount of fine particles of silicious matter which (without the use of a coagulant) even the finest filter paper fails to remove; only asbestos finely packed will clear it, and then the filtration is too slow for any practical use.

The matter in solution is slightly reduced, the amount is insignificant, but is all that can be expected. The non-coagulated alum used in the filters passes through unchanged (·42 grains per gal. was recovered from these filters, or 7·25 parts per million).

The filters remove 98 per cent. of the micro-organisms, as was found by direct experiments in plate culture. It is not expected that any filter can be germ-proof. Spores readily passed through the filtering material.

Ueber die Wirkung der Electricität auf die suspendirten und gelösten Stoffe der Abwässer.

VON

Dr. Claudio Fermi, aus dem hygienischen Institut in München.

Angeregt durch das von William Webster angegebene Verfahren, mittelst der Electricität Abwässer zu reinigen, stellte ich eine Reihe von Versuchen über die Wirkung des electrischen Stromes auf die in den Abwässern suspendirten und gelösten Stoffe, sowie auf die darin vorkommenden Pilze in dem unter Leitung von Prof. Emmerich stehenden bacteriologischen Laboratorium des hygienischen Instituts in München an.

Ich setzte mir folgenden Plan für die Versuche fest:—

1. Durch Vorversuche einigermassen die Art der Electroden, die Stromstärke und die Dauer der Einwirkung der letzteren zu bestimmen, die geeignet ist, um eine gewisse Menge Wassers zu reinigen.

2. Einwirkung des electrischen Stromes auf das Abwasser, verglichen mit der des Kalkes (1 %).

3. Einwirkung des electrischen Stromes auf die in den Abwässern gelösten Stoffe allein.

4. Einwirkung des electrischen Stromes auf verschiedene im Wasser lösliche Stoffe, wie Oxalsäure, Weinsäure, Rohr- und Traubenzucker, NH_3, Harnstoff, Salpetersäure etc.

Die Electrisirung der Flüssigkeiten wurde in der electrotechnischen Versuchsstation in München unter Leitung des Herrn Privatdocenten Dr. C. L. Weber ausgeführt.

Die Versuche wurden stets mit je 1 Liter Flüssigkeit ausgeführt.

Den electrischen Strom lieferte eine Dynamomaschine, resp, Accumulatoren; er wurde stets genau gemessen und durch einen Widerstandsregulator beständig auf constanter Stärke erhalten.

Die Stromstärke variirte von 0·5–2 Ampère. Die Entfernung der Electroden von einander betrug 5 cm.

Bei den Versuchen, auf deren Resultat es in erster Linie ankam, wurden als Electroden Eisenplatten von 80 qcm. Oberfläche angewandt.

Kurz zusammengefasst waren die Ergebnisse etwa folgende :—

1. Bei Anwendung eiserner Platten von 80 qcm. Oberfläche als Electroden ist die Wirkung des electrischen Stromes auf das Wasser viel stärker als bei Anwendung solcher von 40–20 qcm., oder solcher aus Kupfer, Kohle oder Platin.

2. Je stärker der Strom, je grösser die Oberfläche der Electroden ist, und je länger die Electrisirung protrahirt wird, desto schneller und vollkommener geht im Allgemeinen die Reinigung des Wassers vor sich. Die organischen Substanzen in 1 Liter Wasser konnten durch einstündige Einwirkung eines electrischen Stromes von 0·5–1 Ampère und bei Anwendung flacher eiserner Electroden von 80 qcm. Oberfläche und 5 cm. Abstand von einander bis zu $\frac{1}{3}$ reducirt werden. Die Zahl der Pilze wurde dabei um das 50–100fache verringert.

Immerhin war die reinigende Wirkung eines Stromes von 0·42 Ampère auf 1 Liter Kanalwasser, eine Stunde lang fortgesetzt, geringer als bei Zusatz von 1 $^{\circ}/_{\circ}$ Kalk. Durch Kalkzusatz wurde das Wasser vollkommen steril und blieb es auch nach 48 Stunden, während im electrisirten Wasser nach dieser Zeit die Anzahl der Pilze wieder um das fünffache zugenommen hatte.

3. Die stärkere Wirkung des electrischen Stromes bei Anwendung eiserner Electroden mit breiterer Oberfläche kommt nicht durch eine grössere ausgeschiedene Eisenmenge zu Stande, indem im Allgemeinen bei grösseren Electroden weniger Eisen ausgeschieden wird als bei kleineren, da im ersteren Falle die Electrolyse regelmässiger verläuft und augenscheinlich an der negativen Electrode ebenso viel Eisen niedergeschlagen wird, als sich an der positiven löst, während im letzten Falle bei grösserer Stromdichte kein cohärenter Niederschlag an der negativen Electrode entsteht; die an der positiven ausgeschiedene Eisenmenge verbleibt daher grösstenteils in der Flüssigkeit.

4. Schwache Ströme, wie z. B. von 0·063 Ampère, gaben auch bei längerer Einwirkung (bis zu 5 Stunden) keine befriedigenden Resultate.

5. Im Gegensatz zu den meisten bekannten chemischen Reinigungsmitteln werden durch den electrischen Strom auch einige oxydable organische Stoffe in ihrer Menge reducirt. Die gelösten Stoffe des Kanalwassers konnten bis zur Hälfte reducirt werden.

6. Oxalsäure in 0·2 $^{\circ}/_{\circ\circ}$ Concentration wurde durch einstündige Einwirkung eines Stromes = 0·55 Ampère bis zu $\frac{2}{3}$ oxydirt.

7. Weinsäure, ebenfalls in 0·2 $^{\circ}/_{\circ\circ}$ Concentration und ohne Anwesenheit von Chloriden wurde durch einstündige Einwirkung eines Stromes = 0·60 Ampère bis zum 30fachen oxydirt.

Nahm man dieselbe Säure in stärkerer Concentration, z. B. 10 $^{\circ}/_{\circ\circ}$, so entstand auch bei Anwesenheit von NaCl und bei Anwendung stärkerer Ströme (2 Ampère) keine Oxydation. Die Säure wurde nur teilweise neutralisirt.

8. Rohr- und Traubenzucker in schwächeren wie in stärkeren Lösungen, mit und ohne Zusatz von Chloriden, wurden auch bei Anwendung sehr starker Ströme (2 Ampère) nicht reducirt. Im Gegenteil wurde hie und da bei der Titrirung mittels der Chamäleon- oder der Fehling'schen Lösung eine geringe Zunahme beobachtet.

9. Durch Kochen der filtrirten Abwässer mit Kalk nahmen die gelösten Stoffe (durch Spaltungen) an Menge zu.

10. Der Zusatz von NaCl begünstigte durch Entwicklung von freiem Chlor wesentlich die Oxydation einiger organischer Substanzen und die Zerstörung der Pilze.

11. Auf eine Ammoniumchloridlösung (0·0786 °/₀₀) wurde durch die einstündige Einwirkung eines Stromes = 1·1 Ampère keine Wirkung des electrischen Stromes constatirt.

12. Auch auf eine 2 °/₀₀ige Harnstofflösung war keine Einwirkung nachweisbar.

13. Die salpetrige Säure wurde oxydirt. In einer 0·0406 °/₀₀ salpetrigsauren Kalilösung war nach der einstündigen Electrisirung bei Anwendung eines Stromes = 1·2 Ampère keine salpetrige Säure mehr nachzuweisen, wohl aber Ammoniak. Von Salpetersäure war keine Spur zu finden.

14. Das Wesen der Wirkung ist ein physikalischer und ein chemischer Process. Durch die Fällung des Eisenoxydul hydrats nemlich und durch die Gasentwicklung werden die suspendirten Stoffe teils niedergeschlagen, teils an der Oberfläche der Flüssigkeit angesammelt, und es entstehen durch die Wirkung des electrischen Stromes selbst mannigfaltige Zersetzungen, bei welchen NH_3, Sauerstoff und Chlor gebildet werden. Durch den Sauerstoff und das Chlor können leicht oxydable organische Stoffe oxydirt werden.

15. Die Pilze werden durch die Einwirkung des electrischen Stromes wie alle anderen suspendirten Stoffe niedergeschlagen. Jedoch könnte bei Gegenwart von freiem Chlor auch eine Zerstörung derselben zu Stande kommen.

The Water Supply of Maritime Towns.

BY

Edward F. Willoughby, M.D. (Lond.).

The general depression of the water level throughout the basin of the lower Thames which, as seen in deep wells, has amounted to not less than 20 feet in the last 20 years, affords incontestable evidence of the fact that the water companies of London and the neighbouring towns have long been abstracting from the land a volume of water greater than that portion of the rainfall which, percolating to the deeper beds, serves to maintain the natural underground storage; that we are, in fact, drawing on our capital, which is visibly shrinking, and that this annual excess of expenditure over receipts must, sooner or later, end in bankruptcy; in other words, that the lowering of the ground-water, and the drying up of the streams, already reduced in number and volume, will, if continued long enough, convert what are as yet fertile arable and pasture lands into little better than a desert; while schemes for satisfying the increasing demands of the metropolis, or for obtaining a purer supply than that provided by the Thames and Lee, which involve the extension of deep borings into the underlying eocene or cretaceous beds, or intercepting the tributaries of the Thames nearer to their origins, can only have the effect of hastening the catastrophe, and stand self-condemned.

These considerations have suggested to me an essential difference in the conditions of maritime and of inland towns, which, though it has, so far as I can learn, escaped the attention of engineers, has an important bearing on the questions alike of water supply and of sewage disposal. By maritime towns I mean not only those immediately on the sea coast or on estuaries, as Brighton, Plymouth, Liverpool, Hull, and Glasgow, but all such as are situated on tidal reaches, as London and Bristol, or—like Paris and Manchester—on points in the course of rivers where they have ceased to act as irrigators of the valleys through which they flow.

In the case of an inland town every drop of water withdrawn from the land, whether before its absorption by means of catchment reservoirs and the impounding of upland streams, or afterwards by pumping from wells and rivers, is, save under exceptional circumstances, sooner or later returned, directly or indirectly, to the land, feeding the rivers that, in their course to the sea, water the intervening country. I do not ignore the question of the pollution of rivers, for I maintain that sewage should everywhere be treated in the only satisfactory manner, viz., by intermittent filtration through the soil, when the effluent does not appreciably deteriorate the river into which it is discharged, while the full utilization of the fertilizing matters of the sewage, as well as of the water itself, is achieved. Indeed, if, as at Berlin and Königsberg, the sewage is distributed over a wide extent of poor, light soil, and reaches the river or sea only after having undergone the most complete utilization and purification possible, the benefit to the land from an economic, and to the population from a hygienic standpoint is positive and great. All so-called chemical methods of purification are delusions; they may render the effluent inoffensive for the moment, but it undergoes subsequent putrefaction, and is, under all circumstances, wasted.

But maritime towns and those on the tidal and lower reaches of rivers are in a very different position. They pour, directly or indirectly, into the sea the whole of the water they have withdrawn from the land, which is so much the poorer for the loss. If their population be small, and its demands such as not to involve any appreciable lowering of the subsoil water or drying up of the streams, no harm may result, though, even then, the treatment of the sewage by filtration is, in all cases, desirable.

But when the population amounts to a hundred thousand, I would lay it down as a law that any scheme for a water supply to be derived from borings in the surrounding country or from the upper reaches of the rivers running through it, or from springs, lakes, or other sources from which these streams are fed, should be deemed—as it will, sooner or later, be found to be—an economic blunder, an offence against the public good.

Such towns should be compelled to seek their supplies from one or other of two groups of sources, viz., uncultivated mountainous or moorland districts, where the rainfall is greatly in excess of the local needs, and where such abstraction will not cause injury to the agricultural or other interests of the valleys below; or, secondly, from subsoil waters naturally running to waste.

For examples of the former I may refer to Glasgow, Liverpool, and Manchester, which draw their supplies from Loch Katrine, from the Vyrnwy Lake, and from Thirlmere, as well as to Plymouth, Bristol, and Edinburgh, which collect the surface water or impound the streams on the Dartmoor, Mendip, and Pentland hills.

Of the second I cannot give more than one example, but it is in the highest degree interesting and instructive. This is Brighton, which derives its supply from borings and adits driven in the chalk. Since waters from this formation are usually held in high esteem, it will be well to consider the different circumstances of London and Brighton from a geological point of view.

The chalk in this country forms a belt of irregular width and varying contour, stretching from Dorchester to Cromer and the Norfolk coast. From the lofty plateau of Salisbury Plain extend two ranges of hills, known as the South and North Downs, the former ending abruptly in Beechy Head and the latter at Dover and the Kentish Foreland. The beds of which these two ranges are composed are strongly anticlinal. Those of the North Downs are identical with those forming the main belt from Wiltshire to Norfolk, being, in fact, continuous with them beneath the tertiary beds of the London Basin and Valley of the Thames, including the county of Essex. So much of the rainfall as does not go direct to feed the affluents on either side of the Thames is stored up, at least where the adjacent gault clay is not interrupted, in the lower beds, forming a vast but far from an inexhaustible reservoir. The difference between the rainfall and the loss by surface drainage and evaporation does not, however, represent the available storage, for the evidence afforded by the unsuccessful borings at Kentish Town and Richmond shows that the great underground reservoir is by no means perfect, the impervious bottom being wanting in various places, and the ultimate destination of the water at these points unknown. On the other hand, between the North and the South Downs, those of Epsom and of Brighton, the chalk has been removed by denudation following the upheaval of the underlying Wealden, which here comes to the surface, forming what is geologically a valley, though geographically elevated to a water-shed parting the series of streams, running northwards to the Thames and southwards to the Channel, formed by the surface drainage of the heavy clays of the western and larger half of this area. The greater part of the rainfall and storm-waters, owing to the impervious nature of the soil, instead of being absorbed find their way beneath the chalk on either side blending with the rainfall which on the chalk itself is almost wholly absorbed. Northward this supply is added to that beneath the London Basin, but southwards it runs out beneath the cliffs into the sea. At the Brighton Water Works it wells up in such abundance that the excess has to be run off into the sewers to avoid flooding of the station, and at Portsmouth it supplies the deep wells sunk through the dense alluvial deposits in the forts raised on artificial foundations in the bed of the Solent.

This is a typical example of what I have called a water-supply running naturally to waste, and I believe that London might with confidence draw largely on this for its supply of potable water. But there is reason to believe that a like condition will be found in the chalk hills of North Kent, between Farningham and Chatham, or even so far as Faversham and Wye. The dip of these beds is northwards, but it is only on the southern escarpment that rivers arise. At the same time deep wells in Essex do not yield the abundant supply that those in Hertfordshire afford, and hence I infer that much of the water finds its way into the estuary of the Thames, and, coming under my category of waters running to waste, might be without scruple impounded for the use of the metropolis.

I have heard that this view as to the destination of the North Kent water was warmly maintained by the late Professor Ansted; and I cannot agree with those who ascribe the high proportion of chlorides and nitrates in the water of the Kent Company to the access of tidal water to their wells, though I admit that such percolation does take place under the pressure of high tides into wells at Grays, and perhaps elsewhere on the Essex side. But it must be borne in mind that the conditions are totally different; the axis of the trough in the lower cretaceous beds, towards which the deep waters gravitate, being further to the north, the strata on the Kentish side dip from the land towards the river, but on the Essex shore from the riverside landwards, though in most places the percolation of the salt water would be impeded by the deep alluvial deposits in the river bed.

It is highly probable that in the vicinity of other maritime towns, where ranges of hills run parallel to the shore and their stratification is inclined downwards towards the sea, such sources, hitherto neglected, might be revealed by careful investigation. The objections, economic and hygienic, to the use of rivers, except at their upland sources, of lakes in highly-cultivated and populous districts, and of wells when the land is robbed thereby, are, I maintain, each and all indisputable.

On Maps showing the Area of Chalk available for Water-supply in the Central and Eastern parts of the London Basin.

BY

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These maps* are on the old Ordnance 1-inch sheets, and they could be made only for those regions of which the Geological Survey has published Drift maps. As yet, their southern boundary is the range of the North Downs, in Kent and Surrey; their northern, the coast of Norfolk; and their western, the line of the Chalk hills from Hunstanton southward, and then south-westward to beyond Royston, whence there is a temporary gap to Berkhampstead, the line being then continued in the same direction for several miles till it is abruptly turned S. along the edges of Sheets 7 and 8 of the Ordnance map, through Henley-on-Thames.

The maps have four distinct colours, and one of these is divided into two tints:—1. *Red:* Bare Chalk. 2. *Orange:* Chalk, covered by permeable beds only; or tracts in which, therefore, water from the surface can readily find its way into the Chalk. 3. *Green:* Chalk protected by beds of mixed or of varying character; consisting of tracts where surface-water is either greatly hindered in its downward course to the Chalk, or in which it is sometimes free to sink down and sometimes cannot do so. 4. *Grey:* Chalk protected by impermeable beds, forming tracts where surface-water is cut off from direct access to the Chalk by impermeable beds, not only at the surface, but anywhere between the surface and the Chalk. As, however, there are many parts where water flows over impermeable beds to the Chalk, or to permeable beds directly over the Chalk, and as such water then generally sinks, to some extent, into the Chalk, this division has two tints, the paler one for those parts where the drainage is toward the Chalk, the darker for those where the drainage is away from the Chalk.

The result of the whole is that the area of Chalk which may be reckoned on as available for a gathering-ground of water is much less than has often been estimated from an examination of ordinary geologic maps on which the Drift is ignored.

* The maps referred to were exhibited in the entrance hall of the Jermyn Street Museum.

The Influence of Ground-Water upon Health.

BY

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The examination of the historic records or of the published Mortality Tables of this and other countries shows that there are certain conditions which are found to be present when certain diseases are most rife. It is also found that, after eliminating certain meteorological and other influences which are supposed to affect disease, some particular diseases appear to be solely influenced by the hygrometric condition of the ground and the volume of water which is present in the ground.

In historic periods when particular epidemics have been rife, they have mostly occurred in times of drought, in which it has been established beyond doubt, by the evidence of the failure of springs and rivers, that the ground-water was then exceptionally low.

The actual measurements of the ground-water in this country, in some cases, go back for a period beyond that of the registration of death; consequently a comparison can be made between the state of the ground-water and the death-rate of any particular period, and when such examination is made it is found that there is a coincidence between the state of the ground-water and the deaths recorded. The deaths follow, as a rule in the inverse ratio, the state of the lowest ground-water; that is, high ground-water indicates a healthy period, while low ground-water marks the unhealthy periods. Investigations respecting the influence of ground-water upon health should be studied over limited areas, as the distribution of rain is often very local, and there are varieties in the geological character of the soil that affect the result of observations carried on over large areas; and on this account, while observations have been carried on by the author over an extended area, he has always used local observations to compare with the mortality returns in the same district, and he has specially dealt with the records of Croydon, which is the place where the observations as to percolation, evaporation, and the hygrometric condition of the soil have been locally studied.

There is every reason to believe that the ground-water itself, except when polluted, exercises no influence as a cause of disease, but that it is merely the measure or indicator of the influences which are at work within a polluted soil, and of certain organic changes which evidently take place within the dark recesses of the soil, and which lead to the development of the conditions favourable to a certain class of disease. That the earth does exercise a baneful effect upon health is well known from the experience in this country of the unhealthiness of cellar dwellings, and from the fact that persons habitually living upon ground floors are not so healthy as those living in the upper stories of buildings removed from the influence of the ground.

There is a seasonal fluctuation of the waters in the ground, and, as a rule, these waters are lowest in the autumn and early winter, and highest in the spring or early summer; but in some years the periods of both low and high water vary as, for example, the low water of last season did not take place until February of this year (1891).

It is also known that the artificial lowering of the subsoil waters of a district has produced the same effects upon the health as occur when a general lowering of the ground-water arises naturally from drought.

The actual drying of the ground is a condition which is favourable to the general good health in this country, and this circumstance often masks, in the general death-rate, the potential influence of certain diseases, so that the general health of a district appears to be good while at the time it may suffer intensely from a certain class of disease of which low ground-water is the indicator. When, however, the conditions become extremely intense, and the ground-water exceptionally low, the influences at work affect the death-rates as a whole. On the other hand, in periods of excessive rain with high ground-water, the conditions are usually favourable to health, and all places in which the ground-waters are of an uniform level, such as seaside places, which are governed by the mean tide level, and river valleys with porous soils, like that of the valley of the River Wandle, in which the water is headed up to an uniform level by mills, are usually healthy.

It is known that the measure of the effect of the ground-water is most marked in districts which draw their water-supply from the ground, and amongst that section of the inhabitants who use such water for dietetic and other purposes, especially in the case of young children and "teetotalers."

The unhealthy time after the period of excessive low water is that when the first rain begins to percolate through the soil, just as if it washed out matters which had been specially prepared or were retained in the dark recesses of the soil, into the water, or drove out the ground-air specially charged with the poison of disease. It is by no means uncommon both in this and other countries to find that particular epidemic outbreaks which have become rife at a low-water period can be traced to particular rainfalls. In this country since we have had the registration of deaths, those quarters of the year when percolation has first commenced after periods of exceptionally low water are, without exception, the most unhealthy seasons that have been recorded. The quarters of the year when percolation first commenced after exceptionally low water have been the most unhealthy, as for example, the March quarters of 1838, 1845, 1847, 1853, 1855, 1864, 1865, 1866, 1875, 1890, 1891, which, with the exception of the third quarter of 1849 (the cholera year), are the most fatal seasons on record.

There is no doubt that the sanitary condition of the district greatly influences the results of the movements of the ground-water, and the greater the amount of disturbance or the number of disturbances of the ground-water in the course of the season in insanitary districts, the greater and more marked the influence upon health, until the period arrives when the soil has been washed free from its impurities and comparatively pure waters have accumulated in the ground.

Certain diseases have their allotted seasons and conditions favourable for their development and spread, and there are a number of diseases usually most rife when the ground-waters are low, such as enteric fever, cholera, small-pox, diphtheria, and others.

The state of low ground-water, as being a condition accompanying epidemics of typhoid fever, is a matter of constant observation, and it is a well-authenticated fact that all epidemics of this disease in this country have occurred in periods only of low water, or when immediately following a very low state of the ground-water. Ground-water influences both small-pox and diphtheria in a most marked manner, but in directly opposite ways, so that when one of these diseases is present the other is absent. Small-pox is accompanied or preceded by intense dryness of the ground, while diphtheria occurs only when the condition of the ground is one of continued dampness. The year 1871 was a very fatal year from small-pox in this country, and in that year the percolation experiments showed that the ground was intensely dry. In 1876 an outbreak of small-pox occurred at Croydon, and continued until the Autumn of 1877. Outbreaks of this disease have subsequently occurred in this place in 1881–82 and 1884–85. Since September 1885, there have been no deaths recorded from small-pox in Croydon, but diphtheria has been very prevalent during the whole of that period, and the ground has been in a constant state of dampness, so much so, that with the exception of one month, October 1886, a measurable quantity of water flowed from the percolation gauges every month during all this long period. The last outbreak of small-pox, in 1884–85, was preceded by seven months, and that of 1881–82 by five months when no water percolated through the ground. Since the time when the author first observed this marked coincidence between the dryness of the ground and outbreaks of small-pox, he has learned from the report of Surgeon-Major G. Hutcheson, M.D., Sanitary Commissioner of the North-Western Provinces and Oudh, that the counterpart of this has been observed in India in reference to small-pox, which, it is stated, "is "controlled or kept in abeyance by damp and moisture."

The most marked incident in connexion with ground-water is the remarkable parallelism between the deaths of children under five years of age and the lowness of the ground-water; in fact, it is found that the deaths in this case fluctuate inversely in proportion to the volume of the water in the ground.

The following figures give the level of the lowest ground-water, and the death-rate of children under five years of age at Croydon, calculated upon the numbers living at that age :—

Year.	Depth of Water in Wickham Court Well.	Death-rate of Children under 5 Years.
1872	9·00	54·71
1873	20·00	47·15
1874	7·75	51·52
1875	6·08	57·27
1876	7·00	50·98
1877	25·75	47·18
1878	21·83	51·36
1879	31·00	44·57
1880	19·50	50·11
1881	22·08	45·17
1882	18·42	54·84
1883	17·74	41·57
1884	7·33	50·76
1885	5·17	48·90
1886	10·75	40·72
1887	6·44	42·90
1888	9·92	35·72
1889	8·58	38·78
1890	4·00	52·56

In 1882 the excess of deaths was no doubt due to the direct pollution of the water-supply of the district. And it should be observed that since 1884 the low waters in this well are lower than would be the case naturally, as since this period the waters have been abnormally lowered by the establishment of the New Croydon Waterworks Company's station at Addington. If the deaths from diarrhœa are eliminated, as being affected more by temperature than by conditions affecting the state of the ground-water, the parallelism between the volume of water in the ground and the death-rate becomes even more marked.

This coincidence between the rates of mortality of children and ground-water occurring period after period is tantamount to positive proof that ground-water, at least, if not the direct cause, is the measure of the influences at work which seriously menace the lives of young persons.

Those who require further information upon this subject will find it in the Author's recent Presidential Address to the Royal Meteorological Society.

Drainage and Irrigation of Land in their Relations to Health.

BY

RICHARD F. GRANTHAM, M.I.C.E.

At the Brighton Congress of the Sanitary Institute, Sir Thomas Crawford, in his presidential address, remarked, "Putting aside the West " Coast of Africa and other pestilential spots specially dangerous to " life, 'we may confidently say there is not a spot on the globe where " 'men may not be kept in health and vigour by proper attention to " 'hygiene.'"

It is obvious that the possibility of rendering nearly all lands salubrious, suggested by this remark, would be largely due to the agency of drainage in one form or another. We have heard much of late years of the drainage of towns and houses, and of its beneficial effects upon the public health; and many papers on the subject, as the transactions of the Sanitary Institute bear witness, have been read and discussed. But the subjects of drainage and irrigation of land in their relations to the health of the inhabitants of the country have not been as much discussed, although allusion has been made to them in the presidential addresses of the late Dr. Antonio Brady, Dr. Vivian Poore, and Mr. H. J. Marten. Now, having during some years past been engaged in extensive land drainage operations in the fens of Lincolnshire, and having had experience also in the drainage of irrigation fields in various parts of the country, and looking especially to the fact that of late years works of this kind on a large scale have been carried on in France, Russia, India, and other countries, the present seems to me to be a fitting opportunity for discussing the subject.

It has been shown that decaying vegetable or animal matter under a hot sun in damp soils, swamps, or swampy stagnant pools, however small, is capable of generating the poison of malaria in sufficient quantity to infect those who inhale it, and to cause fever which is often mistaken for and treated as typhoid. Malaria has been defined as air or a mixture of air or any gaseous medium impregnated with miasma, *i.e.*, fine floating particles of poisonous matter exhaled from putrefying vegetable or animal substances, and it produces ague, rheumatism, neuralgia, and intermittent fever in those who dwell in localities where the poison is generated. In the spring of 1879, Signor Tommassi, of Rome, and Professor Klebs, of Prague, who made the subject one of special investigation in the notorious Agio Romano, attempted to discover the physical cause or poison to which marsh or intermittent fevers are due. They allege that the fevers arise from germs present in the soil and floating in the air, and they claim to have traced the particular bacillus which is the cause of the evil. It is related that at Versailles a sudden outbreak of ague in a regiment of cavalry was traced to the use of surface water taken from a marshy district, and it is likely that in fen districts more harm has arisen from drinking marsh water than from breathing the air.

There are two sources of malaria from marshes: living and dead plants; and when stagnant water contains more vegetable matter than it can oxidize by means of the absorbed air, then some injurious exhalation from the unoxidized vegetable matter is given off.

The testimony of those who have lived in the fens shows that when land is completely covered with water, or when marshes have been completely drained, there is not the prevalence of aguish complaints which occurs immediately after the water level has been lowered by drainage works, and before the effect of these, in thoroughly drying the ground, has been felt.

Intermittent fever, also, has been attributed in tropical climates to the turning up of soil long undisturbed, and Sir Douglas Galton mentions cases at Hong Kong and in the South of France, where fever broke out amongst soldiers and labourers after the excavation of foundations for barracks. Much attention has been given to the subject of this particular fever by the State Board of Health of Massachusetts. In the annual report for 1889, there is an account of inquiries made into its occurrence in various cities of the state. It would seem, according to the report of the medical officer, that returns were received from 152 cities and towns; that in 86 of these cases the fever occurred, and that in 64 of the 86, the cases occurred near ponds, lakes, reservoirs, streams, marshes, drowned lands, upturned soil, and localities more or less infiltrated with sewage. He points out, however, that these conditions are factors only in the outbreaks of the disease and not the cause, for otherwise the exemption from the disease of other towns similarly situated could not be accounted for. The report concludes with the following suggestive remarks: "Grant that it is a truth 'generally "'accepted that the introduction of a germ is necessary;' grant also "'that water is almost certain to prove to be the germ's habitat "'and the vehicle by which this microbe enters the human organisa- "'tion,' and we have not explained why and how it omits certain "localities and appears in others. This much, however, is true, that "the appearance and spread of intermittent fever in Massachusetts "afford an opportunity for investigation, which, so far as is known to "the writer, has never been systematically undertaken."

In portions of the north-west provinces of India excessive fever mortality has been mitigated by extensive drainage works, by means of which the water which formerly stagnated in the land is now led away by continuously flowing streams. In describing the lagoons in Corsica, the late Dr. Ansted pointed out how the total stagnation and high temperature of so large a sheet of very shallow water produce a rapid growth of confervoid vegetation on the water. This vegetation drifts in enormous masses to the inner shore, where it accumulates and rots. The smell and miasma are carried up the valleys by the prevalent southeasterly winds, and so poison not only the plains adjacent to the lagoons, but the greater part of the eastern side of the island. In all the valleys the villages are unhealthy and the town of Bastia itself suffers severely; the death-rate of Bastia being nearly 22, while that of the communes north of Bastia, and so out of reach of the miasma, is only from 16¾ to 18 per 1,000. In a Parliamentary report on "the causes of reduced mortality in the French Army serving in Algeria," Colonel Ewart and Dr. Sutherland state that a reduction of the water-stead 20 inches below the level it formerly occupied in a certain district in Algeria, had been followed by a reduction of the annual death-rate from 57 per 1,000 to 24·8, and to a rate even lower still.

Much evidence, both in England and America, has been accumulated to prove that consumption is produced by dampness of site, and that in towns where, through sanitary improvements the soil has become dry, it has diminished. Also Dr. Farr held that on the undrained lands of the lower valleys of the Thames and of other English rivers where their waters are slow and sluggish and thrown out of their channels by milldams, thousands of the population suffer from ague, rheumatism, and neuralgia, while many die of these and other diseases. Drainage of the marsh lands, removal of obstructions to the rivers, and engineering improvements of the water channels, would obliterate countless evils.

Mr. R. B. Grantham, in reporting to the Inclosure (now the Land) Commissioners, upon the "Floods of Somersetshire," stated as the results of his inquiries among the medical men, that during the wet weather of the winter 1871–1872, the public health was good, but that ague set in early in the spring, and was then very prevalent on the verge of the moors, not only among the poorer families but also affecting people in a better class of life. Neuralgia and rheumatism prevail at all times of the year in these districts. Upon the floods retiring, ague is the most common, but zymotic diseases, such as typhoid and other fevers, are rarely to be met with, although with an increase of heat and the great length of time that the waters remained on the land, exposing a large amount of decaying vegetation, intermittent fevers do occur in the moors.

In my own experience in Kent and Essex, I have found ague prevalent in the marshes of the Hundred of Hoo, in the former county, one of my own workmen having been attacked by it; while in Canvey Island, with which I am particularly acquainted, where the surface is from five to six feet below the high tides, ague is now unknown. Camden, in his Britannia, 1607 A.D., however refers to the river having passed through "low and unhealthy" grounds in the island. The river walls are now in good condition, and the drainage well maintained, and the present healthiness of the population is no doubt due to the efficiency of these works. Mr. H. Marten, in his presidential address to the engineering section at Worcester in 1889, stated his opinion that the lowering of the line of saturation, or in other words the lowering of the underground water level, effected by improvements in the drainage of the fens, has a most important bearing on their sanitary condition.

Proceeding now to inquire into the effects of irrigation, I must refer to other countries, viz., Italy and India, for systems on a large scale.

It is claimed for India that she possesses the finest irrigation works in the world. They extend over an area of about 8,000,000 acres, an area considerably larger than the whole of Lombardy, or the surface under irrigation in Egypt. These works have unquestionably conferred immense benefits upon the soil, the climate, and the welfare of the people in preserving them from the effects of drought, but at the same time they have produced serious insanitary conditions. Colonel Baird Smith, in his work on "Italian Irrigation," makes frequent references to the unhealthiness and depopulation by malarious influences in that country. Three kinds of irrigation have been practised there for three different states of cultivation; the ordinary periodical flooding; marcite, or winter flooding, when the land is under flood for a certain period; and irrigation for rice cultivation. The first was carried on without prejudice to health, inasmuch as the water simply flowed over the land and passed off; the second was practised during the winter when the temperature was low and the evaporation small, and the water completely covered the land so that no harm ensued; but the third, that used for rice cultivation, was held to be so injurious to health, owing to the stagnation of the water upon the fields, that laws were passed restricting the limits of such cultivation to three or four miles from the outskirts of any town.

It appears that the evils attending irrigation in India are due to interference by the canals with the natural drainage of the country, and to over-saturation of the soil, resulting in the formation of marshes. Inquiries were made to ascertain to what extent the health of the populations living in the irrigated districts suffered, but it was found impossible to obtain statistics of their previous condition for comparison. It was determined, therefore, to rely on the evidence to be obtained as to the enlargement of the spleen—a certain consequence of malarial diseases. Investigations were made, and it was recommended that, as in the plains of Lombardy, great cities and military cantonments should be protected by zones round them, of from at least three to at most five miles radius, being kept free from irrigation.

It has also been stated on high authority that malarial fever is by far the principal cause of disease and death in India. In 1864 it was reported that the whole area irrigated by the western Jumna Canal required thorough drainage, and that 60,000 acres were affected by "reh" efflorescence. The mortality from fever over the area watered by this canal was so terrible that the cantonment of Karnal had to be abandoned. Again, in 1867, it was reported that from 61 to 80 per cent. of the residents were suffering from spleen disease. Dr. Thornton, C.S.I., from whose paper to the Society of Arts, in 1888, I have derived much information, goes on to say that, since his paper was written, "a system of surface drainage is being carried out; but "surface drainage, though valuable and important, merely provides an "outlet for surface waters, and is no remedy for excess subsoil water "resulting from constant irrigation added to the natural rainfall. The "proper remedy is subsoil drainage; but subsoil drainage has not yet "been attempted."

From the evidence thus adduced we are enabled, in some measure, to appreciate the wide extent of land subject to the influence of malaria, and the degree to which inhabitants are affected by it. It will have been observed that malaria is prevalent not so much when the land is completely covered with water as when the water has partly evaporated, or been partly drained off, and the decaying vegetation, in a damp state, is exposed to the heat of the sun. Further, that in winter, the danger is less than in the spring, when evaporation becomes more active.

The only safe conditions as regards health upon which irrigation of any kind can be allowed, lie in its flowing on, to, and off or through the land without being permitted to stagnate; and, where the subsoil is of a retentive nature, or the surface is so flat that water cannot escape, in providing subsoil drainage with proper falls to facilitate filtration, and so avoid stagnation.

Thus far we have considered the varying conditions under which drainage and irrigation exercise an influence upon health, and have seen that, by the proper drainage of marshes, naturally formed, and of swamps, created by irrigation works, malarious diseases will die out. But, although this is the chief benefit of efficient drainage, it is also accompanied by considerable increase in the prosperity of the country, the soil, when drained, being mostly very rich, and fit for profitable cultivation. I propose to refer to some important instances.

Looking abroad, we find several encouraging examples:—In France, near the mouth of the La Gironde, not far from Bordeaux, the drainage and improvement of 1,500,000 acres of desert land has been steadily progressing, and in the plains of Forez, on the banks of the Loire, in the basins of the Mare and Vizezi, works of drainage and irrigation have been carried out over an area of about 100,000 acres; the increase in the value of the land in the basin of the former river having been reckoned at 25 per cent., and in that of the latter at 48*l.* 11*s.* per acre. The cases of fever have been much diminished in number and severity.

Again, in Southern Italy, the marshes near Fondi used to produce pestilential exhalations during the summer months which, it is said, infected and poisoned the atmosphere for miles round. The total area of the marshes was 12,000 acres, of which at least 10,000 have been drained since 1882, and are now under cultivation, and let freely at 5*l.* per acre.

In Russia, the drainage of the Pinsk marshes, on the Russo-Polish frontier, containing about 25,000,000 acres, and said to be the biggest bog in Europe, has been steadily carried on at the rate of about 400,000 acres per annum.

Mr. Bailey Denton, in 1861, stated that the total area in Great Britain, undrained or capable of improvement by draining, was estimated at 22,800,000 acres out of a total of 56,352,000 acres, while the area drained at that time did not amount to 1,500,000 acres. This, however, refers to under or subsoil drainage, and it is not to be supposed that the undrained remainder of 21,300,000 acres would represent surfaces yielding malarial exhalations. But that great benefit would arise to health if that area were drained cannot be doubted. Now, where the subsoil of marshes or swamps is of a retentive character, arterial or surface water drains alone, as pointed out by Dr. Thornton, will not always be sufficient. The surfaces may be so flat that, in wet seasons, the water will rest on them without any chance of escape into the arterial drains.

In view of the importance of the subject, it will be worth while to describe the operations I referred to at the commencement of the paper, which have been recently carried out in the fens and marshes of Lincolnshire.* In the marshes a fine system of arterial drainage exists, and, therefore, no difficulty arose as to outfalls. But, as I have already remarked, the soil being close and retentive, with a very flat surface, and with fields measuring perhaps 100 acres or more without any drain or ditch, the water, in wet seasons, lay for months, thus reducing large and highly cultivated areas to the condition of swamps.

The subsoil of the fens is quite distinct from that of the marshes. That of the fens in which the work was carried out consists of stiff dark brown and blue alluvial deposit, with some beds of black earth or peat, and here and there beds of silt, which form small knolls, one or two feet high, above the surrounding land. The subsoil of the marshes, however, is formed of silt or sandy deposits more or less consolidated, and originally brought in by the sea, containing layers of decayed vegetation which has grown and perished under each successive accumulation of sand.

The wet seasons, which lasted without intermission from 1875 to 1883 inclusive, reduced a large part of these fens and marshes to the condition of swamps. Ploughing and sowing could only be carried on under the greatest difficulty, and a large part of the crops was frequently lost and the pasture lands a good deal deteriorated.

In the fens, open drains already existed which afforded outlets for pipe drains. In the marshes it was found necessary to divide the field into smaller areas by cutting large arterial drains with a level bottom about 5 feet below the surface of the land. By this means it was found possible to give an artificial fall in the absence of any natural one. In this way efficient drainage became practicable, although, owing to the slightness of the falls, extreme care was necessary in laying the pipes.

In the fens, the main pipes were laid about 3 feet below the surface, with the small fall of about 1 in 2,000, and the minor pipe drains were laid at an inclination of about 1 in 1,600. In order to ensure accuracy in cutting the bottoms of the trenches for the pipes, the water in the open drains was dammed up into them before any pipes were laid.

* It may be observed that arterial drainage can only be applied to suit the circumstances of the particular case, while agricultural or subsoil drainage is similar in its character wherever adopted, although its adaptation to various soils requires discrimination.

When the bottom had been proved, the main pipes, which were larger than would be used in ordinary pipe drainage, were laid, and the minor pipes were connected with them, and laid in the usual way. Where the subsoil was alluvial deposit, and the surface level was irregular, the drains were laid in the "hollows" or "lows;" where it was flat, they were laid at distances of 24 and 27 feet apart; while the depths varied from 2 to 3 feet, the greatest obtainable.

In the marshes the main arterial drains generally fairly discharge the water that comes to them. In excessively wet seasons, however, owing to the deficiency of open ditches and of pipe drainage, the water could not for a long time reach them, and the land was meanwhile almost submerged. The outlets of the main-pipe drains were laid 3′ 6″ to 3′ 9″ deep, below the surface, and with a nearly level bottom. The main pipes were laid in a similar manner to that in the fens. The widths apart, however, between the minor drains, varied from 36 to 66 feet, according to the stiffness of the subsoil.

The cost of pipe-draining the fens varied from 3*l*. 16*s*. 3*d*. per acre to 5*l*. 10*s*. 10*d*., and the marshes from 2*l*. 16*s*. 1*d*. to 3*l*. 0*s*. 9*d*. per acre.

I have endeavoured, in this paper, to bring forward from various parts of the world, evidence of the important sanitary and commercial results of efficient drainage of marshes, low-lying lands, and, to a great extent, irrigated lands. It would be difficult, if not impossible, at the present time, to obtain accurate statistics of the relations of the drainage and irrigation of land to health; but, I venture to think, even the statistics we have indicate how largely those operations influence the sanitary condition, and how much they conduce to the prosperity of such districts. There appears to me, therefore, to be good grounds for suggesting further investigation and the collection of precise records of the diseases incidental to these marshy localities.

DISCUSSION.

Mr. Baldwin Latham said that there could not be a shadow of doubt as to the fact that, in India, wherever irrigation was carried out, malaria followed it; but the question of drainage was one of considerable difficulty. It was not so easy as many persons in this country imagined, for very often the water-line was 20 or 30 feet below the surface in the irrigation district (during the low ground-water period of the year), and it was almost impossible in such districts to deal with the question of water-supply. Again, the black soils of the plains of India were so remarkably retentive, that if subsoil drains were put in only 20 or 30 feet apart, they had little or no effect upon the intermediate space. The experiments that had been made conclusively showed that the work of drainage, in the ordinary sense of underground drainage, would be extremely expensive and difficult to undertake in India. Of course very much could be done to ameliorate the condition of affairs by proper arterial drains for the collection of water after irrigation, making them as deep as possible. That had been followed out in a very great measure in many parts of India, and recently in the case of Poona, where an un-irrigated zone had been fixed around the city to prevent the ill effects following the application of water to the surface of the soil. By establishing those zones in the neighbourhood of a populous district, the influences were ameliorated to some extent. The real cause was hardly yet understood, but he thought that the effect was in a great measure due to the dampness of the ground, and to the exhalations at night from the irrigated areas. It was well known in India that malaria was rife at night. In the day-time one could traverse most malarious districts with impunity, but it was extremely dangerous after nightfall. Owing to the high temperature of the ground in India, especially when moist, after rainfall, when the temperature was much lower, exhalations were given off, and with those exhalations probably the malaria was exhaled. With regard to the fens of Lincolnshire, he knew very little about them, but he had been engaged for many years in the fens of Cambridgeshire. The soil of those fens was so remarkably light that no drainage at all was necessary. It simply consisted of decayed peat. A great point in those districts, in a dry season, was the constant habit of letting water in from the rivers which were at higher levels than the land, in order to maintain a uniform level of about three feet below the surface-level. When the water got above that it was pumped out, and when it fell below, as in seasons of drought, the water was let in. Ague was almost unknown since the more complete drainage of the fens; and what might be necessary where the soils were of a silty, alluvial character, was by no means necessary in the larger part of the fens of Cambridgeshire, where the soils were of an exceedingly light character, principally decayed peat lying on the top of Kimmeridge clay, the only manuring being done by digging down and throwing out the clay and mixing it with the surface soil.

Mr. T. H. Thornton, C.S.I., formerly Secretary to the Government of the Punjaub, was exceedingly pleased that Mr. Grantham had called public attention to the very serious results attending the extension of canal irrigation in India, especially in northern India, when unaccompanied by adequate drainage. Speaking from memory, he believed he was right in saying that every year, in British India alone, the deaths from malarial fevers amounted to several millions; and it had been clearly shown that no small portion of that mortality was attributable to malaria developed in canal-irrigated areas. According to Colonel Crofton, the distinguished canal engineer, the introduction of an irrigation canal in Northern India had the effect of adding to the natural rainfall about 70 inches of water per annum. It was clear that, if no special measures were taken for the drainage of land receiving that enormously increased water-supply, the result must be very serious—at any rate, in lands without a porous subsoil—and so it had proved. No doubt there were great difficulties in the way of providing subsoil drainage in India, but there were some measures contributing to the prevention of malaria which were quite practicable and should be introduced. One measure suggested for the prevention of the development of malaria from canal irrigation was to sell the water by strict measurement. At present one great cause of malaria in India was the fact that the peasantry over-irrigated their fields. The reason was that they did not pay for the water according to the amount supplied to them. They were allowed by the subordinate officials to have so many waterings, but the amount of the waterings was not regulated, and the result was, that wherever there was irrigation there was more or less over-saturation. If they could only make it the peasant's interest not to over-saturate, malaria would be diminished. The Government of India had had the question of water measurement before them for years, and many water-meters had been tried, but none had proved satisfactory. They had either been too expensive or too delicate, and the condition of their having to be applied to a rising and falling canal made the matter very difficult. Still, he hardly thought that it was a matter beyond the possibility of invention in the present day. Another preventive measure was to prohibit the supply of water from irrigation canals on what was called the high-level system, by which the water is allowed to flow onto the soil by the force of gravitation. Every peasant who used water from the canal should be required to lift it. Even if he had only to lift it one foot, the extra labour involved in doing so would secure economy, and prevent, *pro tanto*, the over-saturation which produced such terrible effects upon the health of the population. Such prohibition, at any rate, should be enforced in all fever-stricken districts, and in the neighbourhood of all towns. He was glad to learn from the previous speaker that in the cantonment of Poona a zone had been established in which no irrigation was allowed. The measure he had suggested did not go so far as that, but he was inclined to think that it would be as effectual. It had frequently been proposed by experienced administrators in India, but hitherto it had not been adopted, mainly for financial reasons, because the amount of revenue derived from low-level irrigation was not so great as that from high-level irrigation; but surely, when the lives of people in towns had to be considered, the question of revenue ought not to stand in the way.

Mr. William Harpur, M.I.C.E., said he had been much interested in the last two papers, which had clearly shown that the public had not only to look to the defects in ordinary house drainage as affecting the public health. There was a general opinion amongst the public that if any case of sickness arose, it must be due to defective house drainage. It appeared, however, from the papers that had been read, that there were other elements at work which more or less affected the public health. It was only necessary to bring the matter more to the notice of the general public in order that they might be acquainted with the facts, and so understand that there were other elements than those generally regarded as affecting the public health. In the town of Cardiff, in which he lived, they had two very distinct kinds of subsoil. The northern portion of the town lay upon a substratum of gravel, the southern portion was entirely upon an alluvial deposit of clay, which was perfectly impervious; and it was a fact which could be borne out by statistics for many years past, that the death-rate was higher in the southern portion of the town, built upon the impervious stratum, than it was in the northern portion where the soil was light and the drainage good. The question of subsoil drainage was one which, undoubtedly, should be taken up much more than it had been. There could be no doubt that the health of the people was governed to a very great extent by the condition of the water in the ground upon which the town was built.

General R. Maclagan said that, in connexion with irrigation in India, the result, he thought, might be stated thus: that the sickness which occurred in the irrigated districts was due to the abuse of irrigation, and the excess of irrigation, not to the simple fact of irrigation itself. It was true that sickness had followed the course of the construction of many canals, but that was chiefly due to an important fact, mentioned in one of the papers, that the canals in many cases intercepted the natural drainage of the country, and therefore produced marshes and sickness, where there ought not to be either. It should be mentioned, in connexion with certain canals where the greatest amount of unhealthiness had occurred, as referred to by the reader of the paper, and by Dr. Thornton—the Western Jumna canals—that those canals were constructed by the Mohammedan emperors of India, one of them upwards of 500 years ago. One of their endeavours, with very defective means of ascertaining the levels, and so on, was to supply the water on the natural surface of the ground, so as naturally to produce the effect which Dr. Thornton had mentioned. It was given so easily that the cultivators used it in excess, and thus produced a very large amount of malarial marsh, which led to sickness. The canals being raised above the surface of the land produced two effects. The water sank into the ground, and, at certain distances from the canal, it rose again towards the surface. The first effect was the production on the surface of the soil of a saline efflorescence, consisting almost entirely of sulphate of soda, which rendered the soil for the time barren. The next effect of the percolation of water was the production of those unhealthy marshes. The Government having investigated the matter, and having seen how much the excessive irrigation was the cause of sickness, and how much evil was produced by the percolation from the canals which were raised above the natural level of the country, had corrected this old canal by bringing the whole of it "within soil," as it was termed. Facts were being collected, and still more facts were required to enable them to correct the many existing defects of the old canals. He desired to confirm what had been said by other speakers as to the extreme importance to India of an abundant water-supply for cultivation. And as to the subject of the effect of irrigation upon the health of the community, he could assure his hearers that the Government of India was quite alive to the necessity of ascertaining further facts, and of applying further remedies.

M. Maignen said he wished to explain why the death-rate of children was greater when the water was low than when it was high in the wells. The maritime stations of France, from time immemorial, had yearly been afflicted with typhoid fever in the autumn and winter, the time when the recruits arrived. At L'Orient, since precautions had been taken, there had not been one case of admission of typhoid fever to the hospital. Four miles from the port of Brest, where no such precaution had been taken, there had been 250 deaths in a month at one barrack. It was the old hospital of the prison. There were four long sheds, covered in the middle, and between the sheds there were w.c.'s, and a big drain. The water falling from the sheds remained stagnant. It was a plateau surrounded by walls, and there was no escape for the water. There was a central drain at each corner of the four sheds, a well, and a pump, and that was the only supply for the men in the barrack. For 20 or 30 years there were 1,200 men in that barrack, but suddenly the number was increased to 3,000, and from that moment they drew three times as much water; the wells were the natural place for the water and the mud that had been stagnant for 20 or 30 years to flow into, and those unfortunate men actually drank the water that had been stagnant in that superficial area for that time. As the water went lower down in the wells, more water came into the wells from the upper strata. The germs had been long in a dormant state, and deprived of the light which was necessary to the purification of polluted water, and they were only brought to real life when they were subjected to the heat of the body. Two processes of water purification had been referred to, the shaking-up of iron with the water, and sand filtration. That which was done by shaking-up iron and water might be done by other means. It was not a bad method, but it was, he thought, expensive, and the same thing could be done by the cheaper method of throwing a salt of iron into running water. After revolving, the water was sent over into decanting tanks, and exposed to the sun. That, again, was a bad thing, because the light came and helped to multiply the microbes and the vegetable matter, which warmth multiplied so quickly. With regard to sand beds, they well knew that sand beds did not remove all suspended matter. In Berlin, the water was yellow, and by simple, proper, mechanical filtration, that yellow colour disappeared.

Mr. R. F. Grantham, in reply, said he quite agreed with what Mr. Baldwin Latham had said as to the Cambridgeshire Fens. As to the black peaty soil in India, mentioned by Mr. Baldwin Latham, that gentleman had said that it was so stiff that perhaps drainage could not be carried out without great expense. There were very few soils, he should say, stiffer than some of the English clays, and from his own experience he had no doubt that the drainage could be carried out at a reasonable cost, to the immense benefit of those clay soils. With respect to what Dr. Thornton had said as to remedies, he (Mr. Grantham) spoke with all deference as to limiting the quantity of water by measure. He thought if anyone would read Captain Baird Smith's book, on the subject of Italian irrigation, he would find the immense difficulty there was in providing a meter that would really accurately do its work, and measure out the water equally to all parties, or in their respective proportions. That seemed to him one difficulty about limiting the water; but no doubt the lowering of the level of the canal a little below the soil, and making the peasant lift the water a little, would be an immense improvement and an amelioration of the difficulty. In a great many irrigation grounds in this country, subsoil drainage would be of great benefit, although they did not receive an excessive amount of water. He quite agreed with the speaker who said that it was very necessary to look after sub-soil drainage round towns. He had referred to a paper by Dr. Ansted, in which he described the great harm which some lagoons in Corsica created, by the malaria going up from them; the inland towns being healthy, while those parts of the country near the lagoons were much affected by the disease.

Herr Kümmel said that in Altona, with its mechanical sand-filtration and its regular bacteriological examination, it was found that the average was not more than 20 microbes per centimetre, and very often there was no microbe at all. The water of the river had many more microbes than the Seine. The rate of 5,000 was very low, the common rate being 20,000. He therefore believed that mechanical filtration could not be so bad as had often been stated.

Projets pour l'Alimentation en Eau Potable d'une grande partie de la France au moyen de l'Eau des Lacs de Neuchâtel et du Léman.

PAR

M. Guillaume Ritter, Ingénieur, Neuchatel.

Provenance et qualité des eaux.

L'eau du lac de Neuchâtel captée à 100 mètres de profondeur serait celle destinée à Paris et aux villes et villages des départements traversés par l'aqueduc dérivateur, elle pourrait au besoin être distribuée jusqu'aux environs de Rouen.

L'eau du lac Léman ou de Genève, toujours captée à 100 mètres environ de profondeur, serait celle destinée à Lyon et aux villes et villages de la vallée du Rhône ; jusqu'à Orange, elle serait distribuée au moyen d'un grand aqueduc dérivateur central, puis de là, au moyen de deux embranchements principaux, elle serait dérivée du côté ouest jusqu'à Nimes et Montpellier et du côté est jusqu'à Marseille, avec possibilité de la distribuer au delà de ces villes du littoral méditerranéen.

Le bassin hydrographique qui alimente actuellement le lac de Neuchâtel au moyen de l'Aar qui y jette souvent ses eaux par le lac de Bienne, est de 8,331 kilomètres carrés d'étendue.

Le bassin hydrographique du lac Léman est de 7,995 kilomètres carrés.

Donc, le partage entre les deux réseaux de dérivation sera presqu'égal comme puissance d'alimentation, au point de vue de l'étendue des surfaces alimentaires, des bassins récepteurs et de l'eau d'alimentation.

L'eau des lacs suisses, dont il sagit ici, est d'excellente qualité quoiqu'elle soit assez riche en matières organiques, mais celles-ci sont complètement oxydées dans les couches profondes où on ne recontre *jamais* à l'analyse aucune trace d'ammoniaque ni d'azotites, ce qui n'est pas le cas pour les couches très superficielles. La différence de densité entre l'eau des couches superficielles et celle des couches profondes toujours à quatre degrés centigrades en hiver comme en été, rend tout mélange des eaux de surface impossible avec celles à 100 mètres avant plusieurs années, c'est à dire avant une oxydation et une purification infiniment plus complètes que celles des eaux de pluie alimentant, n'importe quelle source souterraine.

La meilleure preuve expérimentale de cette qualité parfaite des eaux est l'expérience faite à Zurich et à Genève depuis plus de 50 années, villes de 60,000 et 70,000 habitants, exclusivement alimentées avec l'eau de leurs lacs, et cependant l'eau y est captée à quelques mètres seulement de profondeur.

Les édilités de ces villes n'ont eu qu'à se féliciter du système d'alimentation adopté, depuis que l'on a éloigné du rivage immédiat les tuyeaux aspirateurs de l'eau; il est vrai qu'il manque à ces eaux la fraîcheur en été, ce qui ne sera pas le cas pour les eaux du projet Ritter captées à 100 mètres de profondeur et ayant quatre degrés seulement de température à leur origine.

La basse température de l'eau permettra de distribuer celle-ci à Paris à 9 ou 10 degrés et à Montpellier et Marseille à 10 ou 12 degrés. L'eau captée dans les lacs si profondément, est presque indemne de microbes ou germes vivants: lorsque M. Ritter a présenté à Paris son projet pour ce qui concerne cette ville, cet ingénieur a prouvé victorieusement, que l'eau proposée, captée de 50 à 100 mètres de profondeur, renfermait considérablement moins de microbes que les eaux de la Dhuis et même que les eaux si réputées de la Vanne employées pour l'alimentation de la capitale.

Dans l'opuscule publié sur ce sujet et rendant compte de la communication de M. Ritter à la Société des Ingénieurs Civils de France dont il fait partie (voir tome d'août 1888 des bulletins de cette société), il se trouve tout un chapitre concernant la démonstration de l'excellence de l'eau des lacs suisses captée à une grande profondeur.

En résumé M. Ritter conclut en disant que l'eau proposée captée dans les conditions de profondeur indiquées ci-dessus, est pour de gros volumes, la meilleure qu'il soit possible de se procurer, car elle est véritablement minéralisée par son séjour de plusieurs années dans les couches profondes, très chargée d'air qui se dégage abondamment quand on la ramène à la surface, enfin parce qu'elle est absolument débarrassée de toute matière organique non oxydée ou en voie d'oxydation comme aussi de tout germe nocif vivant.

Volume des eaux disponibles.

La puissance alimentaire du lac de Neuchâtel sera mise à contribution à raison de 30 mètres cubes par seconde, ce qui représente *un dixième* environ du volume moyen débité par l'Aar avant son entrée dans le lac de Bienne par le nouveau canal de Hagneck.

Avec 30 mètres cubes par seconde d'écoulement, les trois lacs de Neuchâtel, Bienne et Morat, qui en réalité ne feront qu'un seul réservoir, pourront avec une couche de *un mètre* seulement, suffire pendant 138 jours au débit journalier nécessaire de 2,592,000 mètres cubes, soit donc pendant $4\frac{1}{2}$ mois.

Il résultera selon M. Ritter, avec les travaux de parachivement qu'il a prévus dans son projet, des canaux de correction des eaux des lacs du Jura; une amélioration sensible de la navigation; des variations de niveau moins considérables; enfin comme pendant les basses eaux de l'Aar, la réserve des lacs servira seule à l'alimentation de l'acqueduc adducteur des eaux du projet, l'eau de la rivière suffira très largement aux besoins des quelques usines d'aval en Argovie, qui utilisent une faible partie de ses eaux.

Aucune raison majeure ne saurait être mise en ligne pour faire échec au projet, vu le grand bénéfice financier qui résultera pour la

1 p. 2205.

Suisse de l'exécution de l'entreprise projetée, aux recettes de laquelle elle participera.

Pour ce qui concerne les eaux du Léman M. Ritter prévoit également un prélèvement des 30 mètres cubes par seconde, correspondant à un huitième environ du volume débité par le Rhône à Genève.

La France a incontestablement le droit de prélever ce volume d'eau dans le Léman, toutefois un inconvénient grave se produira de ce côté, à savoir que la ville de Genève ayant mis à profit les idées et projets élaborés par M. Ritter lui-même en 1876, a exécuté un vaste système d'utilisation des forces motrices du Rhône, donnant eau force et lumière électrique à la ville; or il résultera de cet état de choses un conflit, vu le détournement des eaux par une autre voie que celle de Genève. Pour éviter ce conflit M. Ritter a prévu dans son projet un moyen de restituer à Genève la force perdue par le détournement des 30 mètres cubes d'eau prévus; conséquemment pas plus à Genève qu'à Neuchâtel l'eau captée dans les lacs n'offrira des inconvénients pour les riverains de ceux-ci.

Mode de dérivation des eaux et particularités relatives au système.

Les projets de dérivation des deux systèmes du lac de Neuchâtel et du Léman comportent d'immenses aqueducs dont les tracés suivent :—

Pour l'aqueduc de Neuchâtel-Paris, la traversée du Jura depuis Auvernier lieu de captation de l'eau, à Maiche dans la vallée du Dessoubre au moyen d'un tunnel, traversée du département du Doubs et de la Haute Saône en passant au sud de Vesoul, de la Haute Marne au sud de Langres, de la Côte d'Or au nord de Châtillon, de l'Aube près de Bar-sur-Seine, de l'Yonne au nord de Seus, de Seine et Marne au sud de Fontainebleau, enfin de Seine et Oise et arrivée à Paris sur les hauteurs de Meudon.

Pour l'aqueduc du Léman la prise d'eau près d'Yvoire fournira l'eau à un tunnel débouchant près de Bellerive dans les gorges du Rhône, de là l'aqueduc longe le Rhône jusque près de Belley, de ce point se dirige sur Vienne au sud de Lyon, longe de nouveau la vallée du Rhône jusqu'au nord d'Orange.

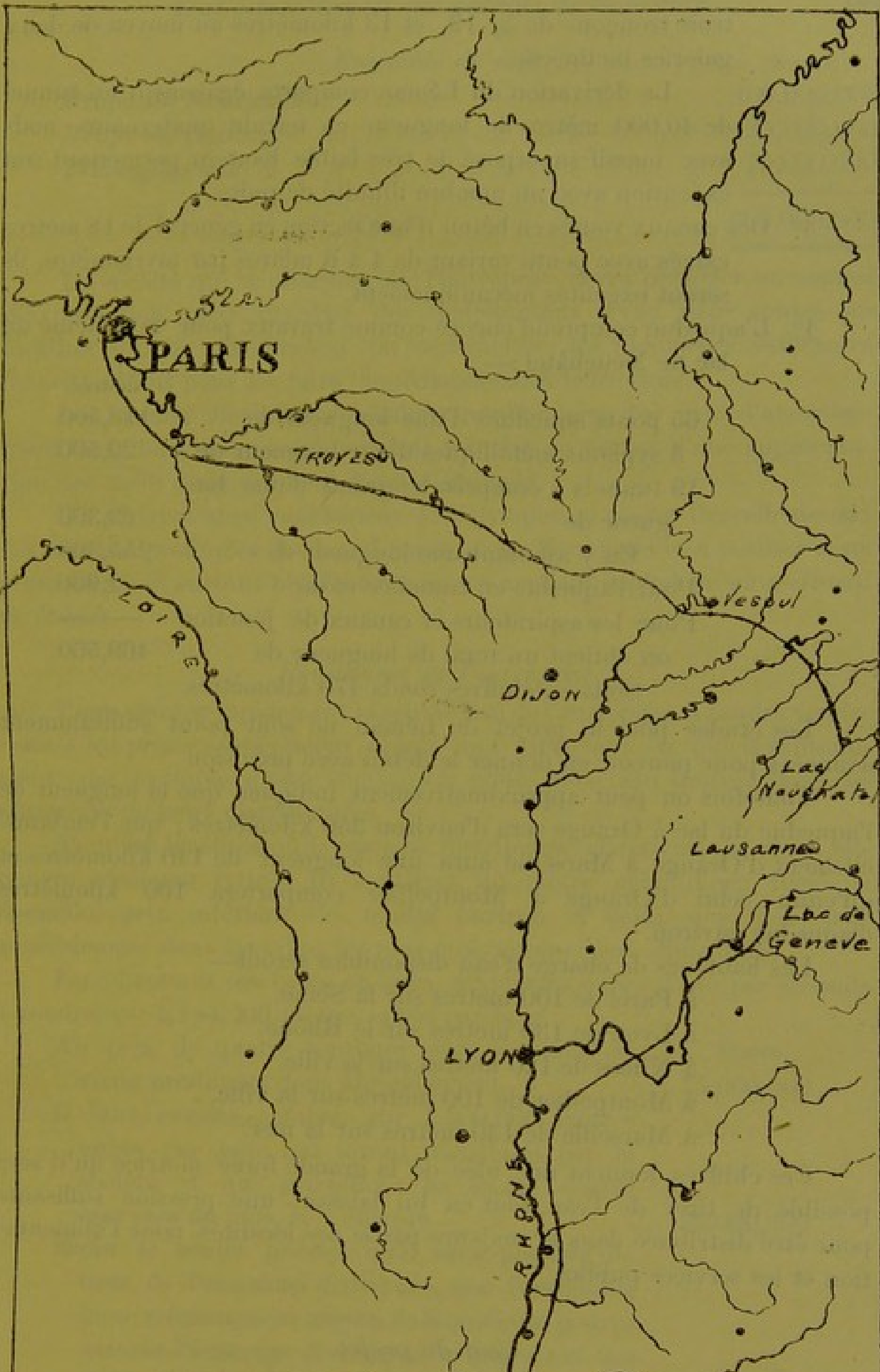
Depuis Orange un embranchement, celui de gauche passe près de Carpentras, l'Isle et Cavaillen dans le département de Vancluse puis s'infléchissant à l'est aboutit à Marseille.

L'embranchement de droite traverse le Rhône, passe au sud-est d'Uzès, quelque peu au nord de Nimes, au nord de Lunel et se termine sur les hauteurs qui dominent Montpellier.

Les travaux des aqueducs comprennent :—

1°. Des tubes métalliques capteurs des eaux qui débouchent dans les aqueducs, ces tubes seront armés de crépines ou cribles gigantesques à roulettes, que l'on pourra périodiquement ramener à la surface pour leur nettoyage.

2°. Des tunnels nombreux, dont un transjurassique de 37,000 mètres pour l'aqueduc du lac de Neuchâtel, qui sera divisé en


PARIS
TROYES
LOIRE
DIJON
Vesoul
Lac Neuchatel
Lausanne
Lac de Geneve
LYON
RHONE
NIMES
Marseille
Toulon

trois tronçons de 5, 19, et 13 kilomètres au moyen de deux galeries inclinées.

La dérivation du Léman comporte également un tunnel de 40,000 mètres de longueur en terrain quaternaire, mais avec massif superposé de très faible hauteur permettant son exécution avec un nombre illimité de puits.

3°. Des canaux voutés en béton d'une section en général de 18 mètres carrés avec pente variant de 4 à 6 mètres par myriamètre, ils seront exécutés mécaniquement.

4°. L'aqueduc comprend encore comme travaux pour le système du lac de Neuchâtel :—

	mètres.
65 ponts aqueducs d'une longueur de -	118,500
5 syphons métalliques d'une longueur de -	29,500
19 tunnels y compris le grand d'une longueur de - - -	63,300
En y ajoutant une longueur de - -	255,300
Pour l'aqueduc en tranchée et de - -	2,960
Pour les aspirateurs et canaux de jonction on obtient un total de longueur de -	469,560

Soits en chiffres ronds 470 kilomètres.

Les études pour le projet du Léman ne sont point suffisamment avancées pour pouvoir en donner le détail avec précision.

Toutefois on peut approximativement indiquer que la longueur de l'aqueduc du lac à Orange sera d'environ 350 kilomètres ; que l'embranchement d'Orange à Marseille aura une longueur de 140 kilomètres et qu'enfin celui d'Orange à Montpellier comportera 100 kilomètres d'aqueduc environ.

Les hauteurs de charge d'eau disponibles seront—

à Paris de 100 mètres sur la Seine.
à Lyon de 130 mètres sur le Rhône.
à Nimes de 120 mètres sur la ville.
à Montpellier de 100 mètres sur la ville. .
à Marseille de 130 mètres sur la mer.

Ces chiffres donnent une idée de la grande force motrice qu'il sera possible de tirer de l'eau, tout en lui laissant une pression suffisante pour être distribuée dans la majeure partie des localités pour l'alimentation et les services publics.

Coût du projet.

	francs.
Le projet de dérivation des eaux du lac de Neuchâtel à Paris coutera avec les intérêts comptés à 3 °/₀ pendant les quatres années de construction -	400,000,000
L'aqueduc de dérivation des eaux du Léman depuis Yvoire à Orange coutera - - -	300,000,000
L'embranchement d'Orange à Marseille coutera -	75,000,000
Celui d'Orange à Montpellier coutera - -	50,000,000
Total - - -	425,000,000

Ensemble du coût.

	francs.
Projet de Neuchâtel - - - -	400,000,000
Projet de Genève - - - -	425,000,000
Frais généraux - - - - -	75,000,000
Total - - -	900,000,000

La société qui se chargera de l'entreprise devra posséder un capital d'exploitation pour installer des distributions d'eau dans toutes les localités qui en désireraient ou auxquelles des ressources suffisantes feraient défaut pour les faire immédiatement à leurs frais.

Les avances ainsi faites seraient remboursées par voie d'amortissement lent, dont les annuités seraient formées au moyen d'une augmentation des taxes d'abonnement d'eau distribuée.

On arrivera ainsi rapidement à distribuer et placer l'excellente eau des couches profondes des lacs Léman et de Neuchâtel et à réaliser cette gigantesque et surtout bienfaisante œuvre avec un capital de *un milliard de francs*.

Rendement de l'entreprise.

Pour assurer rapidement la rentabilité de l'entreprise il faudra vendre l'eau à un prix excessivement réduit aux villes qui en ont insuffisamment, par exemple quatre centimes le mètre cube, eau fournie dans les réservoirs de leurs distributions.

Pour les localités où la société distribuera elle-même ses eaux, elle pourra aisément retirer 10 centimes du mètre cube d'eau livrée à domicile, prix inférieur de moitié environ à celui que l'on paie généralement dans les villes les plus économiquement alimentées.

En admettant ces bases on aura, 60 mètres cubes d'eau par seconde à vendre soit 5,184,000 mètres cubes par jour.

	francs.
Au prix de quatre centimes cette eau mise en vente produirait donc annuellement - -	75,000,000
Il faut ensuite compter sur 1,500,000 mètres cubes par jour qui seront distribués par la société et qui produisont au moins quatre centimes de plus, soit environ - -	22,000,000
Enfin le projet prévoit qu'il sera possible de tirer de l'eau ainsi distribuée, une formidable force mécanique au moyen de laquelle on pourra assurer l'éclairage électrique de la plupart des villes alimentées.	
De ce chef on pourra compter sur une récette de au moins - - - -	5,000,000
Le total des recettes sera de - -	102,000,000
Si de ce chiffre de 102,000,000 francs on défalque pour l'entretien du système, les frais d'administration et généraux, etc. - - -	12,000,000
Il restera net - - -	90,000,000

soit 9 % du capital engagé pour chaque exercice annuel.

Il est bien certain que l'éclairage électrique rendra plus de 5,000,000 car si l'on suppose, que l'on puisse prélever seulement 30 mètres de hauteur sur la chute disponible de Neuchâtel à Paris qui est, de 428 mètres moins 27 mètres, niveaux du lac alimentaire d'un côté et de la Seine de l'autre ; ou que l'on puisse prélever le même chiffre en hauteur sur les 375 mètres de hauteur des eaux du Léman sur la mer, on aurait avec cette chute 60,000 × 30 = 1,800,000 kilogrammètres, soit 18,000 chevaux nets sur l'arbre des dynamos.

Cette force pourra être doublée pendant les heures d'éclairage et alimenter d'énergie 400,000 lampes de 16 bougies, valant 30 f. annuellement l'une, soit donc un chiffre de 12,000,000 annuellement.

Il est encore utile d'indiquer ici, que l'auteur du projet propose d'utiliser parfois la chute d'eau existant entre l'aqueduc et les réservoirs des villes alimentées non pas seulement pour produire de l'électricité, mais aussi pour élever un certain volume de l'eau, dans les quartiers hauts ou même villes voisines plus élévées que l'aqueduc de dérivation.

Ainsi en serait-il à Paris, où Versailles et 65 communes de la baulieue Parisienne, soit plus de 700,000 âmes de population seront éternellement condamnées à ne jamais pouvoir consommer une verre de bonne et pure eau, la ville de Paris comme un vampire malfaisant absorbant et accaparant toutes les eaux des sources environnant la capitale à 200 kilomètres tout autour d'elle.

Tout en alimentant les réservoirs de Montrouge situés à 90 mètres d'altitude on pourra avec l'eau de Neuchâtel arrivant à 120 mètres, utiliser les 30 mètres de chute perdue pour remonter à 160 mètres sur mer, l'eau nécessaire à Versailles et autres localités du la banlieue plus élevées que Paris même.

Il en sera de même dans beaucoup d'autres villes.

Conclusions.

La capitale de la France ruine à tout jamais l'avenir des contrées avoisinantes sous le rapport de l'eau potable, sans jamais pouvoir se satisfaire, l'eau de Seine pendant les mois chauds de l'année est celle consommée tour-à-tour par de nombreux arrondissements de la ville ; l'édilité de cette capitale arrive toujours trop tard, avec des volumes d'eau de source nouveaux, enlevés par voie d'expropriation brutale à des populations qui en ont ou en auront infailliblement besoin un jour, cela sans jamais marcher aussi vite que les besoins nouveaux résultant de l'extension de la ville.

Trente mille maisons ne sont point abonnées aux eaux vu le prix élevé et surtout la mauvaise qualité des eaux souvent distribuées en été.

Les eaux d'Avre que l'on dérive en ce moment ne combleront pas les besoins actuels ; d'autre part M. Ritter prétend que les arrosages des rues pratiqués avec de l'eau contaminée et saturée de vermines microbiennes sont avec l'eau d'alimentation, une cause de la permanence d'action de la fièvre typhoide à Paris.

Cette fièvre dévore à Paris 80,3 pour 100,000 habitants annuellement, et pour la France entière c'est 83,3 pour 100,000, ce qui dit assez ou nous en sommes sous le rapport de la bonne eau d'alimentation, alors qu'en Allemagne la mortalité due à la typhoide n'est que de 20,5 pour 100,000 habitants et en Angleterre, 26,7 pour le même chiffre.

Cet état de grande infériorité de la France doit absolument prendre fin, dit M. Ritter, et il compte sur le concours de tous les Français attachés sincèrement à l'humanité et à leur pays pour lui aider à réaliser le problème *de la bonne eau partout*.

Les 40,000 Français qui meurent chaque année pour cette cause, doivent finalement être rayés de cette lugubre page annuelle de statistique, *il y va de l'honneur de la France.*

Sous ce rapport donc le milliard à employer pour résoudre ce beau projet, pourra tout en rapportant un bel intérêt être appelé le *millard bienfaisant.*

Eindringen von Unreinigkeiten in Druckwasserleitungen.

VON

G. Oesten, Berlin.

Wenn man Wasserleitungsröhren mit innerem Druck in den Boden legt, so pflegt man nicht die Befürchtung zu hegen, dass Stoffe aus dem Boden in solche Röhren eindringen könnten, selbst wenn Oeffnungen in der Rohrwand entstehen. Man wird vielmehr überall die Vorstellung haben, dass, wenn in der Wandung eines gefüllten Wasserleitungsrohrs mit innerem Druck ein Loch entsteht, das Wasser unter allen Umständen mit der dem vorhandenen hydraulischen Druck entsprechenden Kraft ausströmen muss, indem es zugleich jedem fremden Körper den Eintritt verwehrt, und nicht annehmen, dass aus dem das Rohr umgebenden Boden Körper durch die Oeffnung in der Rohrwandung in das Rohr eintreten könnten

Dennoch kann dieser Fall eintreten und kommt in der Praxis der modernen Wasserversorgung vor. Hierzu sind natürlich besondere Umstände erforderiich. Diese können, wie eine einfache theoretische Erwägung lehrt, herbeigeführt werden durch die Art und Richtung des Rohrdefects und durch die Strömungsgeschwindigkeit im Wasserrohr.

Wenn in einem Wasserrohr die in nebenstehender Skizze durch Pfeil bezeichnete Strömungsrichtung besteht, so mag die Geschwindigkeit der Strömung gross oder gering sein, sofern nur das Wasserrohr unter innerem Druck steht; es wird sowohl durch eine Oeffnung in der

Wandung senkrecht zur Axe *a*, wie in stumpfem Winkel gegen die Strömungsrichtung *b* stets Wasser nach aussen austreten, ein Eindringen von Körpern nach innen nicht möglich sein. Anders stellt sich das Verhältniss, wenn der Leck die Richtung *c* spitzwinklich mit der Strömungsrichtung zeigt. In diesem Falle wird, wenn die Geschwindigkeit der Strömung eine geringe oder gleich Null ist, ebenfalls ein Ausspritzen von Wasser aus dem Leck stattfinden; mit der Steigerung der Geshwindigkeit des Wassers im Rohr wird das Entweichen von Wasser abnehmen. Bei einer gewissen Stromgeschwindigkeit wird nach dem Princip des Injectors eine saugende Wirkung des Wasserstrahls eintreten; derselbe wird dadurch fremde Körper in das Innere des Rohrs hineinziehen und mit fortführen.

Fig 1

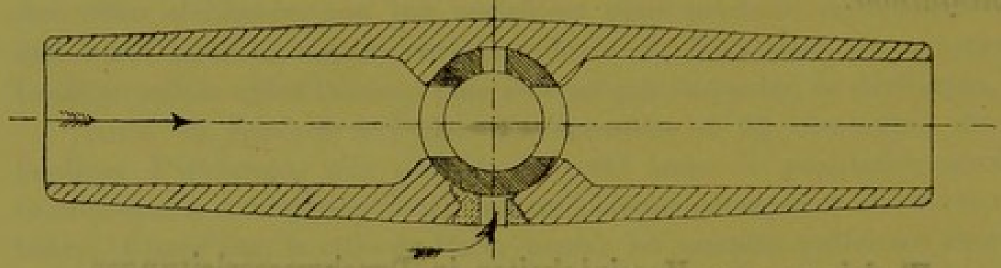


Fig 2

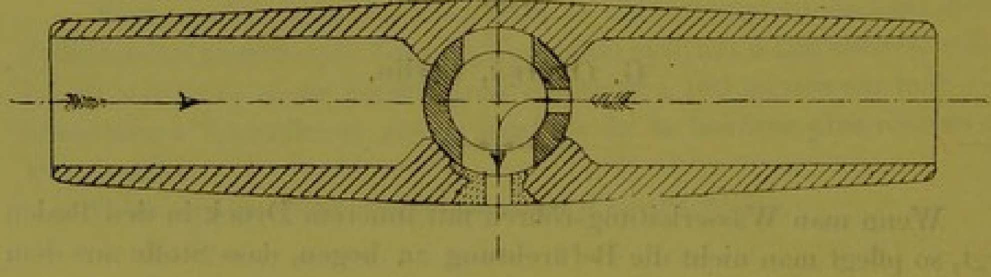


Fig 3

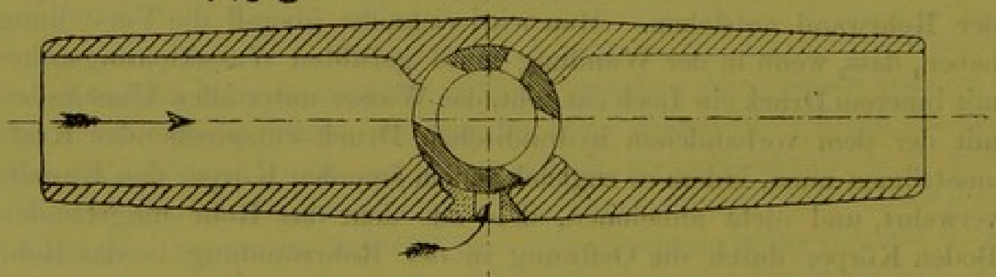
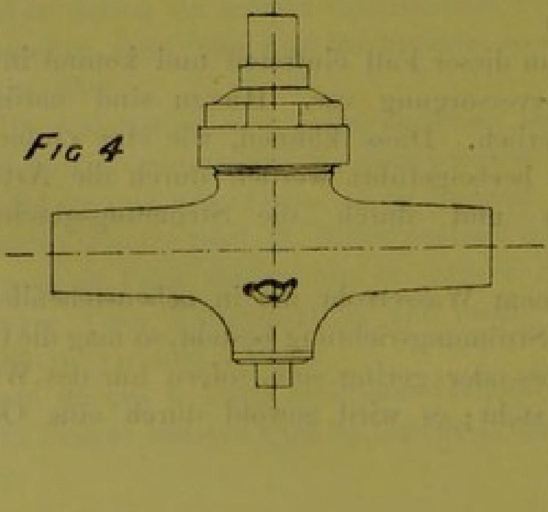


Fig 4



In Wirklichkeit ist dieser Vorgang an dem in Fig. 1–4 abgebildeten Absperrhahn einer Hausleitung in Berlin beobachtet worden. Der Hahn ist ein sog. Absperrhahn mit Entleerung.

In Fig. 1 ist derselbe geöffnet dargestellt; die Entleerungsöffnung in Küken ist hier durch die Wandung des Gehäuses, die im Gehäuse durch das Küken verschlossen.

In Fig. 2 ist der Hahn geschlossen dargestellt; die hinter dem Hahn im Sinne der Strömungsrichtung gelegene Rohrstrecke entwässert sich bei dieser Stellung durch die Entleerungsöffnungen auf dem durch Pfeil angedeuteten Wege.

Fig. 3 stellt eine Mittelstellung des Hahns dar, in der derselbe in der Leitung vorgefunden wurde. Diese Stellung beförderte die Saugewirkung des entstandenen Lecks. Derselbe hatte sich hier als ein kleiner Kanal von der Entleerungsöffnung nach dem Innern des Hahns gebildet. Aus diesem Kanal war zunächst Wasser ausgespritzt und hatte die Entleerungsöffnung im Gehäuse ausgewaschen, wie in der Zeichnung zu ersehen ist. Alsdann aber war bei einer gewissen Strömungsgeschwindigkeit ein Ansaugen von aussen eingetreten und Sand in die Rohrleitung eingeschleppt worden. Dieser Sand lagerte sich wiederholt in den Zapfhähnen des Hauses so ab, dass diese unbrauchbar wurden. Als man dem Ursprunge des Sandes sorgfältig nachforschte, fand man die Ursache.

Es wurde nun das Einsaugen von Sand und gefärbter Flüssigkeit durch den im Hahn befindlichen Leck, sowohl in der Leitung, als auch nach der Herausnahme desselben in der Probiranstalt der städtischen Wasserwerke experimentell ausgeführt und festgestellt.

Aus Vorstehendem ergiebt sich somit die hygienisch nicht unwichtige Thatsache, dass eine Druckwasserleitung unter besonderen Umständen Unreinigkeiten aus ihrer Umgebung aufnehmen und mit dem Wasser fortleiten kann.

Thursday, 13th August 1891.

The Chair was occupied by
The President, Sir John Coode, K.C.M.G.

The Present State of our Knowledge concerning the Self-Purification of Rivers.

BY
Percy F. Frankland, Ph.D., B.Sc. (Lond.), F.R.S., Professor of Chemistry in St. Andrew's University, Dundee.

There is, perhaps, no controversial matter connected with the hygiene of water-supply to which engineers have so frequently had their attention directed as that of the self-purification of river water. Although it is a subject on which most water engineers have a very decided opinion, the present occasion appears to me particularly favourable for reviewing the whole question by the light of the most recent information, especially as we have the benefit of the presence of a number of distinguished colleagues from abroad, whose opinions on this much vexed topic will be very welcome.

The subject of the self-purification of rivers admits of being considered from two perfectly distinct points of view, as indeed do almost all other questions relating to the purity of water, viz., from the chemical and the biological aspects.

Inasmuch as the organic impurities—and the controversy, of course, only refers to organic impurity—gaining access to rivers may be either devoid of life and unorganised, or living and organised, their discussion is in the one case a chemical, and in the other a biological question. Until recently the subject has been only considered from a chemical point of view in consequence of the impossibility which formerly existed of obtaining any precise or accurate information upon such matters of biology.

The firm conviction possessed by many that rivers undergo spontaneous purification in the course of their flow is generally based upon personal observations made upon streams in which the process appears to be going on in such a striking manner that no analytical evidence is required. All engineers are acquainted with streams which are visibly polluted at one spot, and apparently pure a few miles lower down. When such cases are further submitted to analytical tests, the latter, of course, fully confirm the previous ocular impressions. In fact, that such disappearance of organic matter does take place is beyond all shadow of a doubt, and it is mere waste of time to contest it. A bag full of feathers shaken into the air at one spot would similarly be imperceptible a few hundred yards away. That the polluting matter has been destroyed, however, in the course of a few miles flow is almost as improbable as that the feathers should have been decomposed in their short flight through the air. In fact, when these cases of supposed self-purification are carefully investigated, it becomes very doubtful whether the phenomenon is due to anything beyond dilution and sedimentation. The careful experiments which have been made to test this point are by no means numerous.

A series of investigations was made by the Rivers Pollution Commissioners of 1868 to test the point, both as regards highly polluted streams, such as the Irwell, Mersey, and Darwen, and comparatively pure ones like the Thames; but in both cases their results were of a negative character, and pointed to no real purifications, *i.e.*, destruction of organic matter, although there was distinct evidence of considerable improvement in the quality of the water through sedimentation.

Some years ago, I undertook a series of experiments to further test this point in connection with the Thames, which has always been regarded by some as a river possessed of most remarkable self-purifying power, and which undoubtedly often does reach London after a long flow through a cultivated and fairly populated district, in a surprisingly pure state. The experiments in question consisted in taking samples of the water flowing in the river at different points on the same day, with a view to establishing whether on the whole the chemical quality of the water was improved or deteriorated during the course of its long flow. Thus, on one day, samples were taken at Oxford, Reading, Windsor, and Hampton; on another day at Chertsey and at Hampton; and on three different occasions samples were collected both at Windsor and at Hampton on the same day. The results of analysis of these various samples are recorded in the accompanying table, and clearly indicate that the chemical quality of the water undergoes slight but almost continuous deterioration in flowing from Oxford to Hampton. It must be remembered that this deterioration occurs in spite of a very large increase in the volume of the water, a large proportion of which gains access to the river from springs in the chalk and is of the very highest purity. Thus, Mr. Thornhill Harrison, C.E., has determined that the total increase in volume of the Thames between Maidenhead and Thames Ditton was (exclusive of the Colne, Wey, and Mole)—

In April, 1884	- 249,500,000	gallons per day.
On July 8th, 1884	- 49,000,000	" "
July 22nd to 26th	- 131,000,000	" "
November, 1890	- 45,000,000	" "

(Harrison on Subterranean Chalk Water, Inst. Civil Engineers, 1891.)

In the above experiments I purposely limited the scope of my inquiry to the dissolved organic matter so as to avoid the complications arising from the suspended matters, concerning the removal of which by sedimentation there is no dispute. On this account all the above samples were filtered through Swedish paper before analysis. Indeed, it cannot be too strongly pointed out that unless the questions of dissolved and suspended matters are kept wholly distinct in these investigations, no reliance whatever can be placed upon the results.

From the analytical table it will be seen that the idea of any striking destruction of organic matter during the river's flow receives no sort of support from my experiments, the evidence is in fact wholly opposed to any such supposition.

TABLE I.—RESULTS of ANALYSIS expressed in parts per 100,000.

Description.	Total Solid Matters.	Organic Carbon.	Organic Nitrogen.	Ammonia.	Nitrogen as Nitrates and Nitrites.	Total Combined Nitrogen.	Chlorine.	Hardness. Temporary.	Hardness. Permanent.	Hardness. Total.
November 4th, 1883.										
River Thames, above Oxford	30·28	·136	·039	0	·178	·217	1·06	17·09	4·71	21·80
River Cherwell, 500 yards above Thames	36·92	·305	·079	·016	·164	·256	1·44	20·86	6·29	27·15
River Thames, below junction with Cherwell	33·04	·158	·036	·010	·197	·241	1·17	19·43	5·57	25·00
" " below Iffley lock	32·76	·165	·027	·002	·173	·202	1·20	19·16	5·14	24·30
" " below Oxford	31·04	·161	·031	·004	·190	·224	1·18	19·59	4·71	24·30
" " above Reading	33·32	·183	·025	·007	·255	·286	1·23	20·72	6·43	27·15
River Kennet, at junction with Thames	27·80	·128	·036	·008	·215	·257	1·26	19·44	4·86	24·30
" " at Reading	29·24	·125	·030	·014	·220	·262	1·26	21·13	4·57	25·70
" " " near drain-pipe	30·84	·256	·074	·023	·232	·325	1·60	19·73	4·57	24·30
River Thames, just above Windsor	31·80	·224	·038	·001	·219	·258	1·32	20·31	6·14	26·45
" " at Hampton	30·52	·254	·047	·001	·204	·252	1·43	16·99	5·86	22·85
November 17th, 1883.										
River Colne, branch in Staines	36·84	·318	·062	·019	·266	·344	1·45	23·7	3·4	27·1
" " main stream at junction with Thames	31·52	·236	·046	0	·254	·300	1·45	22·8	3·6	26·4
River Thames, above Staines gasworks	32·92	·242	·035	·003	·202	·239	1·33	20·1	5·6	25·7
" " just above Staines	32·40	·230	·036	·004	·194	·233	1·40	19·9	5·1	25·0
" " just below Staines	31·12	·245	·034	·001	·209	·244	1·36	20·8	4·9	25·7
January 2nd, 1884.										
River Wey, at Weybridge	20·44	·270	·085	·030	·223	·333	2·00	9·3	4·7	14·0
River Thames, at Chertsey	34·16	·187	·047	·014	·287	·346	1·45	20·3	4·2	24·5
" " " Hampton	31·92	·186	·035	·008	·281	·322	1·48	17·5	4·0	21·5
January 9th, 1884.										
River Thames, above Windsor	36·68	·197	·045	·003	·193	·240	1·47	20·3	4·2	24·5
" " at Hampton	34·88	·227	·087	·008	·229	·323	1·52	19·1	3·9	23·0
January 13th, 1884.										
River Thames, above Windsor	36·40	·291	·063	·010	·227	·298	1·50	18·8	5·7	24·5
" " at Hampton	33·56	·309	·055	·020	·226	·297	1·52	17·3	6·0	23·3
January 28th, 1884.										
River Thames, above Windsor	28·72	·478	·098	·014	·223	·332	1·7	13·6	6·4	20·0
" " at Hampton	29·76	·451	·082	·024	·222	·324	1·7	13·6	5·3	18·9
River Thames, above Windsor (average)	33·55	·275	·058	·008	·230	·295	1·49	18·66	5·33	23·99
" " at Hampton (average)	32·13	·285	·061	·012	·232	·304	1·53	16·90	5·01	21·91

TABLE II.—RESULTS of ANALYSIS expressed in parts per 100,000.

Description.	Total solid Matters.	Organic Carbon.	Organic Nitrogen.	Am-monia.	Nitrogen as Nitrates and Nitrites.	Total Com-bined Nitrogen.	Chlorine.	Hardness.			Number of Colonies obtained on cultivation of one cubic centimetre of Water.
								Tem-porary.	Per-manent.	Total.	
No. 1.—Taken from River Ure, above Ripon, 27 miles above intake of York Waterworks. The River Ure rises on the western extremity of the North Riding of Yorkshire, passing on its way only small towns and villages	24·08	0·108	0·020	0	0·075	0·095	1·1	13·4	4·9	18·3	1,800
No. 2.—Collected about 16 miles above intake of York Waterworks, and about 3 miles below Boro'bridge, and 10 miles below Ripon, both discharging some sewage into the Ure	31·20	0·118	0·028	0	0·123	0·151	1·6	12·9	7·1	20·0	33,400
No. 3.—Collected from River Ouse opposite the intake of York Waterworks. Between the point of collection of No. 2 and this sample there is no town and only one small river, the Nidd	28·40	0·123	0·025	0	0·077	0·102	1·6	11·5	7·1	18·6	31,200
No. 4.—Sample of water as supplied to York by the York Waterworks	26·20	0·119	0·022	0	0·089	0·111	1·6	10·9	7·1	18·0	122

I have also had an opportunity of making a somewhat similar experiment on the flow of the Ure and Ouse above York, the results of which are recorded in the preceeding table.

In this experiment also, there is not the slightest support to the theory of self-purification. Nor is there any diminution in the number of microbes during the observed flow.

Of foreign investigations on the same subject, there are those of *Hulwa* on the Oder at Breslau (Chemical News, 1883, 104; Biedermann's Centralblate für Agriculturchemie, XIII., Pt. I.), of *Frank* on the Spree at Berlin (Zeitschrift für Hygiene 1887, III., 355), and of *Prausnitz* on the Isar at Munich (Centralblate für Bakteriologie 1890, VII, 404).

Of these investigators, Hulwa professes to have traced the complete purification of the Oder from the sewage of Breslau after a flow of 32 kilometres. It is impossible to make any use of these results without a knowledge of the changes which the volume of water in the river undergoes during this flow.

A most complete account of the condition of the Spree during its flow from Berlin to Potsdam is given by Frank, full account being taken of the changes in volume during the course.

The results arrived at by Frank are, however, very different from those of Hulwa, for Frank maintains that the change in chemical composition is very insignificant throughout, but that the number of microbes undergoes a most striking diminution during the flow, a result which he naturally attributes to sedimentation. Already, in 1885, I had myself ("On the Removal of Micro-Organisms from Water," Proceedings, Royal Society 1885, No. 238) shown to what an astonishing extent micro-organisms are removed in the subsidence of solid particles; this I had proved, not only in the case of laboratory experiments made with the most varied materials, but also on the large scale in the softening of water by Clark's process. The disappearance of the microbes in the water of the Spree during its sluggish flow through the lake-like expansion which it forms after junction with the Havel at Spandau, above Potsdam, is obviously due to causes of a similar kind. In the experiments of Prausnitz on the Isar at Munich, there is the same disappearance of microbes during the flow, which is again attributed to sedimentation.

A careful study, therefore, of these most recent investigations leads us to the inevitable conclusion that sedimentation is the main cause of any self-purification in river water. Of any rapid oxidation of dissolved organic matter there is still no reliable evidence, although of course dilution, which frequently takes place on the largest scale, as in the case of the Thames, without being suspected until made the subject of a most careful scrutiny, will produce a superficial appearance of such a result.

This removal of microbes by sedimentation during the flow of a river is unquestionably of great hygienic importance, and of much greater hygienic importance than the alleged oxidation of dissolved organic matter, which in itself can have no power of communicating zymotic disease; it is, however, a process which cannot be relied upon as furnishing any guarantee that harmful microbes, turned into a stream at a given point, will no longer be present in the water at any point lower down.

From the numerous experiments which have been made on the vitality of pathogenic microbes in water, there can be no doubt that many forms which might have subsided as above indicated, would remain alive for long periods of time, and be carried down uninjured when the river was next in flood. Indeed recent experiments of Lortet (" The Pathogenic Bacteria of the Mud of the Lake of Geneva," Centralblatt für Bakteriologie, IX., 709) have shown that such deposits formed in lakes actually, and not unfrequently, contain pathogenic forms in a state of vitality.

We must not allow, therefore, this sedimentation of microbes to cause us to relax our protective measures to exclude contamination from our streams; but on the contrary, bacteriological research clearly indicates on the one hand, the value and importance of purifying by the very best available means all dangerous liquids, such as sewage, before admission into rivers, and, on the other hand, the advantages to be secured by submitting the water drawn from streams for town supply to the most careful subsidence and filtration through sand before delivery.

Abkuhlung des Wassers durch Anlage von Kühlschächten.

VON

Professor A. Oelwein, Vienna.

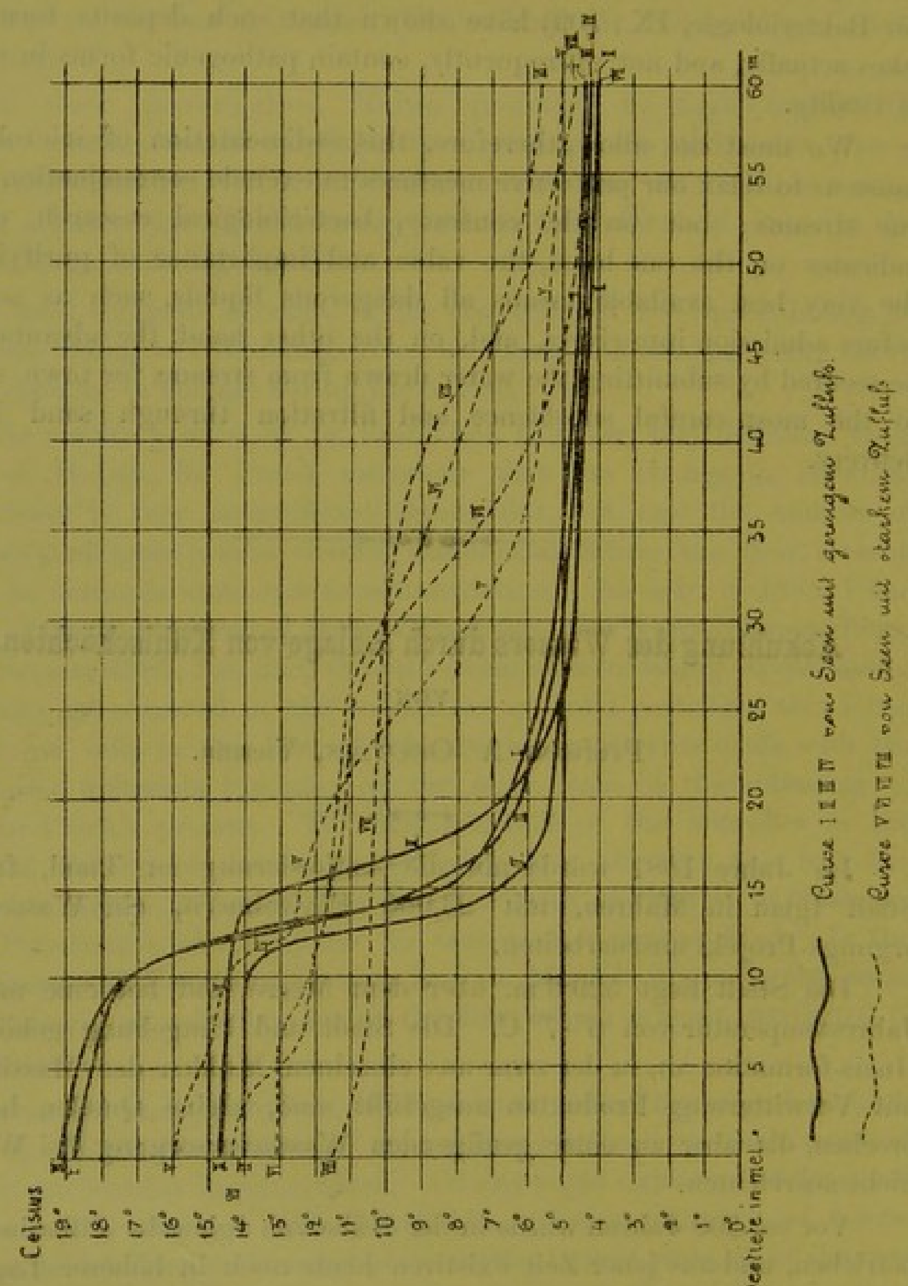
Im Jahre 1887 wurde mir die Aufforderung zu Theil, für die Stadt Iglau in Mähren, mit 23,000 Einwohnern, ein Wasserversorgungs-Projekt auszuarbeiten.

Die Stadt liegt 529·6 m. über dem Meere und hat eine mittlere Jahrestemperatur von 6°–7° C. Die Stadt und Umgebung gehört der Gneis-formation an, in der zwar aus einzelnen Mulden des Massifs, die mit Verwitterungs-Produkten ausgefüllt sind, kleine Quellen hervorbrechen, die aber zu einer genügenden Wasserversorgung bei Weitem nicht ausreichten.

Vor ca. 300 Jahren wurde in der Nähe von Iglau der Silberbergbau betrieben, und aus jener Zeit existiren heute noch in höherer Lage als die Stadt Teiche, die damals das Wasser zum Betriebe der Pochwerke sammelten, und aus denen die Stadt durch eine Holzrohrleitung auch Wasser bezog. Dieses Teichwasser erreichte jedoch im Sommer eine Temperatur bis 23° C., und nahm in Folge der Verwesungsprodukte, meist vegetabilischen Ursprungs, eine bräunliche Farbe und sehr üblen Geruch an. Die chemische und bacteriologische Analyse bezeichnete dieses Teichwasser als ein zum Genusse und Gebrauche *nicht brauchbares.*

Diese Teiche, vier an der Zahl, von 24·9 Hectaren Fläche, liegen, 3 Kilometer von der Stadt entfernt, terrasenartig übereinander. Der unterste Teich liegt 23 m. über dem höchsten Punkte der Stadt. Die grösste Tiefe derselben betrug nur 4·2 m. Sie fassten zusammen 483,000 m³, theils Niederschlags-, theils Quellwasser. Das Niederschlagsgebiet aller Teiche beträgt 368 Hectar, die mittlere Niederschlagshöhe im 10-jährigen Jahresdurchschnitt war 579·5 mm.

FIG. 1.—ABNAHME DER TEMPERATUR NACH DER TIEFE IN ALPENSEEN.



Da mir kein anderes Wasser zur Verfügung stand, entschloss ich mich, diese Teichwässer wieder zu verwenden, die Teiche zu reinigen und das Wasser zu filtriren. Diese Anlage ist seit Anfang 1888 im Betriebe und funktionirt gut. Das Wasser ist durch die Filtrirung

Fig. 2.—Schnitt durch den Kühlschacht in ABCDEF.

ganz rein geworden, und die chemischen und bacteriologischen Analysen erklären dasselbe für *ganz tadellos.*

Ueber die Filteranlagen, Reinwasserkammern, das Rohrnetz, etc. ist nichts neues mitzutheilen,—dagegen über die Anlage, die ich zur Kühlung des Wassers anwendete, und die sich sehr gut bewährt.

Professor Dr. Fr. Simony hatte 1879 einen Vortrag über die Art der Temperaturabnahme in Alpenseen gehalten. Aus den von ihm publizirten Ziffern, die ich in dem folgenden Graficon aufgetragen habe, ergab sich die interessante Schlussfolgerung, dass die Abnahme der Temperatur nach der Tiefe bei Seen mit geringem Zu- und Abfluss, die also ein wenig bewegtes Wasser haben, in einem ganz andern Verhältnisse erfolgt, als bei Seen mit starkem Zu- und Abfluss, also mit einem stark bewegten Wasser.

In ersteren Seen fällt die Temperatur von 10 m. Tiefe an rapid, erreicht ein Maximum bei ca. 20 m., um dann nur noch bis 60 m. Tiefe 2–3° C. abzunehmen. Ganz anders bei Seen mit stark bewegtem Wasser. Da nimmt die Temperatur bis 60 m. Tiefe allmälig und fast proportional mit der zunehmenden Wassertiefe ab.

Ich habe die gleiche Erscheinung noch bei vielen Messungen in Baugruben, Brunnen, tiefen Teichen und Seen constatiren können, dass bei wenig bewegtem Wasser die Temperaturabnahme in Sommer von 10–20 m. Tiefe eine plötzliche und relativ sehr grosse ist und entschloss mich, bei der Iglauer Wasserversorgung den praktischen Versuch zu machen, einen Schacht im untersten Teiche künstlich auszuheben, um das Wasser dann durch Röhren aus der Tiefe dieses Schachtes durch den hydrostatischen Druck der darüber befindlichen Wassersäule auf die Filter zu leiten.

Beifolgende Skizzen veranschaulichen die Anlage.

Dieser Schacht ist im Gneis gebrochen, und wurden die gewonnenen Steine zum Mauerwerk verwendet. Leider konnte der Schacht aus finanziellen Gründen nur eine Tiefe von 17·3 m. unter dem höchsten Wasserspiegel erhalten; der Erfolg dieses

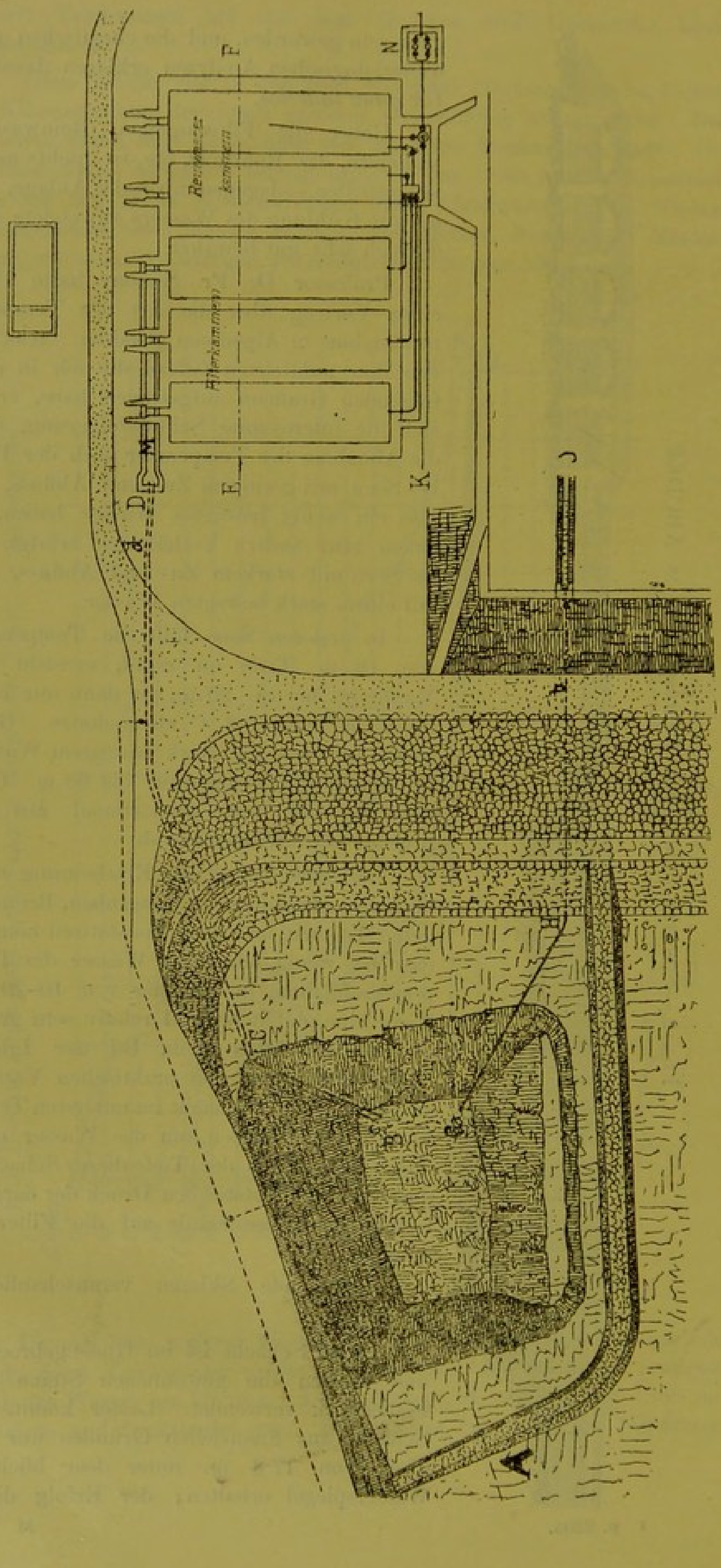


Fig. 3.—Situation des Kühlschachtes.

Kühlschachtes hat aber trotzdem die Voraussetzung vollkommen bestätigt.

Der Kühlschacht fasst bis zur Teichsohle eine Cubatur von rund 9,000 m.^{3} Der Wasserverbrauch wechselt Winter und Sommer von 600-800 m.^{3} per Tag und steigt zeitweise bis 1,000 m.^{3}

Seit 1888 ergaben sich fast unverändert die gleichen Resultate.

In dem folgenden Graficon sind die im Jahre 1888 beobachteten Temperaturen des Wassers im Teiche, 1 m. unter dem Wasserspiegel gemessen, und des aus der Tiefe des Kühlschachtes aufsteigenden Wassers ersichtlich gemacht. Die folgenden Jahre geben ein ganz analoges Bild.

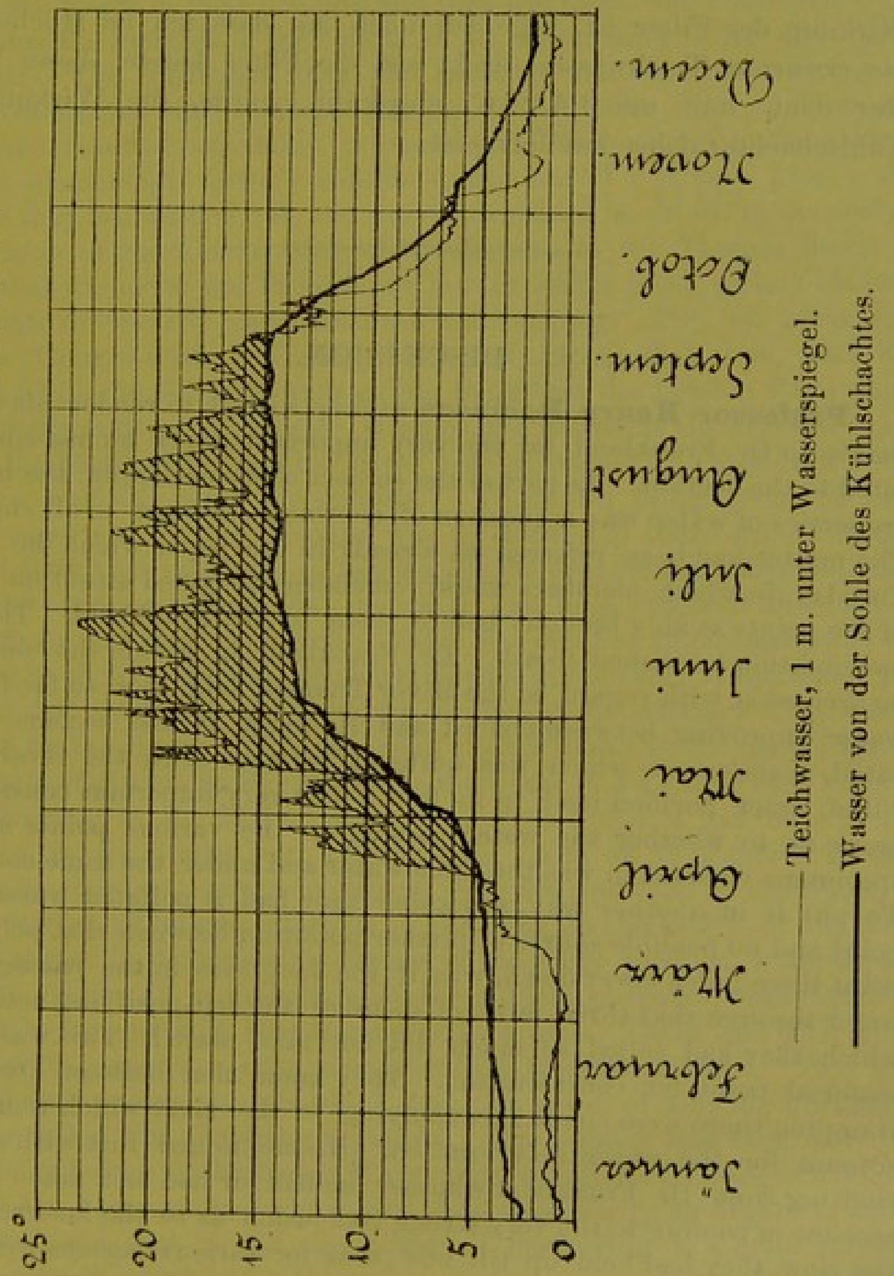


Fig. 4.—Temperatur-Differenzen in Graden Celsius.

Die grösste Temperatur-Differenz tritt im Hochsommer ein, wenn die Teichwässer die Temperatur von 20° C. überschreiten, und zwar bis zu 9·6° C. Die grösste Differenz wurde mit 10·5° C. bei einer Teichwasser-Temperatur von 22° C. beobachtet.

Ich bedauere nur, dass der Kühlschacht nicht mindestens eine Tiefe von 20 m. erhalten konnte, da ich überzeugt bin, dass diese Differenz dann noch um 2–3° C. grösser gewesen wäre.

Der Ingenieur kommt oft in die Lage, im Tieflande Teiche und Thalsperren zu Zwecken der Wasserversorgung verwenden zu müssen, denen er keine grössere Wassertiefe geben kann, als 4-5 m. Dann hat er es im Sommer stets mit sehr erwärmtem Wasser zu thun. Hier ist ein Mittel ohne grosse Kosten gegeben, dieses Wasser auf natürlichem Wege zu kühlen. Deshalb glaubte ich auch, dass die von mir angewendete Methode viele meiner Collegen interessiren wird.

Um etwa dem Einwurfe zu begegnen, dass diese Abkühlung eine Wirkung der Filter ist, füge ich noch an, dass ich im Hochsommer das erwärmte Teichwasser direkt auf die Filter leitete, dieses Wasser aber dann nur um 1·5-2° C. abgekühlt wurde, die Wirkung des Kühlschachter daher zweifellos ist.

DISCUSSION.

Professor Henry Robinson said he wished to render his meed of thanks to Dr. Frankland for the very important paper he had communicated to the section. As part of the subject of water-supply, the hygienic properties of water was a question of enormous interest to all engineers. The matter had been referred to already in the paper which he read on Tuesday, in which members would remember he called attention to some of the points so ably brought before them by Dr. Frankland. There was one question he wished to ask. Dr. Frankland, in giving the conclusions he arrived at with regard to the River Thames, said, that so far from the water improving between Oxford and Hampton it had become deteriorated, a statement which was quite at variance with the theory that a rill of water purified itself in its flow. The very important consideration arose as to whether the water passing at the various points at which specimens were taken was the same water and under the same conditions. To put it in another way, supposing they had a polluted water at one point and no possible source of further pollution between that point and a point three miles lower down, was it the fact that in the passage of the water through that three miles of distance the self-purifying action upon which they had relied so much did not take place? This was a most material point for consideration. They knew that between Oxford and Hampton there were conditions applying to the river which would quite account for the water deterioration. He mentioned this with a view of eliciting from Dr. Frankland whether he had or had not taken that into account in coming to the very strong conclusion as to the incorrectness of the view they had held up till now, that for various reasons with which they were all familiar, a river would in the course of its flow purify itself to a very great extent. That was the view engineers had held up till now, and he ventured to think that unless they had some strong proof that the condition of things which Dr. Frankland had referred to was at variance with that view, he should keep an open mind upon the subject.

Mr. Baldwin Latham said Dr. Odling had put this matter very tersely when, in a discussion on the previous day, he said that the diseased germs were ultimately destroyed when they went into flowing water, and that the only question which arose was as to the destructibility and regeneration of the spores of those germs. With regard to Dr. Frankland's experiments, he wished to draw attention to this very remarkable fact, that the analyses did not represent the same water. They were taken simultaneously throughout the river, and, as it took several days for the water to flow from Oxford to London, it was utterly impossible for the analyses which had been given to be analyses of the same water; and until they got results dealing with absolutely the same water, it was quite futile to say no purification took place in a river. The State Board of Health of Massachusetts had recently made a most elaborate investigation of all the rivers in their district, and they had taken into consideration, by gauging, the increase of the volume of all those rivers in the most careful manner. The conclusion they had come to was that there was a considerable degree of this self-purification taking place after all these other contingencies had been taken into account. With regard to the sedimentation, of course, if matters subside in the bed of a stream, when a flood comes they are washed out, and the result should be shown in the analysis. The most extraordinary thing with reference to the Thames floods was this, that whenever the Thames got into excessive flood, certain classes of chemists universally condemned the water-supply. The last great floods of the Thames were in January 1877, and during that time, week after week, while the chemists were telling them that the London water-supply was totally unfit for all dietetic purposes, the Registrar General was reporting "the health of London has never been surpassed; all classes of disease "are a long way below the average." Those two things occurred in the same reports when the Thames was in flood, and therefore, although it might show that there was an increase in the organic and other impurities in water, it did not show that the water had been rendered unwholesome or unfit for the people to drink. There was another important point with regard to cholera and the germs which pass into rivers; it had never been shown that cholera passed down a river, but on the contrary it universally passed up the rivers. This was most clearly shown in the case of the last epidemic of cholera in Egypt, where there was not a single case recorded as occurring in the higher parts of the river until it had been first developed in the lower part of the Nile. And so it occurred in other districts, showing that the impurities were not conveyed by the water, but were carried by human intercourse, as a rule, up the valleys of the rivers. With regard to the biological aspects of the water question, it appeared to be the fashion, if a multitude of these little microbes were found in a water, to suppose that that water was injurious. There had been a great deal of discussion in recent years about the friendly microbe. They knew that there was an organism which had the power of altering nitrogenous matter called the nitrifying organism. The subject had been more fully worked out since by Professor Warrington and Messrs. Lawes and Gilbert, and it had been conclusively shown that that nitrifying organism existed in water, and that it had the power of destroying to a great extent all those matters which had hitherto been looked upon as injurious. A certain amount of nitrogenous matter must be necessary for the existence of these friendly microbes, and therefore the presence of a certain amount of nitrogenous matter might have a direct beneficial effect in providing food for those organisms which probably were the destroyers of those other organisms which were so destructive to human life.

Mr. Church said that in the papers read yesterday, and also in that read by Dr. Frankland, the question seemed to have arisen whether rivers purify themselves throughout their course, or whether the contrary was the fact. He might, perhaps, give a somewhat important instance on a grand scale of the purfying or non-purifying effect of a great river. He alluded to the upper valley of the Madeira River in the Amazon, with which he was very familiar. That had an area of some 200,000 square miles above the falls of the Madeira. Perhaps 3,000 miles of smaller rivers concentrate at the head of a series of falls, cataracts, and rapids, which for 300 miles continued along the course of the Madeira River. That upper valley, during about three months of the year, was largely flooded to a depth of from two to three feet, or, perhaps, from one to four feet over 40,000 or 50,000 square miles. When the rains commenced to raise the river waters and flood the country they naturally washed off the vast area, and all the sediment and organic matter were concentrated upon the head of the falls. That was the most unhealthy period along the line of the falls, and it continued perhaps for a month or six weeks. Then, while the rivers were high, and the floods existed over the land, it became more healthy. Afterwards, when the floods subsided and the land appeared again, there came another very unhealthy period; and again, in the dry season, it might be said that the country was very healthy. It was notable in that stretch of 300 miles of river which was broken by cataracts and rapids, that at each fall it was very unhealthy; the intermediate stretches of the river were comparatively healthy; and he had noticed that it grew more and more unhealthy as they descended the river, until they reached the last fall of San Antonio, which was almost pestilential. That would seem to carry out the theory that the river did not become more purified as it descended. There might, however, be some reason for this other than the mere flow of the water, viz.: that the main ridge of mountains which ran across Brazil stopped at the falls of the Madeira, and impeded the winds which went up the Amazon from purifying the air at that point. This also was, perhaps, interesting with regard to malaria. From certain observations he had made in the Amazon Valley with regard to malaria, he did not always find that a swamp was more unhealthy than high land; on the contrary, some swamps were more healthy than the high grounds. Then again, if they took 50 acres of ground, felled the trees, and burnt the vegetation, in the course of two or three years a very unhealthy spot might become very healthy; but, strange to say, a period of two or three years might afterwards occur during which it went back to its old unhealthy condition. With regard to the sediment in these waters, the Madeira had affluents which contained a great deal, but it also received some clear-water rivers, notably that which formed the boundary line between Bolivia and Brazil. That river was almost as clear as crystal, but all the Indians and the savages there avoided drinking its waters if they possibly could, preferring the turbid waters of the other rivers. He had noticed that fact also in his own country, in the Western part of the United States on the Missouri River. At Council Bluffs, in ordinary normal times two gallons of water would deposit a pint of sediment, and yet it was considered much healthier than the clear waters of some streams that flowed into it.

Herr W. Kümmel (Hamburg) drew attention to a series of experiments made in two places in Germany on the same subject as that dealt with in Professor Frankland's paper. The first related to an examination made by the Imperial Board of Health in Mecklenburg, as to the condition of a small river; and the second, to experiments made by chemists of the town of Frankfort-on-the-Maine. The Board of Health of Mecklenburg were invited to make experiments with the water of the River Nebel, because the town of Rostock made complaints against the town of Gustrow that they were polluting the river with sewage water. The town of Rostock took its water-supply from the Warnow. The Nebel runs into the Warnow, and the town of Rostock said their water was polluted by the sewage water of the City of Gustrow. The Imperial Board of Health sent a committee to investigate this matter, including an eminent biologist, and these gentlemen made a trip up the Nebel and Warnow from Rostock to Gustrow, a distance of about 80 kilometres. They tested the water at various places from above the town of Gustrow down to the Rostock waterworks. They found that, though the town of Gustrow deteriorated the water very much, and that the water two kilometres below was deteriorated much more by a large sugar manufactory, the number of microbes above the town of Gustrow and that 25 kilometres below the town, and below the sugar manufactory, was nearly the same; that whilst in the interval the number of microbes had increased to 48,000 in a cubic centimetre, the number was again reduced to about 200; and at last, just above Rostock, where the river was said to have been deteriorated by the sewage of the town above, the number of microbes was less than it was above the town of Gustrow, and no town at all was situated above the point where the first test of the water was taken. This experiment was made twice, once during the summer and the second time in October last. The result of the inquiry had been that the Imperial Board had declared the town of Gustrow might send its sewage water into the river. A subsiding reservoir would be made 300 metres in length, and the effluent run off into the river. The account of the second series of experiments in Hamburg and in Frankfort, was published in the last number of the "Deutschen zeitschrift des Vereins für offentlishe Gesand heitspflege." He was sure Professor Frankland could not have read that paper, because it was only published last week. The result of the experiment in Frankfort showed that there was no difference at all in the number of microbes, although the sewage-water was passed through very long subsidence reservoirs; that the number of microbes remained absolutely the same, whether the sewage water had been treated with lime or not. The conclusion arrived at was, that the only way to purify sewage-water was to precipitate all the things which were suspended in the water, and for this purpose a very slow flow and a long subsiding reservoir answered best. This was nearly the same result as that arrived at by Professor Frankland.

Mr. A. Mault said he agreed with Mr. Baldwin Latham, that from an engineering point of view the experiments conducted by Dr. Frankland were hardly satisfactory for proving the conclusions to which he appeared to have arrived; it being evident that the same or similar water was not analysed down the course of the River Thames. To arrive at any satisfactory result it would have been desirable to take the water at Oxford, and again before any further great source of pollution, such as at Reading, had been passed, and to have noticed what had taken place in the water as it went down from one great source of pollution to another.

There would have been no great difficulty in doing that because, as Dr. Frankland had pointed out, there were sources, perhaps, not of purification exactly, but of dilution that were continually entering the Thames. He seemed to make a point that, notwithstanding those sources of dilution, the water was chemically getting worse and worse; that was, the water as tested at points greatly distant one from another; but he (Mr. Mault) felt certain that although these sources of dilution were very considerable, the sources of pollution that were passed increased in a greater ratio even than the sources of dilution. Another point he should like to get a little information upon was as to the ultimate result of purification by sedimentation; were the organisms, whether in a state of perfect vitality and activity, or in a state of spores, finally got rid of by being deposited? As Mr. Baldwin Latham said, to some extent, certainly, they were brought on again in the case of floods; but he could not help thinking, from an ordinary common-sense consideration of the thing, that something else must be continually taking place; also that the beds of sediment must to a certain extent become nurseries and breeding places for the supply of organisms lower down. He did not know, without further consideration, how the matter could be tested as to what effect these sedimentary beds had on the quality of the water lower down the river. That was a point on which it was exceedingly desirable that some information should be obtained if possible.

Dr. Solomon Smith (Halifax) said there were two diametrically opposed propositions before the meeting, both supported by experiment and observations. It seemed obvious that there must be an error in one or the other series of experiments, or in their interpretation; and he confessed to the belief that the error was on the side of the interpretation. The result of Dr. Frankland's experiment and investigation was that there was, as regards the soluble material in the river, a slight deterioration as the river progressed; but that all the time the water was charged with a slowly soluble material. If it were not the case that during the flow a gradual purification was constantly taking place, the later observations at the lower part of the river would show a very much worse result than it did; but the fact was that, coincidently with the process of purification, a process was also going on of fouling by the gradual solution of the slowly soluble materials which were flowing down the stream. That had not been pointed out, and his sole reason for rising was to point out that it was a constant and necessary source of error. If the water was carrying down unsedimented slowly soluble material, which it certainly was; and if all the time that material was being dissolved and tending to make the water foul; and, if at the end of its course it was only slightly fouler than it was before; he believed that in the course of its flow, although the ultimate result was a slight increase of foulness, there had been going on a continuous process of purification to prevent it becoming very much more foul than it had ultimately become.

Mr. Anderson (Bremen) said he wished to place a few facts before the Section. The first was, that at Bremen there was a large stretch of mud which had always been offensive during hot weather as long as he had known it. Whether it was still so he could not tell, as he had not been there for seven years. The second fact was an observation he made in Berne, and possibly the delegate from Berne could explain it. On the River Aar, flowing round Berne to the western side, there was a slaughter-house, and from that slaughter-house the blood ran into the

Aar. Going a little further down the river, all traces of the blood seemed to be lost, and the water looked as fresh and sparkling as champagne. He suggested whether the fish life and plant life had something to do with the purification. He wished also to mention another thing which he had seen under the guidance of Professor Faraday, who showed him how water could be kept pure without any foulness whatever by keeping the plant life and the animal life in balance; that the water in an aquarium need not be changed at all by keeping these in proper balance.

Mr. J. R. Morse asked whether boiling the water destroyed the microbes, or whether they would resist its action? It had been his habit for many years to boil all the water used in his house first, and then filter it afterwards. That appeared to be a prudent course.

M. Maignen, in reply to a question asked by Mr. Anderson, said it was a case of the survival of the fittest, and when there was no more to eat the survivor died himself. That was to say, if they put vegetable matter or animal matter in water and let it alone, fermentation would take place. The time came when the fermentation was finished for want of material. It was the old story. Ships took water from the Thames, and, after a time the water became putrid, and then after a time it was again perfectly sweet. With regard to boiling water, he had in his hand a pamphlet which appeared two months ago in Paris, and these were the exact figures given as to the effect of boiling upon bacteria. If the water was kept for 10 minutes at 130° cent. the water was perfectly satisfactory; but if it only remained five minutes it was not. At 120° it required 15 minutes; and at 10 minutes it was not satisfactory. Therefore, for destroying bacteria, they required to have a closed vessel and to keep the water at 130° cent. for at least 10 minutes.

Dr. Percy F. Frankland in reply, said he felt some hesitation in bringing this paper before the section, inasmuch as it was a subject of considerable antiquity, but it was also a subject on which there was still a very large amount of light required. He very much regretted not having heard Professor Robinson's paper, but he gathered from his remarks, that he was on the whole entirely in accord with what he (Dr. Frankland) had said. The only point on which he apparently differed, was that he considered they had not adequately taken into consideration those pollutions which entered the river between Oxford and London The same point had been raised by other speakers, and it was contended that the mode of experiment, was not a satisfactory one. Of course it was very easy to pick holes in a method of experiment, but it was not so easy to suggest better ones; and he observed that not one of the speakers had indicated a method of examining Thames water which had anything to recommend it in preference to his own. It was absolutely impossible, practically, to take a stream and examine the same water at two different points. There was hardly any stream to be found in which either the volume was not increased, or fresh pollution had not come into it along its course. Some method of compromise had therefore to be adopted, and he believed the method he had employed was as satisfactory a one as could be found. He examined the water at different points, on the same day, and repeating those experiments on a number of different days he took the mean of the results, so that it might fairly be said that the figures obtained represented the relative quantities of impurity in the river at different points along its course. As a matter of fact, the pollutions which entered the Thames came principally along the tributaries, and those tributary streams were themselves already polluted to a certain extent. He might point out that there was no very striking pollution of the River Thames all the way down. The River Thames was one of the best protected streams that could possibly be found, and the work of the Conservancy had improved it enormously within the memory of even the youngest amongst them. The tributaries, although some of them were slightly more polluted than the river, were only very slightly so; so that each of the pollutions entering the Thames between Oxford and London brought with it a corresponding quantity of water, or very nearly so. In addition, however, to these pollutions which came in along with a corresponding quantity of water, and therefore not perhaps interfering with the general quality of the stream, they had an enormous volume of water, as the experiments of Mr. Thornhill Harrison conclusively proved, of the very purest character that it was possible to find upon earth, namely, the spring-water from the chalk beds over which the river flowed in many parts. There was a point raised by Mr. Baldwin Latham which he could not allow to pass without an observation, and that was as to the ultimate fate of pathogenic organisms which might enter the river. Mr. Baldwin Latham referred to a statement made by Dr. Odling in a previous discussion. He (Dr. Frankland) unfortunately had not the opportunity of hearing what Dr. Odling said, but he might surmise what he did say, being acquainted with the experiments upon which he would base his remark. Those experiments were made by Professor Odling, Mr. Crookes, and Dr. Tidy, some years ago on the effect of introducing the bacilli of anthrax, a well-known disease caused by micro-organisms of a particular kind, into water. They found that these bacilli of anthrax underwent very rapid destruction in water. Performing a perfectly similar experiment he had himself obtained a similar result, but with one point of difference. The bacilli of anthrax, as every novice in the study of bacteriology knew, were capable of producing spores. Those spores, or eggs as they might be called, were possessed of enormously greater powers of endurance than the parents which produced them. It ought never to be forgotten that in the experiments of Messrs. Odling, Crookes, and Tidy, the organisms employed were carefully prepared so as to have no spores in them. They could always obtain anthrax organisms free from spores by taking these organisms from animals which had been killed by anthrax. Anthrax produced no spores in the animal body. In the experiments of Messrs. Crookes, Odling, and Tidy the anthrax bacilli used were obtained from animals that had been killed by anthrax, and therefore these organisms, were destitute of spores. In the same way he had introduced anthrax bacilli into water and had found that they were rapidly destroyed; but with spores the thing was utterly different. The spores would last weeks or months, and that was a point which had been confirmed by numerous other investigators; so that it would be very undesirable if the meeting went away with the idea that these pathogenic organisms were rapidly destroyed in water. Mr. Baldwin Latham had spoken also about friendly organisms, and had referred to a particular organism which was a special friend of his (Dr. Frankland's), viz., the nitrifying organism, for which he had a particular feeling of interest, inasmuch as it was discovered by himself. Although he had a great affection for this nitrifying organism, he was bound to say that, at present, there was absolutely no evidence whatsoever that it was destructive of other organisms. In fact, the conditions under which it lived were totally different from those of other ordinary organisms; for, whereas pathogenic bacteria in most cases required a certain amount of organic matter, often very highly concentrated, for their propagation and growth, this nitrifying organism grew by preference in liquids absolutely destitute of organic matter; in fact they only got nitrification taking place where the liquid was practically free from organic substances. He was afraid, therefore, they could not rely upon this very important organism for effecting the destruction of pathogenic forms. As to the movements of cholera epidemics up rivers and not down rivers, although there were cases of that kind, one would be very much surprised if that was not the general course of events when it was remembered that cholera was almost invariably introduced at sea ports, and, of course, found its way into the interior only by transmission along railway lines, and so on. He believed Mr. Baldwin Latham did not wish it to be inferred that cholera travelled up the river-water like a fish swimming against the stream. He would find, on reference to some recent statistics of investigations made by the Indian Medical Department, that cholera did travel down rivers, and there were numerous cases where it had been obviously introduced into rivers above, and people had taken it lower down. Herr Kümmel, of Hamburg, had referred to the pollution of a river in Mecklenburg above the point whence the water supply to Rostock was to be drawn. He had listened to Herr Kümmel's remarks with great interest, but they did not induce him to alter his opinion; and indeed the opinion of all English sanitarians was that it was highly undesirable, whatever the truth might be about the purification of rivers, to admit sewage into a stream at such a short distance, or, in fact, at any distance above that at which a water-supply was taken. They could only learn with great regret that the Imperial Board of Health of Germany should have recommended such a step. The Conservancy Boards, and the Local Goverment Board of this country would never tolerate the admission of sewage into a stream above a point at which water was taken for town supply. There were, of course, in this country a great many cases where water-supplies were being taken, and had been taken for a long period of time, from the river below the points at which sewage gained access. It had been the business of their Local Government Board and Conservancy Boards to diminish that pollution as far as possible, but they would never allow a new case of that kind to arise. It had been remarked that these beds of subsided organisms and subsided organic matter might be the cause of danger afterwards. As he had pointed out, there was no question whatever about the sedimentation of matter, living and dead, taking place in rivers, especially in sluggish rivers. As he also indicated, there was, however, no evidence that the organisms which subsided in that way were destroyed, and consequently the greatest apprehension must always be felt when floods stirred up these things and carried them further on. He, in fact, distinctly referred to some very careful recent researches by two French investigators on the mud of the Lake of Geneva. The Lake of Geneva caught nearly all the suspended matter in the Rhone, and the mud of that beautiful lake had been found to contain numerous pathogenic organisms which were not destroyed by their long residence at the bottom of the lake. He had no intention of saying that there was no purification taking place, even of dissolved matter. Far from it; he entirely belived that there was a certain amount of purification, even in the case of dissolved matter, taking place, but it was not of that sweeping character generally thought to be the case. There was no evidence of that very rapid oxidation or removal of dissolved organic matter. Finally he came to the question of the boiling of water;

and here he should like to point out that they were dealing with an entirely different question. It was extremely difficult to trace the process going on in rivers, but it was very easy to determine what took place when they were boiling water in a kettle, a flask, or anything of the kind, or in laboratory experiments, in which any careful investigator could easily obtain accurate results. It could not be too widely known that the mere boiling of water in a kettle was almost an absolute guarantee against zymotic disease which might be conveyed by drinking water. He very much regretted that those French figures were brought up. All bacteriologists knew that there were forms which were not destroyed, but they could not have a simpler and more perfect method of defending themselves from infection by contaminated drinking water, than by boiling that water. Although it might be true that a few forms did remain alive under exceptional circumstances, there could be no doubt that the simple process of boiling was an almost absolute safeguard against the communication of zymotic disease. There was, however, another channel, and he must just mention it, though it was, perhaps, irrelevant to the present discussion. It was the general belief that far more zymotic disease was communicated by means of milk. The boiling of milk was an operation of even still greater importance than the boiling of water.

The President said he was not very fond of making comparisons, but he could not help feeling that there was probably no subject and no discussion which would take place during that Congress which would contribute, he would not say as much, but would contribute more to the public health than that which had engrossed their attention that morning. He was exceedingly glad to see that they had so full an attendance, and they might congratulate themselves that the subject had been so ably dealt with by the reader of the paper, and by the different speakers.

The Refuse Destructor.

BY

Charles Jones, M. Inst. C.E., F.S.I., Engineer to the Ealing Local Board.

Before dealing with the special subject of this paper, although the time is too short to treat it in anything like an exhaustive manner, I must briefly call attention to the material with which we have to deal, viz., "house and town refuse."

For many years the disposal of this material has occupied the attention of sanitary engineers, surveyors, town councils, and other public bodies, and of many indirectly connected with the sanitary well-being of the country; but so long as there was a vent in the way of brickfields for the breeze, and spare ground for the "soft hardcore," little or no difficulty was experienced. During the last 10 or 15 years these modes of disposal have been generally decreasing. Brickfields have been removed from the neighbourhood of towns, and the growth of sanitary science has put a veto upon the filling up of waste sites with garbage and refuse. In the days of the "Golden Dustman," large sums were paid for the privilege of removing the material. At the present time, great difficulty is experienced and large sums spent in getting rid of what was once considered valuable matter, notwithstanding that it might be said to consist of the contents of ashpits, market-refuse, the sweepings of paved streets, and an heterogenous mass of indescribable material which forms the débris of every establishment and of every town.

Some 20 years ago Paddington was the favoured depôt for this matter, carted principally from the western districts; and the writer of this paper has still an odoriferous recollection of the condition of one of the best conducted of these establishments, having had to arrange, some 14 years since, for an installation of electric lighting in order to keep the place going at night as well as by day. Perhaps nothing more striking can be given than the description of Dr. W. S. Saunders, medical officer of the City of London. He says: "When the dust carts arrive " at the wharf (Lett's), their contents are tipped into heaps at the place " most convenient for the people who are employed as sorters. About " 70 persons, chiefly women, were engaged in this degrading and " loathsome work, most of whom are paid by piece-work, but 16 female " sifters received 7*s.* and a little coal and wood weekly. The appearance " of these women is most deplorable, standing in the midst of fine dust " piled up to their waists, with faces and upper extremities begrimed " with black filth, and surrounded by and breathing a foul, moist, hot " air, surcharged with the gaseous evacuations of disintegrating organic " compounds. . . . . . I shall not forget visiting some of these " poor creatures in a hospital, and witnessing the condition of their skins " when the accident to the chimney shaft occurred." Happily this description is one of the past, but probably the City of London can even now give the best illustration that I can place before you, and from late reports it is evident that some other method will have to be found to rectify this still existing nuisance.

Perhaps the greatest difficulty which the sanitarian has to contend with is the strange idea which possesses the mind of the economical ratepayer, that something is still to be made out of this and other material with which the Corporations have to deal; but the man who boasts that he is going on the Local Board or Council in order to economise the taxes of the people in this way soon finds how hopeless is the task he has undertaken, so far as the treatment of town-refuse is concerned. So far as I can gather, the quantity to be dealt with in London alone, *i.e.*, that portion which comes under the control of the London County Council, is some two and a half millions of tons per annum, more rather than less. This quantity is gathered from the several large London districts. I will simply cite three of the most important, by way of illustrating the different modes of dealing with this subject, viz., Kensington, a western district, Hampstead, N.W., and Camberwell, S.E.

For the year ended 31st March 1891, Kensington disposed of 44,549 loads (23 cwt. to a load). (It will be remembered that the

Kensington Vestry was defeated in the House of Commons in its attempt to deal with the refuse in a scientific manner.) Half of this material is barged away from the parish to Purfleet, where the Board have acquired 17 acres of land; and before very long they will undoubtedly be compelled to deal with the question in some other mode than in forming a mountain of garbage on the banks of the Thames. The cost is 1*s.* 11*d.* per load for barging. The other moiety is barged by contract to some point on the Grand Junction Canal, at a cost of 2*s.* 6*d.* per ton. I do not know the neighbourhood in which the shoot is situate, and if I did know I should not like to tell you; but I have no doubt the inhabitants of that neighbourhood will before long find their legal remedy, as we have had to do at Ealing. The entire cost of the collection and distribution of these 44,549 loads is just about 8*s.* per load, and amounts to a very large item in the accounts of the parish of Kensington.

Hampstead, during the 12 months ending 1890, disposed of 18,441 tons. They have been wise in their day and generation, and have provided a proper mode of dealing with the difficulty with a more satisfactory result in the figures of the local board finances; the cost amounting to not more than 6*s.* 1*d.* per ton, or 25 per cent. less than Kensington.

The last-named district, on the S.E. of the Council's boundary (Camberwell) during 1890 had to dispose of 31,321 loads (24 to 25 cwt. per load) of refuse. Of this quantity, 16,492 was removed by barge (contract), and we are led to suppose that the greater quantity is used in brickfields. Of the other portion, 10,181 loads are delivered at special and other shoots in various parts of the parish at agreed prices, to form probably at no distant date (unless care is exercised and a record kept) foundations for eligible suburban villas; and 4,640 loads are sent away by rail. The cost of this is 2*s.* 3*d.* per dust-load for the first three months of the year, and 2*s.* 8*d.* per load for the remainder of the year, this of course being additional to the cost of daily collection.

It must be borne in mind that the figures which I give grow at an enormous rate; for instance, in Kensington, in the year 1882, a total of 29,922 loads were disposed of, and in 1891, 44,549 loads.

Turn for one moment from London and its surroundings to the second important town in the kingdom, viz., Liverpool. The number of loads (of one ton) dealt with in 1890 was 249,290; of this quantity 156,299 tons were taken out to sea, and we have heard that not a little of this material, like Jonah of old, was subsequently thrown up on dry land. The remaining 92,991 loads were sold to farmers and others. The cost averages much less than in London, being 1*s.* 11*d.* per ton. I am happy to state that, at last, Liverpool has started in the right direction, and is now engaged in erecting a sufficient set of destructors to deal with this troublesome question.

From returns lately issued, out of 93 towns from which particulars have been obtained, 37 (many of large population) dispose of their refuse by carting to shoots, or other less objectionable modes of disposal. The remaining towns utilize or adopt, in some way or other, the principles of the destructor.

In the foregoing remarks I have endeavoured to lead the way to the consideration of the best means of dealing with town and house refuse, viz., by the proper use of the "refuse destructor."

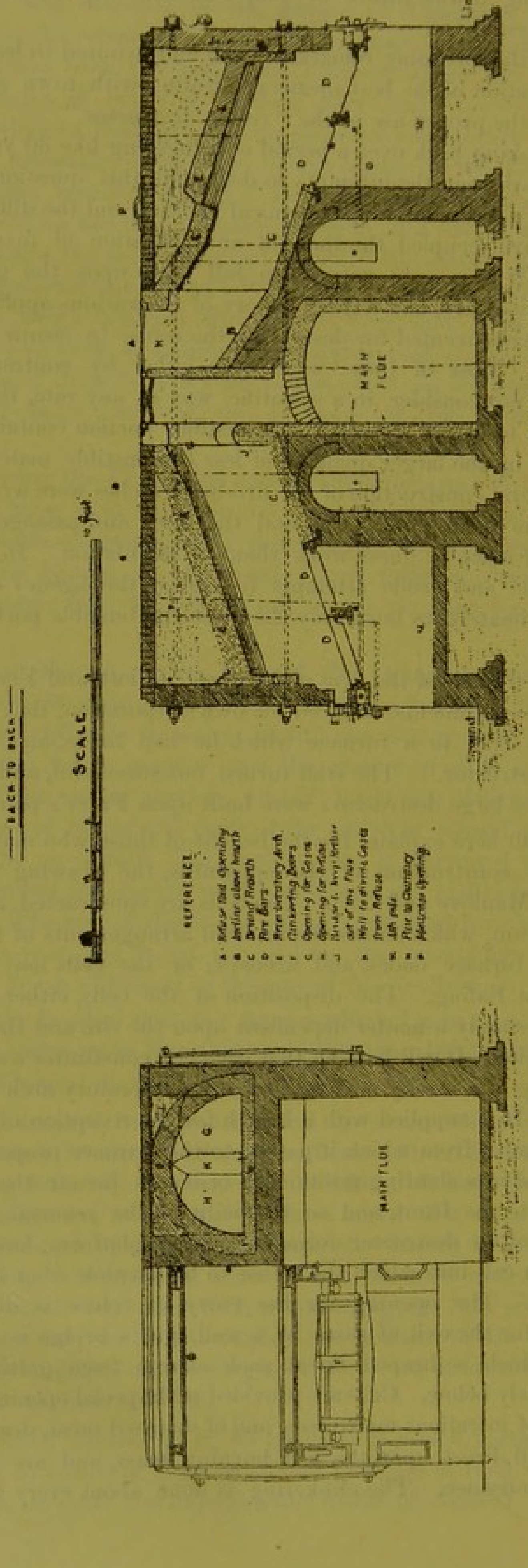
Looking back over a period of something like 30 years, we find that many have been the attempts to deal with this question of house-refuse in a more scientific and economical manner, and the difficulties surrounding it have occupied the thought and attention of inventors for many years. It was only natural to fall back upon the greatest agent of purification, fire, and a short history of the various appliances in the way of furnaces invented for destroying the refuse by means of fire will be of interest. Most of these were built either by contractors, or by those who did not consider, in a scientific way at any rate, the action of heat and how to utilize the small combustible portion contained in refuse for burning up the larger quantity of less combustible material. The shape and general construction of the fire-brick arches were wrong, the arrangements for feeding were bad, and the flues and passages for gases were designed more by guess-work than by calculation. In short, they were but feeble and crude attempts to utilize the agency of fire, and were used, ultimately, to burn only the more combustible portion of the refuse collected.

Mr. Fryer (of the firm of Manlove, Alliott, and Fryer), after several years of experiments, induced his own corporation, that of Nottingham, to give a trial to a furnace which he had made, and which he called "the Destructor." The trial turned out successful, and in a very short time three large destructors were built upon Fryer's patent.

I will here explain, for the benefit of those who may not be familiar with the construction of the apparatus, the drawing (kindly lent by Messrs. Manlove and Co.). The cells are constructed as represented in the diagram, which shows the internal arrangements of the flues, feeding hoppers, furnace doors, and firebars; or the cells may be built side by side, as at Ealing. The disposition of the cells, either one way or the other, is simply a matter dependent upon the site and the convenience of the situation. It will be seen that each cell constitutes a separate furnace, consisting of a cavity enclosed by a reverberatory arch lined with fire-bricks. It is supplied with a hearth for the reception of the material to be consumed, from which it passes to the furnace proper. The firebars are placed in a slanting position, in order to favour the passage of the material to the front, and so to facilitate the removal of the clinkers. The top of the destructor forms a perfect platform, having an opening over each cell into which the refuse to be burnt is shot from the collecting carts. The opening for the entry of refuse is divided from the opening for the exit of gases by a wall, and a bridge is built to prevent refuse which is heaped on at each charge from getting into the flue immediately below. Cells are provided with special openings for the introduction of infectious mattresses, and of diseased meat, dead cats and dogs, which fall direct upon the red burning mass, and are there consumed without nuisance. The clinkering is done about every two hours. To

FIGURE I.

FRYER'S PATENT DESTRUCTOR FURNACE.



these details I may add sundry improvements made by myself, in work at Ealing; the principal ones being, 1st, an automatic damper acting at the back of each flue, and shutting off four-fifths of the flue-space whenever the furnace door is open for clinkering, and so preventing the sudden rush of cold air into the flue; and 2nd, dishing out the ash-hearth, so that it will contain a certain quantity of water, thereby preventing the inconvenience of the dust when the ashes are cleared away, much to the comfort of the workmen.

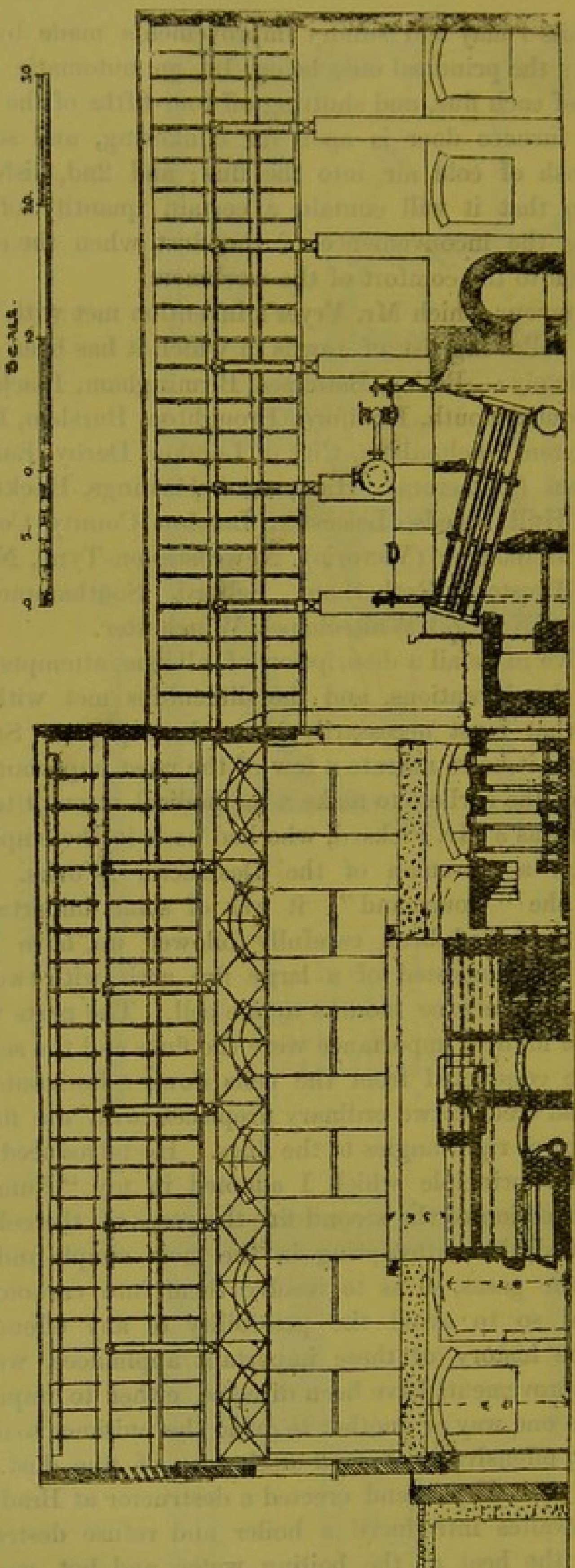
The favour which Mr. Fryer's invention met with may be gathered from the following list of towns in which it has been adopted more or less completely:—Batley, Battersea, Birmingham, Blackburn, Blackpool, Bolton, Bournemouth, Bradford, Broughton, Burslem, Burton-on-Trent, Bury, Buxton, Cheltenham, City of London, Derby, Ealing, Eastbourne, Georgetown (Demerara), Hampstead, Hastings, Heckmondwike, Huddersfield, Hull, Leeds, Leicester, London County Council, Liverpool, Longton, Melbourne (Victoria), Newcastle-on-Tyne, Nottingham, Para (Brazil), Preston, Rotherham, Salford, Southampton, Warrington, Wellington (New Z.) Whitechapel, Winchester.

To give in detail a description of all the attempts to deal with the question, the inventions, and the difficulties met with, would unduly prolong what must necessarily be a short paper. Sufficient for the purpose will it be to narrate a few of the most important.

One of the earliest to make a methodical attempt to deal with these difficulties was a Mr. Pickard, who had been in the employ of the Leeds Corporation as foreman of the Destructor Works. He called his invention the "Gourmand"; it was of some importance, and would no doubt, if it had been carefully followed up, have been a valuable invention. It consisted of a large fire arch, with two sets of furnace bars and two furnace mouths to one cell. The parts which I consider were of the highest importance were the flues and the second fires. The gases were conducted from the cells down a horizontal flue, in which Pickard had erected two ordinary fireplaces, with the fire crossing it, or the fire bars at right angles to the flues. He introduced exactly the first part of the principle which I adopted in my "Fume Cremator,"—*i.e.*, by the action of the second fire the gases of the cells were to have been purified, thus attempting in the most simple and obvious way to consume the gases, so as to resolve them into carbonic acid gas and water, and so to avoid the possibility of any offence. And as we look at the history of these important appliances, we find that the various improvements have been directed either to improve the furnace itself, or in one way or another to avoid the nuisance so often complained of, namely, offensive smells and discharges of fine dust. Next, Healey combined with Fryer, and erected a destructor at Bradford; and afterwards Thwaites introduced a boiler and refuse destructor combined, in which the heat of the boiling water and hot gases was said to prepare the refuse for combustion. Then came Young, of Glasgow, who arranged a destructor with closed ashpit and a powerful fan to facilitate combustion. The next to enter the field was Mr. Wilkinson, of Birmingham, whose destructor was somewhat similar to one invented

FIGURE II.

WARNER'S "PERFECTUS" DESTRUCTOR.



SECTION THROUGH FURNACES, CREMATOR, AND BOILER.

by Messrs. Pearce and Lupton, of Bradford,—but more successful. Another form was that of Burton, who constructed a long simple furnace with two fires, the refuse being dragged through by a long endless chain, which was moved at intervals by a windlass as the refuse became consumed. Messrs. Stafford and Pearson, of Burnley, invented the "Beehive," followed by the "Nelson," in which the gases of combustion are conducted over a reservoir of water, on the surface of which a small quantity of petroleum is allowed to run automatically, and are afterwards turned into a furnace heated with coke. Hardie, also of Burnley, introduced an apparatus consisting of saddle boiler, with an inclined furnace underneath, and driving air below through the fire artificially. Then Odger, also of Burnley, constructed a furnace in which the offensive gases were passed through a coke fire; and Horsfall, of Leeds, has designed one in which steam and air are thrown under the fire bars; this is now before the public, and the inventor is very sanguine as to its success. Amongst the more recent inventions we have that of the "Perfectus" destructor, by Mr. Warner (Goddard, Massey, and Warner), which has been adopted at Hornsey, Bournemouth, Newcastle-on-Tyne, and other places. It may be described as consisting (generally speaking) of a block of brickwork, 34 feet wide by 30 feet long, by 10 feet 6 inches high, strengthened on the front of each furnace with heavy segmental cast iron facia plates, to protect the brickwork, having sliding rails to support the furnace doors, with baffle plates of special construction, so that the fires may be examined quickly without allowing the admission of cold air. The ashpits are of the same width as the furnace arches, and their front parts are also covered with ironwork having sliding doors, so that they may be closed if necessary, and the air regulated or the fires blown up by means of a large blower, which forms part of the plant erected over the top of each furnace. There are two dampers worked from long, wrought-iron spindles, and balanced on the outside of the furnaces. These dampers are closed each time the men clinker, and each time they draw down fresh refuse to be burnt, so that the furnaces are kept very hot. Internally, the block of brickwork contains six reverbatory fire-brick arches, 5 feet long by about 10 feet. One half of the arch is made to cover a special drying hearth, upon which the refuse is prepared for actual combustion. The other half of the arch covers the fire-grate, which is made wholly of wrought iron, supported upon strong bearers. The structure is tied together by wrought iron tie-rods, and at the back and front supported by channel-irons, and at the ends by massive cast iron buck-stays. Over each damper a vertical flue is constructed, terminating in the main flue leading to the cremator, and is covered by a cast-iron frame and cover to allow a passage for workmen for cleaning. The top of the furnace forms a level platform, upon which the refuse is tipped from the carts as delivered. Each furnace has an opening, or hopper, capable of holding about the third of a cart load of refuse, and the contents of this hopper are discharged by means of a wrought iron lever projecting through the furnace roof; there are two doors at the end of the main flue for taking out fine dust, and there are special pockets at various distances provided with frames and covers for cleaning purposes while the destructor is in operation. The engineer of the Hornsey Local Board speaks highly of this apparatus.

Passing on, as I have done, rapidly over the various inventions, we feel that the whole discussion has now passed beyond the stage of experiment, if not of criticism; for at the present moment the destructor is at work in some 40 towns in England, is in course of erection in several other towns, and is not confined to England, but is being adopted in our Colonies and in several Continental cities.

The garbage burnt varies very much according to the district; and the quantity of clinker and fine ash will vary in proportion to the class of material burnt. In some cases it has been as low as 10 per cent., and in other cases as high as 33 per cent. of the material collected. At Ealing, with which district I am officially connected, the average is 25 per cent., the residuum being a good hard clinker, but here it is applied to an altogether different purpose to that originally intended. The settlement or sludge in the sewage deposit tanks is pumped into sludge beds and mixed with the town refuse before it enters the destructor, thus solving, so far as Ealing is concerned, the much vexed sewage question. The residuum or clinker is valuable for various purposes, and is used for concrete, tar paving, artificial stone for building, and when ground up, as sand, paths, hardcore for roads, and makes a splendid and indestructable material for the construction of walls. So far, the house-refuse is transformed from a filthy and deleterious matter into a material at once inoffensive and useful. This does not, however, conclude the usefulness of the apparatus, it has still another property to which we shall have to refer a little further on, viz., its immense steam-producing power, heat.

The opposition which this useful invention has experienced in almost every town in which it has been fixed is almost incredible; and one would think, by the arguments advanced against it, that it was an invention of the devil rather than one of the most useful sanitary appliances which a town can possess. No doubt, in its earlier forms, there were defects; but at the worst they were as "nothing compared "with the offence and injury to health which are so successfully obviated "by the rapid destruction of tons of objectionable matter, which "must, in some way or other, be dealt with." We admit that, formerly, the vapours given off in the drying, and the vapour and gases given off from the material in the first stage of burning, and before it got well into the fire, were perceptible, and were the cause of complaint, as was also the very fine dust which escaped from the shaft. These are now things of the past, and the fact that some of our health resorts have the destructor in full and successful operation, whilst in London, in such suburbs as Battersea, Hampstead, and Ealing the same class of work is done, goes to prove beyond a doubt that the destructor, if properly worked, may be used anywhere and everywhere without the slightest fear of any complaint arising in connexion with the same.

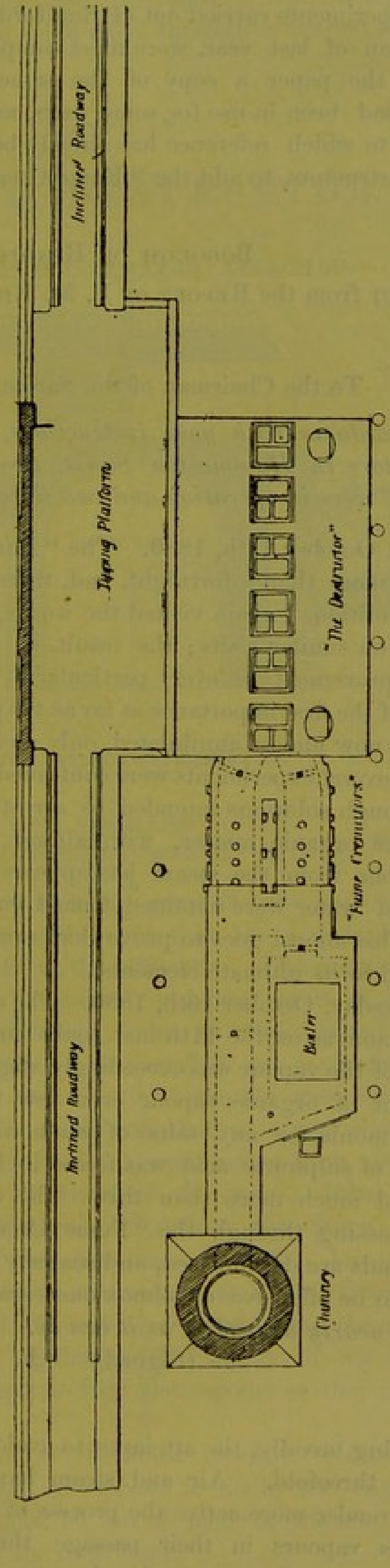


FIGURE III.

PLAN OF TWELVE CELL "DESTRUCTOR" AND "FUME CREMATOR."

ERECTED AT BATTERSEA, 1887.

The experiments carried out at Bradford, by the Borough Analyst, in the autumn of last year, were most complete, and I think it well to include in the paper a copy of the same—simply stating that the destructor had been in use for some years, and it was found desirable, for reasons to which reference has already been made, and which apply to all the destructors, to add the "Fume Cremator" with the following result;—

BOROUGH OF BRADFORD.

EXTRACT from the REPORT OF F. M. RIMMINGTON, Esq., F.C.S.

October, 1889.

To the Chairman of the Sanitary Committee.

In accordance with your instructions, I have made four visits to the destructors in Hammerton Street, two visits before the "Fume Cremators" were in operation and two since.

Friday, October 11th, 1889. The "Fume Cremators" having now been in use more than a fortnight, and, therefore, considered in perfect working condition, I again visited the works, and made similar tests to those made on similar visits; the result, in every instance, indicating a decided improvement in every particular. The smell of the escaping vapours is of the first importance as far as the public is concerned, and this objection is now almost annihilated, only an almost imperceptible taint is present. Several experiments were continued for more than half an hour, passing through solutions intended to arrest any compound of sulphur, ammonia, or organic matter, with almost negative results; even the watery vapour from the steam jets appears to be decomposed, for only $5\frac{1}{2}$ grains of water were obtained from 1 cubic foot ($6\frac{1}{4}$ gallons) of the vapour. This almost goes to prove that every compound is decomposed and reduced to its ultimate elements.

Wednesday, October 16th, 1889. The experiments on this occasion were the same as on the 11th inst., only carried on for a longer time. The smell of the vapour was exceedingly slight, and difficult to describe; the amount of organic vapour even less than before, almost *nil* in fact. Ammonia or any salts of ammonia were quite absent, and 0·19 grain of sulphuric acid was found in 1 cubic foot. A kitchen fire would yield much more than this. The effect of the gases from the furnaces passing through the "Fume Cremators" appears to be that all compounds are decomposed, and scarcely a vestige of any that can be construed to be offensive or obnoxious escapes, and in my opinion the result it as *nearly as perfect as it can be.*

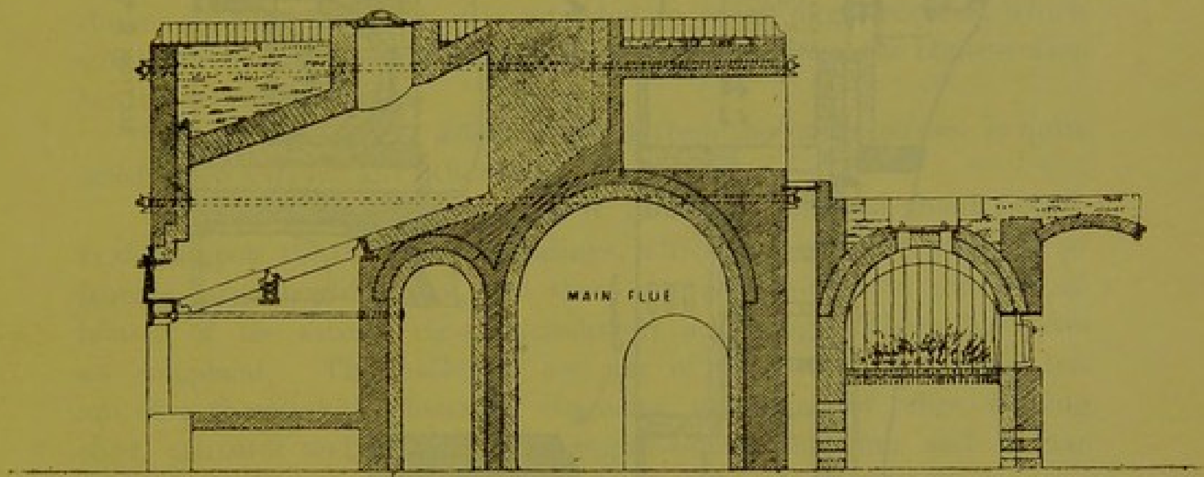
(Signed) F. M. RIMMINGTON, F.C.S.,
Borough Analyst.

Speaking broadly, the attempts to avoid the nuisances complained of have been threefold. Air and steam have been driven through the furnace to render more active the process of combustion, and to consume the various vapours in their passage through it. Then, the gases have been conducted over troughs of water in the hopes of deodorising the gases and precipitating the fine dust. And lastly, the gases from the furnace have been conducted through a second fire and there consumed.

FIGURE IV.

EALING DESTRUCTOR,

WITH FUME CREMATOR ATTACHED.



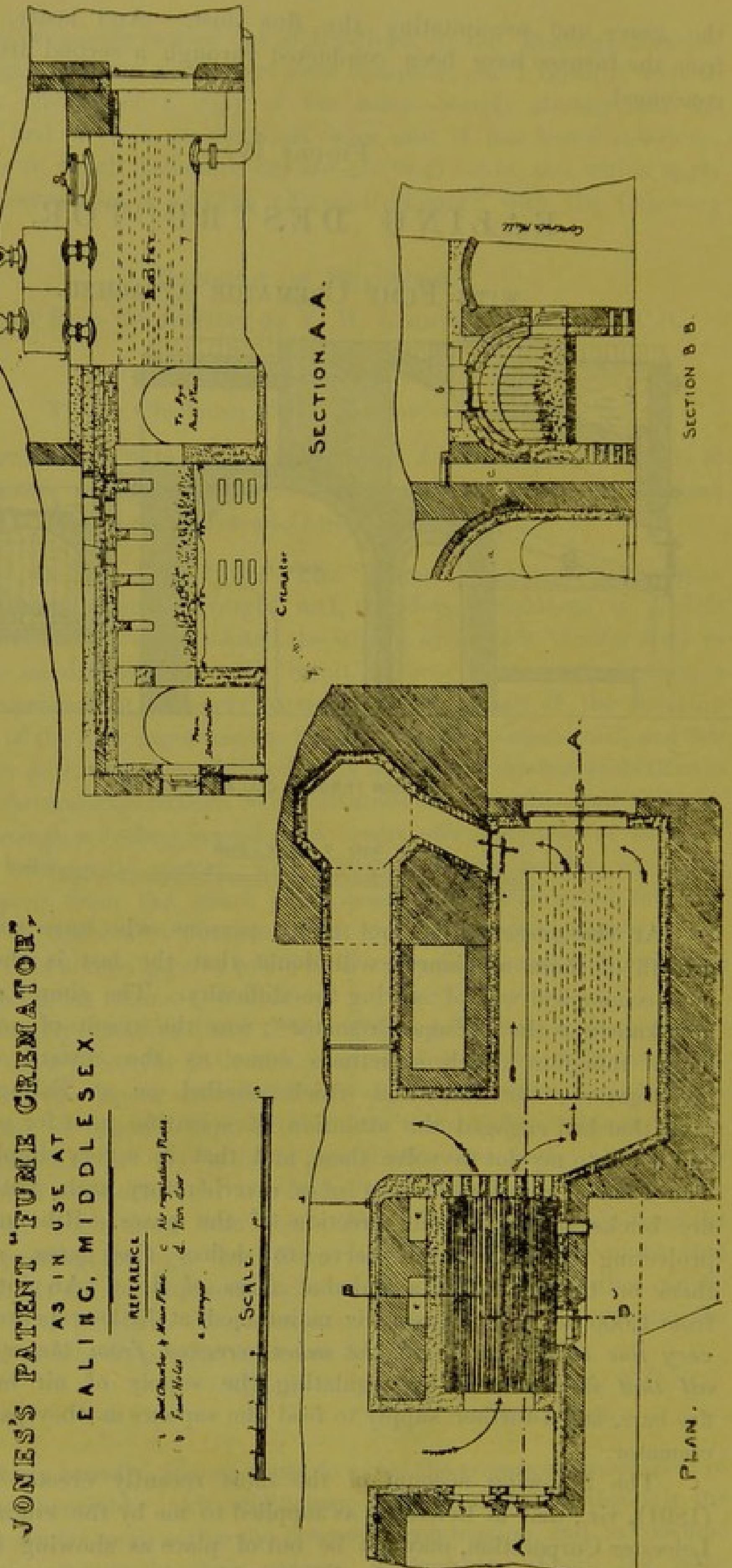
SECTION THROUGH CELL & CREMATOR

Scale 4 Feet to 1 Inch

10 feet

At the present time not many persons who have watched the growth of these appliances will doubt that the last is the best and most economical way of solving the difficulty. The simple contrivance now known as the "Fume Cremator" was the result of one of those happy thoughts which sometimes come as the reward of earnest investigation; the difficulties which assailed me at Ealing were the same that had engaged the attention of scientific men for some years, and it fell to my lot to solve them, and that in a very simple manner. The Fume Cremator consists of a reverberatory arch, with rings of fire bricks placed in the direction of the gases. Ribs of firebrick projecting from the arch serve to deflect the gases, and direct them on to the top of a red hot mass of fire. An intense heat, from 1,000 to 1,500 degrees, is maintained at little expense of fuel—*very fine coke breeze and the ashes screened from the refuse being all that is required*—by regulating the supply of air beneath the fire bars, and a further supply to feed the vapours as they pass into the cremator.

The following account of the most recently erected destructor (1891), viz., that at Leicester, as supplied to me by the engineer of the Leicester Corporation, may not be out of place as showing initial cost and the work performed by the destructor.



JONES'S PATENT "FUME CREMATOR",
AS IN USE AT
EALING, MIDDLESEX.
REFERENCE
SCALE
Boiler
Cremator
SECTION A.A.
SECTION B B
PLAN.

FIGURE V.

BOROUGH OF LEICESTER.

Destructor at Nedham Street.

22nd June 1891.

"Our Nedham Street destructor is a six-celled one, on Messrs. Manlove, Alliott & Co's system, with a Jones's "Fume Cremator," and a multitubular boiler, which provides steam for a 14 h.p. horizontal engine. The power is at present only used for driving a mortar and clinker crushing mill; but it is intended to erect jigger screens, which will be driven off this engine, for extracting ashes from the house-refuse for the cremator furnaces.

"This material, viz., ashes screened from the house refuse, is quite satisfactory *without* any other fuel.

"The stack is a little over 160 ft. in height, and cost about 1,000*l*. It abuts upon the destructor buildings, which are only five yards or so from a large board school, and there are a considerable number of houses of the artizan class immediately adjoining. There has been no complaint. The buildings are not of the mere shed type, but are of a thoroughly substantial character, consisting of office, tipping shed, cremator and boiler house, engine-house, and lime and mortar shed.

"They cost, including roads, drains, and a rather extensive area of granite paving and long lengths of retaining wall, about 3,300*l*. Total cost of the works, without land, 7,000*l*.

"Six stokers are employed, three on day and three on night duty, and they work off about 220 tons of ashes per week of 138 hours (last week, ending 20th June 1891, they did 6½ tons per cell per day of 24 hours).

"For the cremator we use about one ton of screened ashes per day, this being an addition to the above-named total quantity.

"The residue in the shape of clinker is about ¼th (154 tons of ashes yielded 38 tons of clinker and flue-dust).

"The temperature of cells varies according to period of charge from 850 to about 1,470 degrees, and the temperature of cremator from 1,420 to 1,500 degrees.

"The whole borough yields about 38,000 tons of house refuse per annum, and it is calculated that the destructor will dispose of 10,000 tons at least.

"It is intended to at once erect two other destructors, one of six cells, and one of 10 cells.

"These works will be more complete in their arrangement than the Nedham Street works, inasmuch as it is purposed to use the engine power for driving mortar mills, screens for cremator ashes, pumps for water-supply to street watering posts, dynamo for lighting purposes, &c."

I desire to refer specially to an outside but most valuable feature in connexion with the destructor, viz., the immense amount of steam-creating power that for many years has been literally thrown away. At Southampton the heat derived from the burning of the refuse is applied in connexion with a 30 h.p. tubular boiler, which is used for pumping some 500,000 gallons of sewage effluent, for the working of one of Shone's pneumatic ejectors, the driving of a dynamo for generating electricity, and for working the machinery in use at the sanitary works. At Hastings it is used for pumping sea water, and also for electric lighting. At Ealing, for driving machinery and electric lighting. At Blackpool, Preston, and other places, the immense power is utilized for electric and other purposes.

Every cell will burn sufficient fuel in 24 hours to keep a 5 h.p. engine going; and, as I have before stated, there are some 200 cells at work in England, equal to something like 1,000 horse-power. In most cases it may be said that the proper utilization of this power will effect a considerable saving, and, paying the principal and interest upon the 30 years' repayment scale, will leave a considerable balance. At Ealing this has been proved most thoroughly, leaving in this case a good balance in favour of the rates, inasmuch as, using coke breeze for the cremator, the cost for the 7-cell destructor is under 2*l.* per week of 7 days of 24 hours. When the destructor and cremator are not at work in consequence of repair, or for other reasons, the cost for fuel for supplemental boiler is 5*l.* per week, or a balance to the good of 3*l.* per week in favour of the destructor and cremator.

Before concluding this paper I wish to make a few remarks appertaining to one of the "burning questions" of the day, viz., the London sewage or sludge question. It will be remembered that one of the recommendations of the Royal Commission was resolved into the word "fire," and I am still sanguine enough to believe that at no distant date the advisers of the London County Council will see their way clear to giving a fair trial to the treatment by fire.

I have stated that in England at the present time there are some 200 cells at work employing less than 100 men, and dealing with something like 500,000 tons of refuse. How much room do you think these 200 cells would take, supposing they had been built at Barking, where I believe there are some 70 acres of land available? You will be surprised to hear that they can be put upon an acre of land, with plenty of room to work between them, and that the cost of erecting them would not amount to more than 300*l.* or 350*l.* per cell. Supposing the 200 cells had been built, and the question tried, there would have been, according to the data which we have, and which there is no disputing, as it is in daily work, 1,000 horse-power at hand, or in other words the coal bill would have been saved. No nuisance would have been created by the adoption of the process, which, after all that has been said with respect to other systems, has held its ground, and will do so. I refer to the milk-of-lime process, which will ultimately come about. I know that it may be replied that the effluent that is turned out by this process is not pure. No one in the present day would say that it is; but the question is, is it not pure enough to be discharged into the Thames at Barking and Crossness? I have been sending, to the satisfaction of the Thames Conservators, from 750,000 to 1,000,000 gallons of effluent per day for many years into the Thames, and many visitors, and not a few of them members of the Metropolitan Board of Works, have asked Why cannot we do the same? And I say, unhesitatingly, that under the lime-process and the destruction of refuse, as suggested by me, the river would assume a character in every way satisfactory, and at a mere bagatelle of cost when compared with the expensive schemes already proposed. Other points might be raised in connexion with this effluent water, for instance, that of aëration. And here I may add that sufficient steam would be produced from the refuse, over and above the quantity required for ordinary pumping purposes, and might be brought to bear upon the effluent in aëration, which, to my knowledge, can be productive of immensely beneficial results.

On the Cleansing of the Streets and the Removal of Household Refuse in German Towns.

BY

TH. WEYL, Berlin.

1. With whom does the responsibility for the cleanliness of the streets rest?

(a.) *Thoroughfares and Foot Pavements.*—The principle generally acted on is that the persons resident in a street, and not the owner, shall be responsible for its cleanliness. In spite of this, however, the cleansing of the streets is, in most of the large towns, undertaken by the municipal authorities. In other towns, only a part of the roadway is cleansed at the expense of the authorities, the house-owners (resident) being responsible for the remainder. Moreover, the authorities have also undertaken the cleansing of street gullies, of public urinals, &c., the watering of the streets, and, in most cases, the removal of snow, &c. As a general rule, tramway companies are obliged to contribute towards the cost of the cleansing of the streets. The cleansing of the footways and pavements is left to the resident householders. In Berlin and other large towns the pavements also are cleansed by the municipal authorities.

(b.) *Household Refuse* (*Dust*).—The removal of dust has, in many cases (*e.g.*, in Berlin), been left to the house-owners; the town authorities, however, retain a right of supervision. In cases where the contract system obtains (*vide infra*), the contractor undertakes the removal of dust as well.

2. Who carries out the cleansing of—

(a.) *Streets, Squares, &c.*?—Some German towns, such as Bremen, Cologne, Munich, make arrangements with contractors for the removal of all street refuse at a fixed rate (contract system). In other towns (Berlin, Hamburg, Breslau, Frankfort-on-Main, Hanover, Leipzig) the cleansing of the streets and the watering, &c. of the same, is carried out by the town authorities (municipal system). The necessary plant, such as brooms, barrows, street-sweepers, dung carts, watering cart, snow ploughs, &c. are the property of those by whom the cleansing is carried out. The draught animals do not seem to be, in any case, the property of the municipal authorities.

Of 23 German towns with a population of 100,000 in the year 1890, 13 employed municipal labour alone, six employed municipal and private labour, seven employed private labour alone.

3. Time at which the cleansing is effected, and frequency of the same :—

The cleansing of the streets is, as a rule, only done at night, and the removal of refuse is also performed either at night or in the early morning.

The frequency with which each street is cleansed depends upon the amount of traffic on the same. In Berlin, one-third of the whole street area is cleansed daily ; in Hamburg, one-fourth of the whole area.

Household refuse is removed, usually, three times a week.

4. Comparison between the employment of manual and mechanical labour in the cleansing of the streets :—

—	Cost per Hectare.	
	Manual Labour.	Mechanical Labour.
	Marks.	Marks.
Frankfort-on-Maine - - -	11	6–8
Berlin - - - - -	32	18

5. Disposal and utilization of street and household refuse :—

Under the system of municipal working, the utilization of refuse has, up to the present, been comparatively restricted. It is carted off to dust-heaps, and there left to, so-called, natural influences ("naturforschen"). From April 1892, onwards, the city of Berlin proposes to spread its street refuse over some waste lands at a considerable distance from the city, so as to raise this low-lying and unproductive land to a higher level, and otherwise to improve it.

Under the contract system the contractors sell the household and street refuse as manure.

The plan of separating the rubbish into useful and worthless parts does not obtain to any great extent in Germany.

There is an establishment in Berlin for burning the refuse, but it is merely experimental.

Experiments in the Burning of House Refuse.

BY

J. F. Meyer, Chief of the Department of Streets and Sewers, Copenhagen.

It seems strange that at a Congress held here in London, a foreigner should come forward to discuss the subject of the destruction of refuse, but it is not my inclination to dwell upon facts which are generally acknowledged on this subject, and which England was the first country to fully appreciate, for in all sanitary municipal questions England has always been in the van, and has been the advocate of reform.

When Dr. W. Sedgwick Saunders, in his well-known report on the disposal of refuse, said, "The removal and disposal of refuse is a "problem which has exercised the intelligence and often strained the "resources of many a sanitary authority, and he who can indicate "the means whereby it can be successfully solved without detriment to "health or the creation of nuisance, should be regarded as a public "benefactor," he certainly, in a few words, put the case in the right light.

All who are assembled here certainly agree that the old system of disposing of refuse ought to be abandoned. It is only strange that it has taken so long before it has been acknowledged that the plan of dumping the refuse in places where houses are afterwards built for people to live in is altogether objectionable. It is perfectly permissible to use such refuse for agricultural purposes from a sanitary point of view; but it is well known that it is very difficult for a large town to get rid of it in this manner. Some localities may be very favourably situated for getting rid of the refuse by transporting it into deep water, &c. The question of the economical value of refuse has often been raised, and it has been said that it is wrong to deprive agriculture of this valuable material; but when circumstances are such that it is impossible even to get the agriculturists to fetch it for nothing, then every city must be allowed to regard its own interests first, and to get rid of its refuse in the most favourable way. From this point of view there is no doubt that the best way of disposal of refuse is destruction by fire. England has here shown the way, and the ever-increasing number of destructors is the best proof of the success of this method.

The reason why this method has only been used in rare cases on the Continent is, not that there has been any doubt as to its advantages, but because there has been some fear that the refuse of continental cities was not likely to be so fit for being burnt as that of English towns. Certainly there is a difficulty on this point, as everybody who has gone into these questions will have remarked that the English refuse is much richer in such substances as unburnt coal than is the refuse of most continental cities.

The question now is whether the refuse that differs from the English by its want of coals can be burnt without the addition of combustible substances. The city of Copenhagen resolved to make some experiments to answer these questions, and it is these experiments and their results which I, who conducted them, have the honour of stating.

The destructor in which the experiments were performed was built at the municipal gasworks. In its construction much attention was paid to making the destructor as like the English destructors on Fryer's system as circumstances permitted, using the existing brickwork, &c. as far as possible to avoid unnecessary expense. The destructor was built in one of the old retort-furnaces not in use at present, after taking out the retorts, so that the old flues and the large chimney belonging to the retort-house were used. This chimney gave an excellent draught; but as the experimental furnace was the only source of heat for the chimney, the draught began to fail very quickly as the temperature of the furnace fell, so that there was only a suction of 12 to 10 millimetres (of water), while at a high temperature there was a suction of from 16 to 25 millimetres. If there had been other sources of heat, the bad burning in a single furnace would not have had this disastrous influence on the draught. For the rest, the furnace must, upon the whole, be said to correspond with a single cell of Fryer's destructor.

The burning experiments were divided into two parts:—

A. The Winter Experiments. — My original intention was gradually to use house-refuse from a series of different districts. By that means I hoped to be able to decide what influence the social position of the inhabitants and their way of living would have upon the refuse, particularly as to the relative quantities of coke and coal, together with the substances of animal and vegetable nature. This purpose had to be given up on account of practical difficulties.

I will state here that the weight of one load of house-refuse varied from 550 kgr. to 2,600 kgr.; while the average weight can be taken as 1,500 kgr.; one cubic foot weighs on an average 21 kgr.

All the refuse treated during the winter consisted almost entirely of house-refuse, on account of the weather.

The refuse from one district was exceedingly meagre. Almost no food-refuse was found, and very little coke and coals, but a considerable amount of ashes. The quantity of such finer substances (mainly ashes) was estimated by an experimental sifting, and it was then proved that in one cubic foot of refuse there were 0·58 to 0·33 cubic feet of particles less than one-tenth of an inch in diameter.

The refuse from some other districts was a good deal richer; and one cubic foot of refuse showed, when sifted, 0·42 to 0·33 cubic feet of fine ashes.

I. First experimental period (from January 30th to February 18th).

(*a.*) *Experiments with poor and middling refuse.*—After having dried the furnace properly and fired up with ordinary fuel, unmixed house-refuse was put in on the 30th of January in the morning.

For a preliminary drying it remained for an hour-and-a-half on the back plate made for that purpose, and was then spread over the fire in a layer six inches deep; it burnt very well, which was a direct consequence of the coke fire beneath. The residue was taken out after two-hours-and-a-half, and a new layer was spread over the fire left, though not so thickly, as already the first trial had shown that the great quantity of ashes checked the draught. In spite of this, the temperature sunk so much that a little coke fire had to be used in the front on the grate. The refuse was not sufficiently burnt, and the few remaining embers were not capable of lighting the next sample. The decrease by burning was, according to volume, only 15 per cent. An experiment repeated after having fired up did not succeed.

Experiments with added fuel were than tried; as fuel, coke-breeze, was used. It was mixed with the refuse in the same manner as when mixing concrete. The mixture consisted of one volume of coke-breeze and four volumes of refuse. The experiment carried out on 31st of January was satisfactory, the temperature was good, and the decrease of the volume 50 per cent.; 4·8 tons (at 1,000 kgr.) refuse were burnt in the first 24 hours.

Before continuing the experiments, it was tried if *less* fuel would give the same results. On the 1st of February, one part (volume) of coke-breeze and six parts of refuse were mixed. The temperature sunk lower, and the combustion was not complete. In 24 hours 4·8 tons were treated, but the decrease in volume was only 42 per cent.

The next thing to try was if a greater addition of fuel than a proportion of 1 to 4 would perceptibly increase the rate of burning. This experiment was carried out in 48 hours (on the 2nd and 3rd of February), so that the mixture was one part of coke-breeze to three parts of refuse, but it was proved that this addition was not advantageous: 4·2 and 4·8 tons were respectively burnt, with a decrease of 56 per cent. and 53 per cent. in volume.

The experiments were then continued with the proportions of 1 to 4 during the days from the 4th to the 7th of February inclusive. In each 24 hours, 5·4, 4·2, 4·2, 5·1, and 5·1 tons were burnt. The decrease averaged 50 per cent. of volume.

(*b.*) *Experiments with better refuse.*—The furnace was fired up with coke-breeze and on the 8th of February, at 2 o'clock, unmixed refuse was put into it. The draught during the firing was 22 mm. The temperature was rather better maintained than with the poor refuse, but still the draught had sunk down on the 9th of February in the forenoon to 12 mm., and the temperature was so low that a fresh firing with coke breeze had to take place. Experiments with unmixed refuse continued to give unfavourable results, as well as another experiment that took place in the night from the 9th to the 10th of February.

The next day the supply of refuse was not sufficient, and the heat in the furnace was therefore in the night kept up with refuse that happened to be in the gas-works, such as straw, paper, coal dust, sand, &c. In the day-time the richer refuse was burnt in the proportion of six parts refuse to one part of coke-breeze. Perfect combustion took place, but only 3·6 tons in 24 hours were burnt.

The addition of coke-breeze in the proportion 1 to 4 in these experiments gave 4·8 tons per 24 hours, and a decrease of 58 per cent. in volume.

I then tried to separate the finer parts of the refuse (ashes and sand), as it had been proved that it was these which most checked the combustion; three riddles with different openings were used for the sifting.

On the 13th of February sifted refuse was put into the furnace, which had been previously fired up. It burnt exceedingly well, and gave a high temperature. It caked more on the grate than in the earlier experiments, and the grate had therefore to be cleaned oftener. The stuff that had been sifted out was a mixture of ashes, sand, and organic matter, which afterwards smelt very badly, when left to stand for some time (the thermometer showed 54° C.).

As it proved that a considerable amount of this sifted refuse could be burnt, and as it was impossible during the next few days to procure a sufficient supply, I made up my mind to stop the experiments for some days, so as to get sufficient refuse collected and sifted to make more complete experiments. However, before stopping, I made some smaller experiments by burning sifted refuse from the 14th to 18th of February, mostly by adding coke-breeze to the finer matter that had been sifted from the coarser material. But even with a mixture of one part of coke-breeze to two-and-a-half parts of these finer matters, the combustion of the latter did not succeed.

II. Second Experimental Period (from February 23rd to March 12th).

Experiment with sifted refuse.—On the 23rd of February the furnace was again fired up, and sifted refuse was put in, and the stuff proved to be able to burn continuously without adding fuel.

Every 24 hours there was burnt, on the 23rd of February, 12·4 tons; on the 24th, 15·4 tons, on the 25th, 13·4 tons. The decrease in volume was in the proportion of 83 per cent., 83 per cent., and 75 per cent. The openings of the screens used for these experiments were large, but afterwards riddles with very fine openings were used, by which only the finest ashes and sand were removed. *This proved to be completely sufficient to make the stuff burn.*

The experiments of combustion gave the following results: on the 27th of February, 7·1 tons were burnt with 80 per cent. decrease in volume; on the 28th, and on the 29th of February, and on the 1st of March from 5·7 to 7·0 tons were burnt: on the average 6·2 per 24 hours with 60 to 68 per cent. decrease in volume. From the 2nd of March to the 8th of March, 7·6, 7·7, 7·1, 7·0, 5·8, and

5·9 tons were burnt per 24 hours with a decrease of 56, 60, 67, 80, 75, and 75 per cent.

On the 9th of March the refuse was so damp that a thorough-going treatment on the finer riddle was impossible. From the 9th to the 12th of March we tried how far this damp refuse could be burnt after it had been treated on the riddle with the larger openings. Complete combustion was possible, but was of course less rapid than with dry refuse. The damp refuse was burnt in the proportion of seven tons per 24 hours, with a decrease of 67 per cent. in volume. On the 12th of March the experiments ceased.

B.—The Summer Experiments (from the 25th August to the 27th August).

In these experiments the important thing to learn was whether the altered condition of the summer refuse (there being less unburnt coals and a great deal more vegetable refuse) would influence the combustion. As it proved impossible to procure unmixed house-refuse, stuff mixed with street-refuse had to be used.

The first result (using the screen with the largest openings) gave perfect combustion; but only four to five tons were burnt in the 24 hours, with a decrease of 70 to 75 per cent. in volume. The sifting had to be repeated, as the men were inexperienced, and because the stuff was mixed with street-refuse; after this we burnt six tons in the 24 hours, with a decrease of 77 per cent. With this the summer experiment ceased.

The clinkers withdrawn after the combustion formed a compact mass, in which glass, &c., was found in a molten condition; they were just like the results of combustion from the English destructors.

The above-mentioned sifting (the finer stuff that had gone through the riddle) was examined in the municipal laboratory. It is unnecessary to state the details. The result was that the stuff is chiefly gravel and sand, and that the quantity of organic matters is very small. It hence appears that the stuff cannot be advantageously used for manure, while it is not innocuous enough to be used for filling up. By arranging the furnace so as to let the products of combustion be conducted above and under the siftings, the stuff can however be very easily made innocuous. We found that after three hours all water had evaporated, and all organic matters had been destroyed. When treated in this way the stuff may be used for filling up, or for roadwork, &c.

In summarising the main results of these experiments, I must first state that what did not succeed with this primitive furnace might very well succeed with a regular destructor; and the latter would, of course, prove satisfactory in the cases which succeeded in our furnace.

The furnaces I have seen in England had the advantage of drying the stuff lying behind a great deal better, especially the lower layers. I could find no especial reason for this, but is probably one of the things as to which a little alteration in the construction of the furnace may have a great influence during the experiments.

The experiments have certainly proved that Copenhagen house refuse, which had not been prepared, could *not* be burnt. Of the above-mentioned modes of treatment, mixture with fuel is not to be recommended, while sifting seems to give successful results. The sifting ought to be less primitive than in the first experiments. The riddles may be moved by steam generated by the heat of the furnace itself, and this may be the rational manner of sifting. The best results are obtained with riddles with openings of about $\frac{1}{8}''$ to $\frac{1}{4}''$ in size. The riddles ought to be constructed so that a riddle with larger openings can be substituted when the refuse is too damp to be sifted through the finer openings.

The experiments show that the Copenhagen house-refuse, when sifted, is fit for burning, both in summer and winter, and can burn continuously. The quantity burnt in 24 hours, as well as the quantity and quality of the clinkers, are the same as have been found in other places, especially in England.

The expenses of a rational destruction by fire of the Copenhagen refuse will amount to the same as in the average of English cities.

I am convinced that this destruction by fire of house-refuse, which is so satisfactory in a sanitary point of view, will make its way on the Continent. When this is universally acknowledged and carried out, a new link will be added to the chain of domestic and municipal sanitary improvements, which the Continent has adopted from England; improvements, for which not only everybody here present, but all inhabitants of the Continent, will have to honour and thank England.

Refuse Burning.

BY

W. Geo. Laws, M.I.C.E.

Any paper on refuse burning must of necessity partly include the subject of refuse removal, as before we can discuss the advantages of burning the refuse of a city we must know of what it consists, where and how it is collected, and what part of it, if any, is so injurious to health that it must be quickly removed from the neighbourhood of human dwellings.

A short walk before breakfast in almost any part of London, or any provincial town, will furnish us with the needful data.

We see the scavenger leisurely sweeping into the channel the "slop" or "dust" (as it happens to have been a wet or dry night), for which no theory but that of "spontaneous generation" has ever fully accounted. It is diversified by paper in every possible form (except the clean sheet), but especially from the advertising hoarding, and dotted here and there with countless and indescribable odds and ends.

Many of the latter puzzle us until we notice on the sidewalk carefully set out before each door a series of boxes, pails, buckets, and anything that will hold, or will not hold, the various offal of a retail shop, paper, again as card boxes, wrappings, and cuttings, with ashes, straw, and sawdust, bottles, tins, and scraps of food.

If the district is residential there is more of the animal and vegetable refuse and less of the sawdust and straw, but still the paper and tin. If we happen to be near a market, the slop, &c. is rich and slab with relics of the particular goods dealt in.

We notice that a rough selection is being made among the rubbish already. All that comes under the scavenger's broom is shovelled into one form of cart, while the "box ashes," as they are technically called, are tipped into another, and still others are filled from baskets carried by the dustman from the interior of the houses in the residential districts. If these latter are followed to their dumping place there is still the same variety and still the same staples, paper, ashes, coal, bread, waste food stuffs, and wasted food, bottles, and the all-pervading tin. And whether the walk be taken in London or the provinces, in England or on the continent, Europe or India, there will be very much the same component parts, and but little difference in their proportions.

The first thing that strikes one is that amidst all this medley there is much that is useful, much that is harmless, and a good deal that is neither, but that these three classes are very badly mixed, and here we begin to touch the fringe of the refuse-burning problem.

That part of the material which contains enough manurial matter to be worth laying on the land is easily got rid of; and will pay its own carriage by rail far enough to clear the town of it, if sent as crude manure. If handled or treated in any way, either chemically or mechanically, its value is increased, but its cost raised as much or more. But the less of the other classes of stuff it contains the better the value as manure, and the wider the area over which there will be a demand for it. The best treatment we can give it is the negative one of not mixing it.

Again a great deal of the scavenger's part of the refuse is harmless and may be used to fill up excavations or to raise land, without any fear of future decomposition, and here also we must not mix it with either of the other two classes or it ceases to be harmless. We have, therefore, three broad classes of material to deal with, and practically in about equal proportions :—

(1st.) Crude manure, one-third.

(2nd.) Sound material, one-third.

(3rd.) Unsound stuff, one-third.

This last class is the troublesome part of the refuse to deal with. It cannot be used, cannot be left alone, and spoils whatever it is mixed with, we *must* get rid of it, and at any cost.

Well, we can send it off by rail and dump it in a convenient spot within the borders of some other sanitary authority. We do so, and all goes smoothly for a while until one of two things happens, this friendly neighbouring authority changes its sanitary inspector, and he in the first flush of official zeal takes the gloss off his virgin broom by attacking our rubbish dump, and having right on his side, and well aware that he will not tread on the corns of his own masters, he covers himself with glory and sends us further afield in search of fresh fields and pastures new.

Or even worse, some fine day the heap gives unmistakeable signs of being on fire and rouses the country for miles around with hideous stinks, and the only remedy is to cover it with a thick coat of sand and retire, lucky if not indicted.

If our town is situated on a tidal river the troublesome material can be sent to sea, but here again difficulties beset us.

For about 50 days in the year the barges will not be able to get over the bar. In the winter season there may be a full week at a time when it is unsafe to venture out.

We must provide barge room enough for a week's supply to be kept on hand, and to be kept where it is pretty sure to become a nuisance, real or imaginary, it matters little which.

When we have got it fairly out to sea we find that one half of it floats, and though with the best intentions we have cast our refuse on the waters, after many days it may return to us and strew the beach at some neighbouring watering place, and again we are in trouble.

On the whole this is a dirty way of keeping the town sweet, and should only be adopted in cases of emergency, and until better means can be devised.

After all then we are driven to look for some means by which the obnoxious third can be dealt with within our own boundaries, and destruction by fire seems the only course available. It is at best but a clumsy mode of attaining our end, it is not at all a cheap plan, and worse, it is at present an unpopular one. But it is fairly effective and always available.

Theoretically, the stuff should be sorted and utilized, the useful parts sold, and the refuse made into manure. Unfortunately this cannot be done by town authorities at even a reasonable cost, and the manure making part gives rise to unholy stenches.

Private enterprise may succeed in paying expenses, and even in getting a small profit, but this has not yet been proved; certainly public bodies cannot—first, because they would be at once indicted for doing what private manufacturers may do with impunity; secondly, because there is no finality with public bodies, and they are constantly trying new and costly experiments, and making expensive alterations to their plant which swallow up any possible economy.

It is a pity that popular prejudice should have turned so strongly against refuse burning, as it certainly has the merit of very quickly resolving decomposable and, therefore, dangerous matter into its first elements, and with a minimum of nuisance in the process.

Even a large destructor furnace in full operation does less to pollute the air than the smoke from an ordinary dwelling-house. But popular prejudice is always unreasoning and generally unreasonable, and the more formidable on that account, as it is beyond the reach of argument or proof.

The destructor furnace is pretty well known, being merely a wide but shallow arch generally with the fire grate laid on a slope to facilitate charging. This is done from the upper end, the stuff being tipped down a sort of hopper mouth and pushed and raked in a uniform layer of about 12 or 15 inches thick, over the glowing embers of the last charge.

This description really covers the essential principle of refuse burning,—a fire grate of considerable area with a fire of moderate thickness and a good draught.

Very few real improvements have been made on the original pattern, and in most cases complication has only served to increase cost without improving the result.

Various plans have been tried for applying a forced draught, and though they have given good results, yet, when brought down to the final test of the cost per ton burnt, their supposed advantage vanishes.

A fault which has more than any other led to partial failure and public complaint, has been insufficient chimney power. Shafts have been built with too small an area for the work to be done, and hence too rapid a current.

The material burnt is one which naturally produces much dust, and a quick draught carries this dust with it out of the chimney to fall somewhere in the neighbourhood and causes a nuisance and legitimate complaint. On the other hand a shaft of twice the area would do the same work with a current of half the speed and most of the dust never reaches the outer air, but can be caught in very simple dust-traps.

The writer's experience decidedly leads him to prefer an ample natural draught (which may even require to be stopped down by dampers) to any of the forms of forced draught, which are an expensive way of getting work done by machinery that is too small for the purpose, and only justifiable where space is unavoidably limited.

The state of the material burnt leads to another form of nuisance. It contains from 25 to 40 per cent. of water, and sometimes, when sludge is burnt, even more. This moisture must be driven off in the form of steam, and however hot the fire, a certain time is occupied in the partial distillation, and fumes and empyreumatic vapours are carried over with the steam, which, however innocent, are very distinctly traceable by smell.

That they are harmless makes little matter, they are slightly pungent and aromatic, but distinct enough, and the honest British ratepayer has a nose of wonderful power when applied to the detection of official sins.

To meet this difficulty the fume-cremator has been devised by which the vapour from the destructor cells in passing to the chimney is drawn over a bed of incandescent coke, and in so passing is raised to a heat of 1,200° to 1,500°, practically completing the partial distillation commenced in the cells, and resolving the empyreumatic vapours into their primitive gases, odourless at last.

The fume cremator has effectually met a real want, and gone far to render possible the introduction of the refuse destructor into situations where prejudice would otherwise have been too strong for it.

It may be useful to give the practical results of a trial of refuse burning extending over five years, in which care has been taken to set down accurately every item of expense, and so to arrive at a reliable result, in no way biased by trade considerations.

The authorities of Newcastle-upon-Tyne in 1885 determined to make a trial of refuse burning, and having secured a suitable site on their own property, put down the plant for a destructor of 12 cells.

Wishing to feel their way, they erected at first six only of these cells, which were completed in June 1886, and have been steadily burning night and day ever since.

The capital cost of erection was 5,060*l*., which included a chimney shaft large enough for 12 cells, and also roads, tramlines, and other works necessary for the larger establishment, so that the increase to 12 cells now just completed has cost in all 7,000*l*.

The results now given are of the working of the six cells only, and they have been debited with the full capital at first expended, viz., 5,060*l*. The interest on this has been taken at 4 per cent. being one-half per cent. more than the Corporation of Newcastle pays on its stock.

No charge for redemption has been taken into account, it being considered that where the plant was fully kept up by repairs and renewals, a fairer estimate of the actual cost would be arrived at by taking interest only on capital, and charging repairs and renewals as they occurred.

The site on which the works stand had been let by the corporation for market gardens at 5*l*. per acre, and when handed over to the Sanitary Committee the rent was raised to 10*l*. per acre or 25*l*. for the 2½ acres occupied. Rates and taxes are charged as paid, the site being within the boundaries of another authority.

A careful and regular account has been kept of all the material brought to the destructor.

A charge of 1*s*. per ton is made to all private persons, tradesmen, and others, who send refuse for burning, and also when diseased meat or food stuffs condemned as unfit for use are dealt with.

Clinker and ashes are sold to contractors and others at what prices they will fetch, and when used by the corporation themselves are charged at the same prices as paid by the public.

These various receipts are treated as credit items and deducted from the total cost of burning.

The result of the whole five year's work is as follows :—

We have burnt 61,120 tons of material at a nett cost, including all expenses, of 3,097*l*., making the cost of burning just over 1*s*. per ton, or more exactly 12·16*d*.

This cost may be divided thus—

	Per cent.	Per ton.
		d.
Interest, rent, rates, taxes, &c. -	37·6	4·56
Repairs and renewals - - -	8·8	1·10
Labour - - -	53·6	6·50
	100·0	12·16

With respect to this last item of labour there is a somewhat noteworthy fact to record. For the first three years and a half the work was done by two shifts of 12 hours each. At the end of 1889 there was considerable agitation in the labour market, and the gas stokers got a very material reduction of hours and increase of pay. The destructor men claimed a similar change, and the shifts were reduced to eight hours each, that is, three shifts are now employed working eight hours and resting 16 hours. The wages, by agreement with the men, remained the same per shift, so that the cost of labour was raised just 50 per cent. Naturally it was expected that the cost of burning would rise proportionally, that is, about 25 per cent., as labour formed about 50 per cent. of the work.

On working out the results, however, at the end of 1890–1 and up to date, the cost of burning, which up to the end of 1889 was 12·3*d.* per ton, has actually fallen to 11·9*d.*, or nearly ½*d.* per ton, while labour alone for the first three-and-a-half years was 6·9*d.*, and for the last 18 months 7·7*d.* per ton.

This is an interesting and significant fact, and though perhaps it is really more suited for discussion in another section of this Congress, yet the writer cannot but call attention to it as throwing a light on the labour question which must be specially interesting to engineers.

Here is a case where with identically the same plant and machinery, a lessening of the hours of work by one-third, viz., from 12 to eight, while increasing the total wage paid by 50 per cent., actually so far increased the output as to slightly reduce the cost per ton. It would be interesting to have the experiences of other employers of labour in this direction.

To return to the experience gained at Newcastle, it appears that, with three shifts of eight hours each, the burning capacity of each destructor cell is slightly over 2,500 tons per annum, or eight tons per day of 24 hours. When it was attempted to increase this output it was found that the stuff was not so well burnt and that the residue was more bulky.

As nearly as can be estimated the total residue is from 25 to 30 per cent. of the material burnt. It consists of a hard clinker, which has been found very useful for many purposes, and of sound dry ashes, which readily sell at 6*d.* per ton up to the full demand for them, but so far the output far exceeds the demand, and the unused part is tipped into an old quarry where it is gradually forming useful land that will one day come into the market as building land.

The clinker has been much used for making the concrete bed in which the sanitary pipe sewers of Newcastle have been laid for the last nine years. It may be mentioned in passing that an ordinary sanitary pipe when thus laid in concrete for half its depth is just doubled in strength. A pipe 12 inches in diameter, which laid in clay, bore 30 cwts. laid on it before breaking, when laid in concrete required three tons to break it.

The great difficulty in the way of refuse burning is the securing of suitable sites for the furnaces. It is not easy to overcome the prejudices of the people, and each ratepayer is anxious that the work should be done at his neighbour's door and not at his own.

Probably every householder runs more real risk from the keeping of his own share of the refuse in his backyard than from the burning of the offal of a whole district within 50 yards of him; but the people have a great deal to learn as to their own interests and their duty to the community, and till a great stride has been made in that direction a needful reform will be cramped and hindered, and where not actually prevented will be saddled with difficulties and expense that ratepayers of the future will regret.

It is important that refuse destructors should be central for the district which they serve so as to reduce the cost of cartage, which generally far exceeds the cost of burning, and for the same reason they should be placed on low rather than on high ground so that the loads may be downhill. Taking Newcastle again as an example, carting the refuse up or down hill makes from 1*s.* to 1*s.* 6*d.* per ton difference in cost, more than the total cost of burning.

There should also be a ready means of getting rid of the 30 per cent. of residue which does not so far find a market. If this is to cart again, the cost becomes heavy.

The real value of a destructor is, that however clumsy and costly the plan of burning our refuse may be, it is at any rate effectual as a means of getting rid rapidly and completely of readily decomposable and, therefore, dangerous matter.

With proper destructor power and efficient daily collection of refuse it should always be possible to get rid of dangerous material within 24 hours, before it has time to ferment and develop its peculiar powers. In no other way can this be done with so much certainty or so quickly. There is also this further advantage that by so dealing with about one-third of the refuse we render another third saleable and the remainder harmless. And the cost of this advantage is 1*s.* per ton on one-third of the refuse, 4*d.* per ton on the whole. Surely not an extravagant price.

Newcastle-on-Tyne.

Five Years' Refuse Burning.

—	Refuse Burnt.				
	Box Ashes.	Ashpit Stuff.	Market Refuse.	Condemned Meat and Bedding.	Total.
	Tons.	Tons.	Tons.	Tons.	Tons.
1886-87 (9 months.)	6,675	405	210	27	7,317
1887-88	9,764	542	318	116	10,740
1888-89	10,356	546	323	91	11,316
1889-90	11,631	584	314	93	12,622
1890-91	14,263	390	403	142	15,198
1891 (3 months)	3,700	100	100	30	3,930
	56,389	2,567	1,668	499	61,123

Cost of Five Years Refuse Burning.

—	Rent, Rates, and Interest.	Labour.	Repairs and Renewals.	Total.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1886-87 (9 months)	230 0 0	207 0 0	21 0 0	458 0 0
1887-88	247 0 0	317 1 6	74 7 8	638 9 2
1888-89	245 0 0	317 17 3	41 13 6	604 10 9
1889-90	245 0 0	355 9 1	53 16 2	654 5 3
1890-91	245 0 0	492 19 2	86 6 10	824 6 0
1891 (3 months).	60 10 0	123 5 0	20 0 0	203 15 0
	1,272 10 0	1,813 12 0	297 4 2	3,283 6 2

—	Receipts.		
	For Burning Private Refuse.	For Clinkers and Ashes Sold.	Total.
	£ s. d.	£ s. d.	£ s. d.
1886-87 (9 months)	4 10 8	26 13 6	31 4 2
1887-88	32 4 4	30 5 6	62 9 10
1888-89	34 4 8	24 6 6	58 11 2
1889-90	34 4 6	16 17 5	51 1 11
1890-91	48 0 0	18 12 9	66 12 9
1891 (3 months).	12 0 0	4 13 0	16 13 0
	165 4 2	121 8 8	286 12 10

	£ s. d.	£ s. d.		d.
Total cost -	3,383 6 2			
Deduct receipts -	286 12 10	3,096 13 4		
		————	=	12·16 per ton.
Net cost -	3,096 13 4	61,123 tons.		

	£ s. d.		Per cent.		Per ton net. d.
Rent, &c. - - -	1,272 10 0	=	37·61	=	4·56
Labour - - -	1,813 12 0	=	53·60	=	6·51
Repairs - - -	297 4 2	=	8·79	=	1·09
				=	12·16 per ton net.

How best to Dispose of the Refuse of Large Towns.

BY

William Bruce, M.D., LL.D., Medical Officer of Health for Ross and Cromarty.

This question has now narrowed itself down to destruction by fire. It has become impossible to deal with the many and various waste products of the household in cities by any other means. Their value as manurial agents is not equal to the cost of transport, and year by year the sums paid to the dust contractor for his trouble in disposing of refuse increases. Such being the answer to our query, what, then, is the best form of destruction? Is it to be by one large or many small destructions? The objections to large destructions are (1) the great bulk of the products to be dealt with, (2) the great expense of transport of the material to be destroyed, (3) the dangers of diffusion of disease, the necessary offensiveness of the process, and the noise of perpetually rumbling carts along the route traversed.

The advantages of small local destructions would be proximity, and the saving of the expense in cartage.

It has occurred to me that the best form of destructor would be a portable steam-engine, provided with a suitable fire-box, into which all combustible matter could be thrown. The heat generated by the burning of the refuse would, I calculate, be almost sufficient to propel the locomotive. Trucks would be attached, into which the cinders might be passed, and these could be stored at suitable depôts, such as railway stations. The plan of operation would be something like the following:— The traction-engines would start, each on its rounds, at 12 o'clock at night. As the engine passed along a particular street (notice having been previously given of its route), the ashes and other matters would be taken away in buckets of a suitable kind, and emptied into the furnace; and so, progressing slowly, the engine would finish its rounds about 5 a.m. next day.

The chief difficulty would be the smell of the gases set free. This need not trouble us much, since, 1st, almost all the houses would be shut up as the engine passed along, and, 2nd, effectual means, by steam-jet or otherwise, can be easily devised so as to make sure that every inch of gas is burned up before being allowed to escape into the atmosphere.

No doubt a certain amount of noise and vibration would accompany the process. These might be met by special construction of the engine, by cushions of steel, so to speak, on the wheel. On the whole, it may be safely asserted that the noise and vibration would be less than the noise and rumbling of carts. It would be very easy to show how this process of disposal of waste matter would be cheap. Take the tons of waste paper alone, and the bulk it occupies, carried miles and miles away, when it could be disposed of so easily by incremation. It is not altogether a far-fetched idea that, in times of plague and pestilence, cremation might thus be brought to the very doors where death and disease were playing havoc, and all traces of their progress at once dealt with and disposed of.

DISCUSSION.

Mr. Manning said there was one way of disposing of solid refuse which had not been alluded to, it was the way solid refuse was disposed of in Paris. The gardeners there brought a cart-load of carrots and cabbages and took away a cart-load of refuse from those vegetables, and that was used as manure, and it formed a manure of a very valuable character. If they were afraid of any smell by its decomposition before it got into the ground there were plenty of antiseptic products of a liquid or solid character that would suspend for a time the decomposition of this vegetable refuse.

Mr. Henry Whiley, Superintendent of the Health Department of the Corporation of Manchester, said Mr. Jones had mentioned that in the north they were a long way behind the south. He wished to state that in the north they had been burning refuse for the last 16 years. The Manchester Corporation were the first to build destructors, and they had continued their use ever since 1874–5, and were now burning at the rate of 80,000 tons a year. They had destructors of nearly all kinds working. There were some that were antiquated, and difficult and expensive to work and others which they had given up. It would be observed that Fryer's Patent Destructor was copied from theirs in 1874 or 1875. The refuse was then tipped from carts, and the material had to be dried before calcination, by the heat from the furnace door; the stench went up the chimney; but this was not the case now, with the new destructor. Mr. Jones had built a cremator, but that was not at all necessary. The refuse went in at the wrong end of the furnace. It ought to go in at the commencement without any handling; everybody objected to handle such stuff. He was ashamed to see men handling it, particularly that in the north, which was very bad to deal with. The principle was altogether wrong. The stuff ought to go in at the front and be projected mechanically, on movable fire-bars, and empty itself automatically, without being handled. No fume-cremator was required, because it cremated as it went on. If it did not, then there was a special furnace suggested and invented by Mr. Davis, Inspector of the Alkali Works. Rochdale was the first town to construct it, and he believed that Manchester was the next. It did its work admirably. In a furnace, such as they had in Manchester, they could burn 10 or 12 tons in 24 hours, and destroy the fumes from the evaporation of 600 gallons of urine per hour, and there was no smell given off by the chimney. He wished to mention the matter, because they had met to devise the best means that could be adopted. In Manchester they had to get rid of a thousand tons of refuse a day, and they did it in various ways. Of course it was objected to everywhere. The only sensible people he had to deal with were the thinking working classes who fully appreciated the difficulty of the matter. Respectable people said, "Go anywhere, but do not come to us; go into the lower districts." He did not believe in that. He thought each locality should bear its own share, and he hoped that the time would come when everybody would be made to burn his own refuse. It was a very simple matter and saved a great deal of expense. As to the clinkers that came out of the furnace, it was abominable to have to draw the fire out every two hours. It was worse than being in a gas house. When sprinkling it with water to cool it, the stench from it was worse than the fumes from the chimney, and people complained of it most bitterly. The dust, also, was very bad. In London, all the neighbours complained of the dust. They had no dust in Manchester. They had had complaints about paper, but they had remedied that. After the Congress, nobody would burn paper for the sake of burning it. They would make paper of it again, and there would be no more complaints on that subject. With regard to the remark made by Dr. Bruce, they had tried that plan of collecting the refuse at night in Manchester. They did not try it with a steam-engine, but on tramways. But let them fancy having to carry the refuse of a large city from houses, many of them more than a mile distant from the tramways, and the suggestion became obviously impracticable. They converted most of their clinkers into mortar, of which they made from 10 to 12 tons a year. It was the best mortar in the town, and everybody used it, except the jerry builders.

Mr. Washington Lyon said that, as Mr. Jones had mentioned Dr. Saunders, Medical Officer of the City of London, and had also referred to the destructor used at Lett's Wharf, a few words from him (Mr. Lyon) would not be out of place, as he had taken part in the deputation that went with Dr. Saunders to Leeds to see the first destructor. The result was that they, after some little difficulty, did persuade the Corporation of London to adopt the destructor; but he agreed with Mr. Jones that they were not using that destructor properly. There was a prejudice on the part of some of the old officials against adopting these modern improvements; and until they get some younger men and had a few more Congresses like the present, they would have great difficulty in adopting modern systems of getting rid of the refuse. If they could only get the vestries and local boards to attend such Congresses they would be able to advance. He had been on the Camberwell Board between 30 and 40 years, and had been fighting this question from time to time. He brought it before the board only the other day. A deputation went to Ealing to see the destructors there. They all came back delighted. The sub-committee passed a resolution to adopt them, and when that resolution went before the board the gentlemen on the board said "No, we will wait a little longer." They all knew what that meant. They must convert the masses; for until that was done these advanced notions could not be well carried out. He believed they were losing sight of the health question in connexion with dust. In the Corporation of London, before the erection of their destructor, there were about 100 women employed in separating the dust and rubbish. It was perfectly disgusting to see human beings at such an occupation. They succeeded, he believed, in getting rid of this system; but he heard that some of these women were still employed in doing part of the work, separating paper from the rubbish, when in a few hours the whole of it could be destroyed, and a residue left which would do no mischief to anyone, but which was useful for building purposes, tar paving, the foundations of houses, &c. Surely the day was come when they should try to adopt some of these systems, and not—as they were doing now—distribute disease in all directions by sending their filth all over different parts of London.

Mr. Alliott said a very large number of the furnaces to which reference had been made had come under his own personal observation. The number of cells of Fryer's destructor which had actually been constructed, and were in operation and ready for operation, would be more like 300 than 200, the number mentioned in the paper, and those cells were capable of dealing with from 80 to 100 tons of refuse each hour in a day. That the system of destroying refuse of that character by means of fire was extending, and extending somewhat rapidly, would be shown when he stated that during the present year something like 100 cells would be constructed and put to work, capable of dealing with something like 250,000 tons of refuse annually—taking into consideration that sewage work was stopped on Sunday, and often also for a portion of Saturday and the early part of Monday. One application of the system of burning refuse had not been mentioned. It was not because Mr. Jones was ignorant of it that it had escaped his attention, but perhaps he thought it would not be so generally interesting. It was the adoption of a special miniature furnace, very much of the destructor type, for dealing with such material as hospital refuse. Such material was of an exceedingly difficult character to deal with, because much of it was infectious. It could not with safety be carried through the streets or burnt in any ordinary fire. It was a great nuisance, and, if buried, the danger from it was not altogether done away with; and special furnaces, very much of the destructor type, had been introduced for the purpose of dealing with it. Whilst destructor furnaces of various kinds had been erected in different places, yet there was only one class of those furnaces—the Fryer's furnace—which so far had been adopted in any considerable number of towns. There was no other class of furnace which at the present time was used in more than two, or, at the very most, three places. Mr. Whiley had referred to the use of destructor furnaces in Manchester. It was quite true that when Mr. Fryer first patented his destructor furnace, Manchester was the first town to adopt that patented furnace; but when Mr. Whiley said that at present Manchester was ahead of all the rest of the world in regard to these matters, he must be ignorant of what the rest of the world was doing. At any rate, the merits of the system in use there had not been so obvious to those who visited Manchester as to lead to its extensive adoption elsewhere, as had been the case with some other furnaces.

Mr. Joseph Hall (Borough Surveyor, Cheltenham), said the only matter he wished to speak on was Mr. Laws' reference to the employment of labour. He had been through the same experience, and could fully confirm it. He had tried it with lamp-lighters, with street-sweepers, and with every department. He found that by taking off the half-day on Saturday they actually gained by the alteration, and did not lose by it at all. He found that with the street-sweepers he could increase the quantity of work by one-fourth, and the wages by one-fifth, so that they got more work done, and better done at the same time. More work was done at a slightly less cost. They took two sections of men, and dealt with one on one plan, leaving the others as they were. Those that were dealt with under the new system he watched every fortnight as they came to the pay-table; and he believed it simply amounted to this, that they were getting better paid and therefore better fed. The whole question of labour resolved itself into that. If they were to have a full day's labour, such as they would expect from the best men, they must pay the others so that they could get that amount of food which would enable them to do it; and he did not think the ordinary rate of wages in many parts of England would allow of that. Where wages were 15*s.* a week they would, as a rule, get more work for 18*s.*, and better value than they did for the 15*s.*

Mr. C. Jones did not know that he had very much to say in reply to the criticisms that had been offered. They had been all fair, and the remarks of their friend, Mr. Whiley, had been particularly so. One did not mind an occasional dig in the ribs. They were all striving for one end, viz., to bring about a fine and splendid result from the Congress, and he could not but think that its outcome would be such as he would be the first to recognise, that the best man, the best apparatus, would win. In travelling about hither and thither in connexion with the Association of Municipal Engineers, they had gathered up ideas from one and another, which they had made use of, improved upon, and done the best they could in connexion with. He did not think there had been a single criticism made which he could call adverse. Nothing could be more interesting than the question of purification by fire, and, no doubt, ultimately they would have to consider the question of the destruction of London sewage rather than sending it out to sea. It was the third heading of the Royal Commission upon the very question to which they had been referring, and he was only surprised it had not been brought forward in connexion with their various societies.

Mr. W. G. Laws said that he, unfortunately, was not in the room when Mr. Whiley's statement was made. Some years ago he went to Manchester, and Mr. Whiley very kindly showed him, and some of the members of the deputation that went with him, the whole of the process by which the refuse was dealt with. They were extremely struck with the great ingenuity displayed in making use of every possible thing which had value in it. Mr. Whiley was kind enough to give the figures, and he was sorry the thing was not more widely known. It was, however, very well known within a couple of hundred yards of the place, they could not mistake it. When he got home, he worked out Mr. Whiley's figures, and, to his surprise, he found the cost of refuse removal and disposal in Manchester was 5*s.* per head. In Newcastle, where they did not go to that extreme, the cost was 2*s.* per head. He would admit that it was upon Mr. Whiley's experiments, at Manchester that his belief was chiefly founded, that it was better to let the stuff alone than to try to utilise it.

Mr. Whiley, in explanation, said Manchester was not a water-closet town, and the 5*s*. per head included dealing with the fæcal matter. That accounted for the difference between 2*s*. and 5*s*.

The President said there had been handed to him for presentation to the Section two very valuable books by Dr. Samuel Abbott, containing the result of experiments in America, one on the purification of sewage and of water, and the other on the examination of water-supplies. He was sure the Congress would authorise him to convey personally to Dr. Abbott their very best thanks.

Friday, 14th August 1891.

The Chair was occupied by
The President, Sir John Coode, K.C.M.G.

Municipal Engineering.

BY

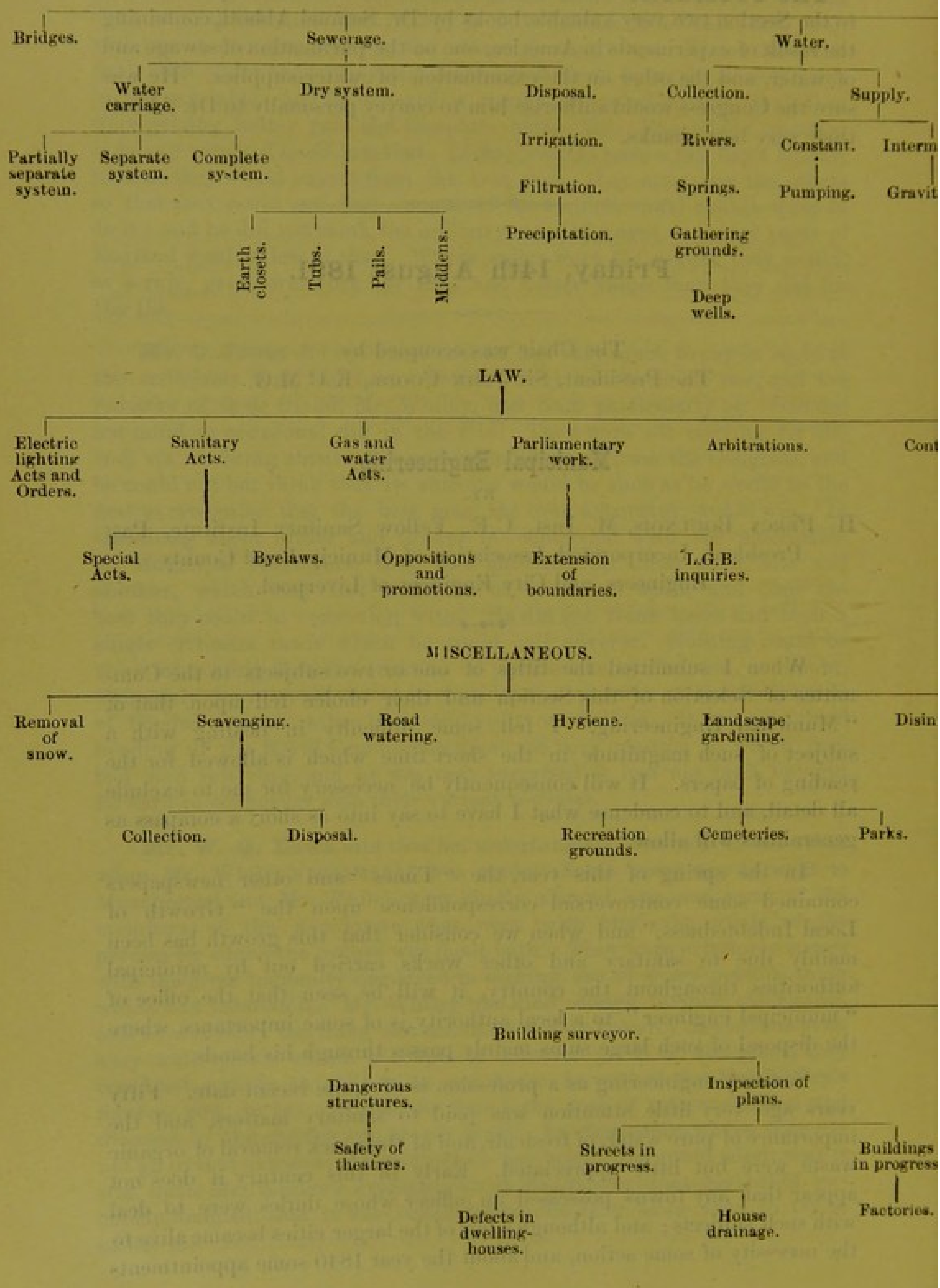
H. Percy Boulnois, M. Inst. C.E., Fellow Sanitary Institute, Past President, Incorporated Association of Municipal and County Engineers, and City Engineer of Liverpool.

When I submitted the titles of one or two subjects to the Committee of Selection of this Section and their choice fell upon that of "Municipal Engineering," I felt some difficulty in dealing with a subject of such magnitude in the short time which is allowed for the reading of papers. It will consequently be necessary for me to exclude all detail, and to condense what I have to say into as short a compass as generalities will allow.

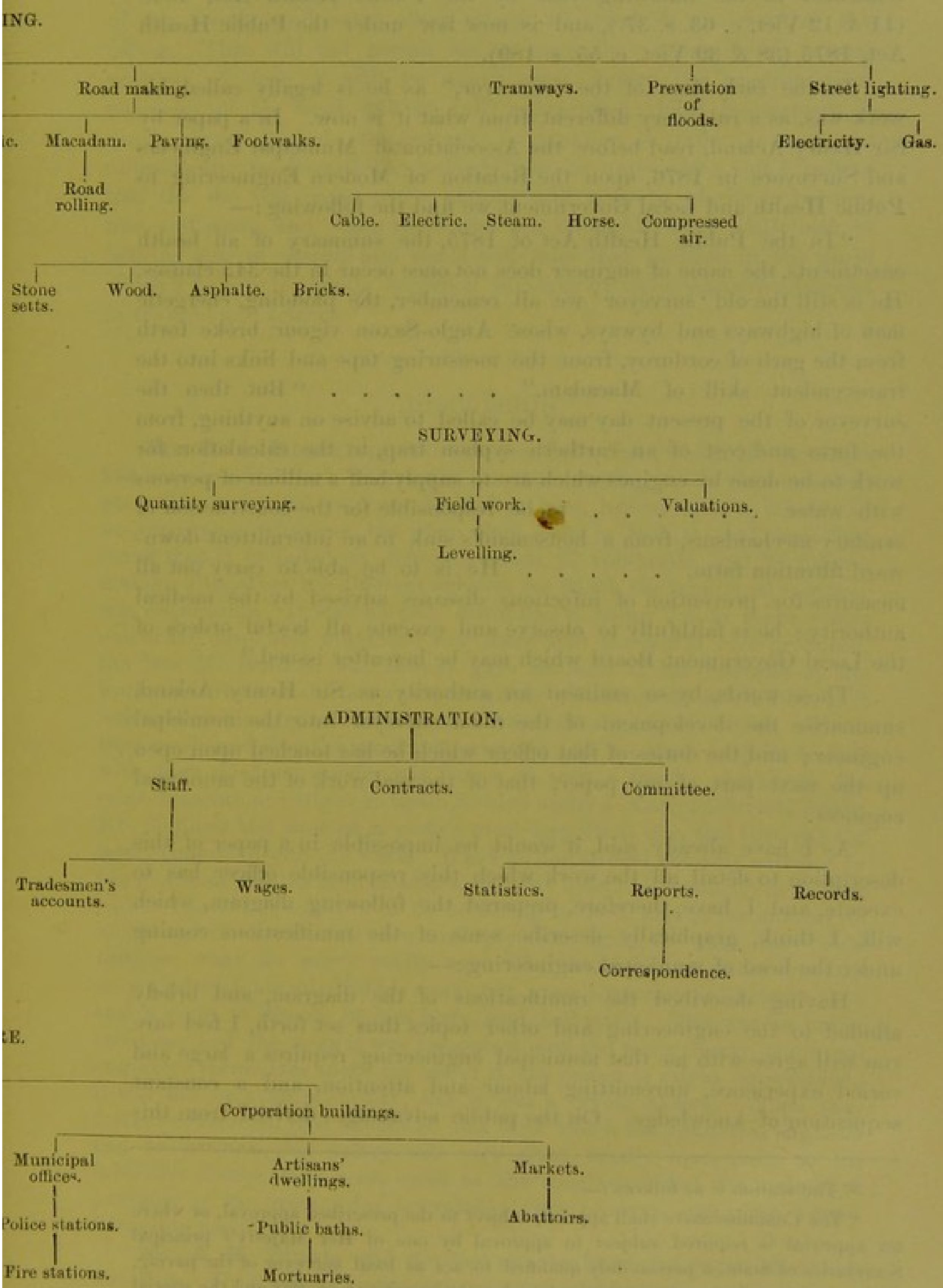
In the spring of this year, the "Times" and other newspapers contained some controversial correspondence upon the "Growth of Local Indebtedness," and when we consider that this growth has been mainly due to sanitary and other works carried out by municipal authorities throughout the country, it will be seen that the office of "municipal engineer" to a local authority is of some importance where the disposal of such large sums mainly passes through his hands.

Sanitary engineering as a profession is of quite recent date. Fifty years ago very little attention was paid to sanitary matters, and the importance of pure water, of fresh air, and of the quick removal of organic waste were but little appreciated. Early in this century it does not appear that any towns possessed an officer whose duties were to deal with such subjects; and although a few of the larger cities became alive to the necessity of some action, and about the year 1840 some appointments

THE SIX CHIEF BRANC



MUNICIPAL ENGINEERING.



were made similar to that of the "town surveyor," it was not till the year 1847 that this officer was first legalised under the Towns Improvement Clauses Act (10 & 11 Vict. c. 34. s. 7*). This was confirmed in the following year by the Public Health Act, 1848 (11 & 12 Vict. c. 63. s. 37.), and is now law under the Public Health Act, 1875 (38 & 39 Vict. c. 55. s. 189).

In the early days of the "surveyor," as he is legally called, his work was, as a rule, very different from what it is now. In a paper by Sir Henry Acland, read before the Association of Municipal Engineers and Surveyors in 1876, upon the Relation of Modern Engineering to Public Health and Local Government we find the following:—

"In the Public Health Act of 1875, the summary of all health enactments, the name of engineer does not once occur in the 343 clauses. He is still the old 'surveyor' we all remember, the plodding, energetic man of highways and byways, whose Anglo-Saxon vigour broke forth from the garb of corduroy, from the measuring tape and links into the transcendent skill of Macadam." . . . . . . "But then the surveyor of the present day may be called to advise on anything, from the form and cost of an earthern syphon trap, to the calculation for work to be done by engines which are to supply half a million of persons with water . . . . to be responsible for the construction of sanitary mechanisms, from a housemaid's sink to an intermittent downward filtration farm. . . . . . He is to be able to carry out all measures for prevention of infectious diseases advised by the medical authority; he is faithfully to observe and execute all lawful orders of the Local Government Board which may be hereafter issued."

These words, by so eminent an authority as Sir Henry Acland, summarise the development of the town surveyor into the municipal engineer; and the duties of that officer which he has touched upon open up the next part of my paper, that of the real work of the municipal engineer.

As I have already said, it would be impossible in a paper of this description to detail all the work which this responsible officer has to execute, and I have, therefore, prepared the following diagram, which will, I think, graphically describe some of the ramifications coming under the head of municipal engineering:—

Having described the ramifications of the diagram, and briefly alluded to the engineering and other topics thus set forth, I feel sure you will agree with me that municipal engineering requires a large and varied experience, unremitting labour and attention, and a constant acquisition of knowledge. On the public advantages derived from this

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* The section is as follows:—

"The Commissioners shall appoint, subject to the prescribed approval, or where no approval is required subject to approval by one of Her Majesty's principal Secretaries of State, a person duly qualified to act as local surveyor of the paving, drainage, and other works authorised under the provisions of this and the special Act . . . . . . and the Commissioners with the like approval may remove any such surveyor."

officer's work I will not dilate; well-paved and lighted streets, well sewered and drained towns, pure water delivered to all parts of our dwelling-houses, the sanitary improvement of those dwelling-houses, public recreation grounds and parks, the amelioration of the condition of the people, and many other things, all speak of the work of this officer. Time will not permit me to more than allude to his present position. I fear it will be many years before the unostentatious character of his work will be fully appreciated; local government is nearly always decried; the necessity for taxation in order to carry out unproductive works will for a long time be unpopular; but I believe that the day will come when nations will cease to glorify in politics, war, and pomp, and when those who are engaged in the daily task of battling against disease and death will take that position in the world which I believe is already accorded to them by those who are advanced in thought and science.

DISCUSSION.

Mr. H. A. Roechling (Leicester) said the chart which Mr. Boulnois had been good enough to prepare for that meeting was a very excellent one. The municipal engineer had often been looked upon as a being of no importance whatever, but when they came to look at that chart they found that it included six different heads, 27 sub-heads, and 72 others, making altogether 105 different subjects for which the municipal engineer was responsible. It was his (Mr. Roechling's) happy lot to serve under one of the most able municipal engineers that the world ever produced, the late Mr. Gordon, who always gave the best of his energies to his work, and who was cut down very suddenly with heart disease, killed, as it was said of him, by an over-conscientious discharge of his duties. When they considered that the municipal engineer had all these subjects to deal with, they need not wonder any longer at such a result. Although the subjects mentioned might be again divided under as many additional heads, Mr. Boulnois had omitted to state a most important one, and that was the worry connected with the work. When he had to deal not only with one or two gentlemen at the head of affairs, but with about 150 councillors as they had in London, it might well be appalling to look first at the number of heads and sub-heads, and then multiply them again, for then they could imagine what the worry really was. The municipal engineer was not only tied with his mind to his work, but some corporations thought they had a right to dispose of him body, soul, and spirit. This was an entire mistake; and the more it was recognised, and the more clearly municipal engineers themselves spoke out about it, the sooner it might be rectified; it was not only an absurdity, but it was a crying shame. When they further considered that besides all this work which the municipal engineer had to perform, his salary was very often totally inadequate to his laborious duties, they must come to the conclusion that the municipal engineer of the present day occupied a very onerous, and often a very harassing position.

Mr. A. R. Binnie said the fact was he knew too much about this question. They were all conscious of what had been so well put before them by Mr. Boulnois, the onerous duties they had to perform. They were aware also of those little worries that had been mentioned, but he

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thought their duty to the public and to themselves was to try and do their best, waiting for their work to be properly appreciated as time went on.

Mr. J. Thornhill Harrison said he quite agreed with what Mr. Boulnois had pointed out as to the multifarious occupations and employments of municipal engineers. He hoped they would soon receive that acknowledgment which their services deserved, that they would be put on a good footing by the Government, and that their salaries would be made adequate to their work.

Mr. Boulnois, in reply, said he must take a very short discussion on his paper as showing that he had filled up all the blanks upon his diagram. He was afraid, when he submitted it, that he might have left out a great many subjects; for instance, the question of the prevention of the encroachment of the sea was a matter which in seaport towns engaged the attention of municipal engineers to a very considerable extent. And that was omitted from the diagram. As to the worry that the municipal officer had to go through, any man who was conscientious, and who took an interest in his work, was bound to worry, and the man who did not worry was not worth his salt. What he should do was not to let anybody know that he was worrying. After all, there were a great many compensations for the worry they had to submit to; for they did occasionally get a crumb of comfort in the belief that they had done their duty to the best of their power, and had in some way ameliorated the condition of suffering humanity. He should like to say a few words about the Association of Municipal and County Engineers, of which he was ex-president. That association held district meetings at which papers of great value were discussed, and the works of different towns inspected. Every town surveyor who attended those meetings went back with a considerable amount of knowledge derived from what he had seen and learned, in addition to exchanging ideas with officials from other towns. He wished to state publicly that it would be greatly to the advantage of local boards if they paid the expenses of their surveyor's attending those meetings, instead of expecting him to do it himself. Of course, in towns where officials were getting perhaps larger salaries, it was not so important; but in many towns where the surveyors were very poorly and inadequately paid, it appeared to be a great injustice that they should have to pay, out of their own pockets, the expenses of attending the meetings at which they gained information afterwards to be applied for the benefit of the ratepayers whom they were serving. In conclusion, he recommended the use of black calico and white paint for the preparation of large diagrams such as that which he had placed upon the wall; for although it was very formidable in size, he could assure them that it could be packed up in a very small compass.

Die Typhus-Epidemie in Altona 1891 und das filtrirte Flusswasser.

VON

W. KÜMMEL, Altona.

In den ersten Monaten dieses Jahres ist in einer grösseren Zahl deutscher Städte ein epidemisches Auftreten typhöser Erkrankungen beobachtet; zu diesen Städten gehört auch Altona, in welcher Stadt auch in den Jahren 1885, 1886 und 1888 der Typhus epidemisch aufgetreten ist. Während nun aber in den genannten Jahren auch in der Altona unmittelbar benachbarten grösseren Stadt Hamburg Typhusepidemien, deren Culminationspunkt zwei bis drei Monate vor dem der Altonaer Epidemien lag, herrschten, ist in diesem Jahre die Stadt Hamburg völlig verschont, ja die Typhusfrequenz dieser Stadt ungewöhnlich niedrig geblieben, während in Altona die Zahl der Erkrankungen ungefähr ebenso hoch, wie bei den Epidemien der Jahre 1886 und 1888 war, im Verhältniss der inzwischen durch die Einverleibung mehrerer nahegelegener Ortschaften erheblich gestiegene Einwohnerzahl berechnet. Hamburg, bei etwa 560,000 Einwohnern, meldete stets weniger als 10 Erkrankungen pro Woche, während Altona, bei 146,000 Einwohnern, durchschnittlich im November 8, im Dezember 11·2, im Januar 21·2, im Februar 103, ja in der dritten Februarwoche 147 Erkrankungen aufwies. Besonders auffällig war dabei, dass die unmittelbar an Altona stossende Vorstadt St. Pauli, deren Bodenverhältnisse, Bevölkerungsart und -Dichtigkeit den Altonaern durchaus gleichartig ist, gleich der übrigen Stadt Hamburg völlig verschont blieb, während die dieser Vorstadt benachbarten Strassen Altonas, wenn auch nicht ganz so viele wie andere entfernter liegende Stadtheile, doch eine sehr erhebliche Zahl von Erkrankungen zeigten. Wenn zwei Städte, deren Bauart, Bevölkerung, Lebensbedingungen sich so sehr gleichen, einer Epidemie gegenüber sich durchaus verschieden verhalten, so liegt es nahe, die Gründe zu erforschen, durch welche sich diese Verschiedenheit erklären lässt. Im Nachfolgenden soll versucht werden, dies zu thun, zunächst klar zu stellen, in welchen Dingen die Verhältnisse Hamburgs und Altonas von einander abweichen, um so die Unterlagen zur Lösung der Frage zu gewinnen.

Ein grosser Theil der Stadt Hamburg ist auf den Niederungen der Elb- und Alstermarsch, im Alluvium, erbaut, und besitzt, da die Gewässer der Alster, der Bille und der Hammerbrookkanäle durch Schleusen aufgestaut werden, einen ziemlich constanten Grundwasserstand. Sehr beträchtliche Theile der Stadt, fast die gesammte Neustadt, der östliche Theil der Altstadt, die Vorstädte St. Georg zum Theil, St. Pauli fast ganz und die meisten sogenannten Vororte sind auf Geestgebiet, im Diluvium, erbaut; hier schwankt der Grundwasserstand stärker, soweit er nicht durch die schon seit langen Jahren vollendete

Canalisation des gesammten Stadtgebietes festgelegt wird. Altona liegt fast in seiner ganzen Ausdehnung auf dem Geestgebiet, im Diluvium, und zwar ist die Bodengestaltung derart, dass in nächster Nähe der Elbe die höchste Erhebung des Bodens liegt, von welcher das Elbufer steil gegen den Fluss abfällt, während das gesammte Stadtgebiet von dem hohen Uferrücken aus nach Norden sanft sich abdacht, nach Osten zum Theil stärker fällt gegen den die Grenze der beiden Städte bildenden früheren, jetzt canalisirten Grenzgraben, in dessen Nähe eine räumlich sehr beschränkte Fläche im Alluvium belegen ist. Der Untergrund der Geest ist Lehm und Sand, der Untergrund der Marsch Thon und Moor. Im Stande des Grundwassers verhält sich der gesammte Untergrund Altonas wesentlich abweichend von dem der Marschteile Hamburgs. In Altona wechselt, namentlich in der auf Lehmboden erbauten erheblich grösseren westlichen Hälfte der Stadt, die Höhe des Grundwasserstandes sehr bedeutend; hier sind ganze Strassen, in denen alle Keller an Grundfeuchtigkeit, mitten im hohen Sommer an Grundwasser leiden, und durch allerlei Hülfsmittel und Mittelchen nicht trocken zu legen sind. Auch in Hamburg giebt es einzelne Gegenden mit ähnlichen feuchten Kellern, doch nicht in der dicht bebauten Stadt, wie in Altona, und nicht in gleicher Ausdehnung.

Die Art der Bebauung ist in beiden Städten einigermassen gleich, auch die Wohnungsverhältnisse sind sich ähnlich, in Altona im Ganzen aber dürftiger. Die Einwohner beider Städte, wenn auch dem gleichen Stamme entsprossen, unterscheiden sich doch in manchen Einzelheiten, vor allem aber darin, dass die Bevölkerung Hamburgs ganz erheblich wohlhabender ist als die der Nachbarstadt, in welcher der billigeren Wohnungsverhältnisse wegen zahlreiche Arbeiter und Gewerbtreibende wohnen, die in der grossen Handelstadt ihren Beruf ausüben und ihr Brod finden. Ganz besonders fehlen Altona fast vollständig die in Hamburg sehr zahlreichen Grosskaufleute und der reiche Mittelstand, welcher es vorzieht, in einem eigenen Hause mit Garten allein zu wohnen, anstatt in den bekannten "Etagenhäusern," Miethskasernen, mit mehreren, oft recht zahlreichen Familien ein Haus zu theilen. Diese Miethshäuser, Revenueerben genannt, deren einziger Zweck darin besteht, ihrem Eigenthümer eine möglichst hohe Verzinsung seines Kapitales zu liefern, giebt es in beiden Städten massenweise, in Altona im Verhältniss zu den Einzelhäusern aber weit mehr. Ihre Erbauer, denen thunlichst billige Herstellung der Gebäude zur Erreichung des Zweckes die Hauptsache ist, führen einen stillen Kampf gegen die im Interesse der hygienischen und bausichern Anforderungen erlassenen Baupolizeigesetze, indem sie in den weitaus meisten Fällen das in den Gesetzen bestimmte Mindestmass der Anforderungen an gesundes Wohnen thunlichst genau einzuhalten, wenn möglich durch geschickte Auslegung des Wortlautes noch zu unterbieten wissen. Die Folge davon ist dann ein Zusammenpferchen der Einwohner, eine Beschneidung von Luft und Licht bis an die Grenze des Möglichen und nur irgend Erlaubten, und wenn in den letzten Jahren in Altona, in Folge erheblich verschärfter Gesetze und strengerer Controlle durch die Behörden es wesentlich besser geworden ist, so bestehen doch noch erbärmliche Wohnungen in sehr grosser Zahl, werden auch jetzt noch immer Wohnungen, welche früher einer Familie eben ausreichenden Raum gewährten, in zwei und drei Theile getheilt und an zwei bis drei Familien vermiethet, die dann in allen gesundheitlichen Lehren spottender Weise in diesen völlig unzulänglichen Räumen untergebracht werden. Leider bieten unsere Gesetze den Behörden nur sehr unzureichende Handhaben, derartigen Ueberfüllungen der Wohnungen entgegen zu wirken; die von dem deutschen Verein für öffentliche Gesundheitspflege entworfenen Bestimmungen über gesundes Wohnen sind bisher noch nicht von den Reichsbehörden zum Gesetz erhoben. Dass durch derartige Uebelstände die Gesundheitszustände einer Stadt herabgedrückt, Epidemien befördert werden müssen, ist wohl unzweifelhaft, wie es auch wohl nicht zu bezweifeln ist, dass in Altona, wo sie wesentlich schlimmer sind als in Hamburg, sowohl absolut wie im Verhältniss zu der Zahl der durchaus guten und unbedenklichen Wohnungen, eine einbrechende epidemische Krankheit sich stärker und leichter entwickeln kann, als in Hamburg mit seiner durchschnittlich wohlhabenderen, besser genährten und besser wohnenden Bevölkerung.

Bezüglich der Entwässerung stehen sich beide Städte ebenfalls ziemlich gleich, doch auch hier Hamburg besser. Letztere Stadt hat bald nach dem grossen Brande 1842 bis zum Jahre 1848 die derzeit abgebrannten Strassen vollständig canalisirt, und dann von 1853 an das Sielsystem über die ganze Stadt und die Vorstädte ausgedehnt, sodass gegen 1860 die derzeit städtisch bebauten Theile sämmtlich mit tiefliegenden Canälen in bester Weise ausgestattet waren. Von 1871 an hat man ferner ein grosses Stammsiel für die Entwässerung der Land- und Aussendistricte gebaut und nach dessen Vollendung alle bewohnten Gegenden mit Sielen versehen, sodass in der bebauten Stadt mehr als 300 Kilometer Siele vorhanden und schon seit Jahren nur in neuen, der Bebauung zu erschliessenden Bezirken neue Siele zu erbauen sind. In Altona hat man mit der Erbauung von Sielen erst sehr viel später begonnen; nachdem in den Jahren 1855–57 der Grenzgraben zwischen Altona und Hamburg canalisirt war, begann man zu Anfang der sechziger Jahre die diesem zunächst liegenden Strassen und dann weiter den höher gelegenen Theil der Stadt mit Sielen zu versehen, später auch den nördlichen Abhang der Stadt mit zum Theil sehr flach liegenden Sielen nach der Isebek, einem in die Alster mündenden Bache zu entwässern, es waren aber im Jahre 1880 im Ganzen erst 25·5 Kilometer Siele erbaut. In den Jahren 1882–85 ist, da das Grenzsiel erheblich überlastet war und jeder stärkere Regenfall heftige Ueberschwemmungen der Keller veranlasste, ein Parallelsiel des Grenzsieles erbaut, auch das nördliche Stadtgebiet zum Theil an dieses, zum Theil an das Hamburger Geeststammsiel angeschlossen, sodass seit wenigen Jahren die vormalige Stadt Altona bis auf einige Strassen vollständig canalisirt ist. Dagegen ist die vormalige Stadt Ottensen, welche 1888 in Altona einverleibt wurde, nur zum Theil, und zwar die südlich gelegenen Strassen in den letzten Jahren nach der Elbe zu, die nördlich belegenen und die Strassen des alten Dorfes nach der Isebek in zum Theil sehr mangelhafter Weise schon länger entwässert. Heute beträgt die Länge der in Altona vorhandenen Siele etwa 40·5 Kilometer, immer noch erheblich weniger als die Länge der bebauten Strassen.

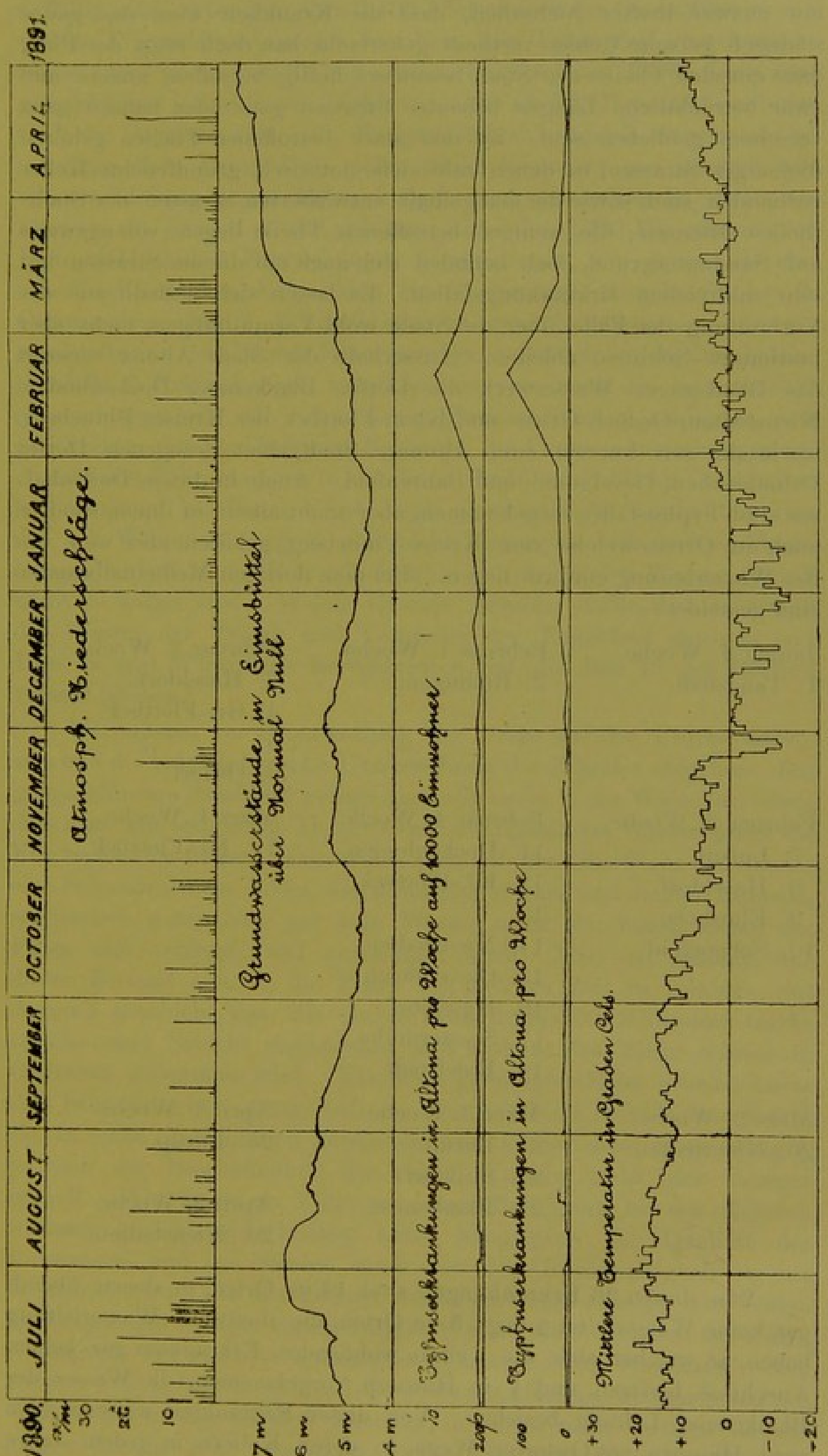
An die Siele müssen in Hamburg schon seit langen Jahren alle bewohnten Grundstücke angeschlossen werden und in diese ihre unreinen, insbesondere die menschlichen Abflüsse abführen; in Strassen, welche mit Sielen versehen sind, mussten die früher allgemein üblichen Eimerprivets beseitigt und durch Wasserclosette ersetzt werden. Altona gestattete in seiner Bauordnung von 1874 die Anlage und den Anschluss von Wasserclosetten, schrieb ihn aber erst 1877 für alle Neubauten und grösseren Umbauten, und erst im September 1888 für alle Grundstücke vor, welche an Strassen mit öffentlichen Sielen belegen sind. In diesen, also nahezu in allen älteren Gebäuden sollte bis zum 1. Oktober 1889 der Anschluss an die Siele hergestellt, die bestehende Einrichtung von Eimerprivets beseitigt und die Ableitung aller unreinen Abflüsse, sowohl von den Höfen als von den neu anzulegenden Wasserclosetten in die Siele ausgeführt sein. Die Folge dieser Handhabung der Gesundheitspolizei war, dass bis zum Jahre 1888 nach und nach in den besseren alten Gebäuden und Neubauten der Jahre vor 1877, sowie in allen Neubauten an besielten Strassen des südlichen Entwässerungsgebietes nach 1877 allmählich Wasserclosette die frühere mangelhafte Beseitigung der Excremente verdrängten, jedoch erreichte deren Zahl in der ganzen Stadt im Jahre 1888 noch nicht 9,000, bei mehr als 105,000 Einwohnern. Erst als die Verordnung von 1888 erschien, und gleichzeitig in den Strassen, welche früher nach der Isebek entwässerten, die Einleitung der Fäkalien in die Siele erlaubt wurde, wurde die Anlage von Wasserclosetten allgemein, und stieg deren Zahl von 9,000 auf mehr als 20,000, trotzdem noch immer der grössere Theil des Stadttheils Ottensen keine Closette anlegen durfte. Mit der Zahl der Closette stieg aber gleichzeitig auch die Zahl der Anschlüsse an die öffentlichen Siele; solange dieser Anschluss nicht zwangsweise gefordert wurde, unterblieb er in den meisten alt bebauten Grundstücken ganz oder wurde höchstens bis zu einem bequem gelegenen Punkte auf den Höfen geführt, an dem das Schmutzwasser entleert werden konnte. Die erzwungene Anlage von Wasserclosetten, welche von den Höfen, dem Aufstellungsorte der Eimerprivets, in die Wohnungen, oft auch nur in die Keller oder Dachräume verlegt werden mussten, führte zu der Einführung der Abflussleitung bis in die Wohnungen und veranlasste, dass in den Küchen Einrichtungen zum Ausgiessen des Schmutzwassers ausgeführt wurden, die bis dahin in den billigeren Wohnungen nahezu allgemein fehlten. Die Ausgüsse wurden naturgemäss mit Wasserzapfstellen verbunden, sodass die Bewohner nun in ihrer Wohnung, und nicht an gemeinsamer Zapfstelle auf dem Hofe ihr Brauchwasser nehmen konnten, und wurde durch diese Verbesserungen erst der Zustand herbeigeführt, welcher in Hamburg schon längst bestand und in jeder grösseren Stadt vom gesundheitlichen Standpunkte aus als der allein zulässige bezeichnet werden muss.

Die Wasserversorgung erfolgt für jede der beiden Nachbarstädte selbstständig. Hamburg besitzt seit 1849 eine von W. Lindley erbaute Centrale Wasserversorgung, für welche jetzt eine Sandfiltration eingerichtet wird; sie versorgt ihre Abnehmer bis heute noch mit unfiltrirtem Wasser, welches der Elbe oberhalb der Städte bei Rothenburgsort entnommen wird. Altona dagegen wird ebenfalls aus der Elbe versorgt durch eine Centralanlage in Blankenese, etwa 12 Kilometer unterhalb der Grenze beider Städte, welche seiner Zeit nach Sir Thomas Hawksley's Vorschlägen erbaut, und seit 1859 in Betrieb und mit einer vollkommenen Sandfiltration ausgestattet ist. Das Altonaer Wasserwerk versorgt ausser Altona auch die Dorfschaften, welche zwischen dem Werke in Blankenese und Altona liegen und zahlreiche von reichen Hamburgern bewohnte Landhäuser mit schönen Parks enthalten. Die Schöpfstellen beider Wasserwerke liegen in Flutgebiet des Stromes, die Flut dringt noch, je nach den Oberwasserständen 20 bis 40 Kilometer oberhalb der Hamburger Schöpfstelle aufwärts in den Fluss; man will aber ermittelt haben, dass der Abfluss aus den Hamburger Sielen, welcher ungereinigt dem Strome zugeführt wird, selbst bei stärkster Flut nicht bis zur Hamburger Schöpfstelle gelangen kann. Dies ist naturgemäss für das Blankeneser Werk nicht erreichbar; für dieses muss einerseits auf die grosse Menge des nicht verunreinigten Wassers aus den verschiedenen zwischen Hamburg und Blankenese sich vereinigenden Stromarmen, sowie auf die Selbstreinigung des Flusses auf dem 12 Kilometer langen mit grosser Geschwindigkeit zurückgelegten Laufe, andrerseits auf die Vorzüglichkeit der Filteranlagen gerechnet werden, um durch das Zusammenwirken aller dieser Kräfte aus dem Wasser diejenigen Verunreinigungen zu entfernen, welche ihm die Abflüsse einer Bevölkerung von mehr als 700,000 Seelen zuführen. Wie sehr dies gelungen, beweisen die Resultate der bakteriologischen Untersuchungen, welche früher mehr gelegentlich, seit etwa Jahresfrist regelmässig, und zwar nach der Methode von Professor Dr. Robert Koch erfolgen, einerseits durch das Untersuchungsamt der Provinz Schleswig-Holstein in Kiel, bezw. dessen Vorsteher Dr. R. Wollny, andrerseits durch die Ingenieure des Wasserwerks selbst, welche sich entsprechend ausgebildet haben. Ob das Hamburger Wasserwerk sein Wasser gleichfalls bakteriologisch untersuchen lässt, ist uns nicht bekannt; veröffentlicht sind bisher ab und an einzelne Untersuchungen; wir haben auch wiederholt Versuche mit im Innern der Stadt geschöpftem Wasser angestellt, haben aber stets gefunden, dass die Zahl der entwickelungsfähigen Keime die im allgemeinen als zulässig anerkannte höchste Zahl so ausserordentlich übersteigt, dass von diesem Standpunkte aus das Hamburger Wasser als ein gänzlich unzulässiges bezeichnet werden müsste, wenn nicht andrerseits unzweifelhaft feststände, dass dieses Wasser ohne Schaden für die Gesundheit täglich von vielen tausenden von Menschen benutzt wird.

Bezüglich des Klimas, der Regenfälle u. s. w. kann zwischen den beiden Städten ein Unterschied von irgend welcher Bedeutung nicht bestehen. Es ist deshalb zulässig, die von der Kaiserlichen Seewarte, belegen in St. Pauli etwa 1 Kilometer von der Grenze beider Städte, ermittellten und täglich veröffentlichten mittleren Temperaturen und Niederschlagshöhen als für beide Städte gleich zutreffend anzusehen. Grundwasser-Beobachtungen werden von amtlicher Stelle weder in Hamburg, noch in Altona angestellt; die einzige, schon über längere Jahre sich erstreckende derartige Beobachtung geschieht durch den Beamten des Hamburger Medicinal-Bureaus, C. C. H. Müller auf dem kleinen Schäferkamp, etwa 500 Meter von der Altonaer Grenze entfernt. Bei dem Mangel eigener Altonaer Beobachtungen ist diese in der Nähe angestellte wohl zum Vergleich heranzuziehen, da bei den jedenfalls gleichen Niederschlagsmengen auch die Grundwasserschwankungen des Hamburger and Altonaer Geestgebietes nicht wesentlich von einander verschieden sein können.

Die Zahl der Typhus-Erkrankungen, welche nach den Gesetzen bei dem staatlichen Medicinalbeamten von den Aertzten gemeldet werden müssen, betrug in Altona: 1890—im Februar 26, März 34, April 30, Mai 28, Juni 24, Juli 24, August 13, September 27, Oktober 32, November 32, Dezember 56; 1891—Januar 107, Februar 412, März 137, April 68, Mai 25, Juni 21; während der Grundwasserstand zu Anfang August zu + 6·47, am 20. Oktober zu + 4·70, am 25. Januar zu + 4·55 Meter über Normal-Null ermittelt ist, dann aber bis Mitte März auf + 7·00 Meter stieg. Also auch hier bewährt sich die Regel Pettenkofer's, dass die Typhus frequenz, sobald die Incubationszeit berücksichtigt wird, fast genau dem Stande des Grundwassers entsprechend ist, mit dem fallenden Wasserstande steigt, bis zum niedrigsten Stande, der der höchsten Frequenz entspricht und mit dem Steigen des Grundwassers sofort wieder abnimmt; der Culminationspunkt des Typhus liegt 31 Tage hinter dem Tage, an welchem das Grundwasser seinen tiefsten Stand erreichte. Trotz dieses Zusammentreffens ist es aber doch nicht zulässig, in dem Sinken des Grundwassers ohne weiteres die Ursache der Epidemie zu suchen, denn mit Recht wäre dagegen einzuwenden, weshalb denn, da die Grundwasserverhältnisse in St. Pauli und Altona nahezu gleich sind, die Epidemie nur die Stadt Altona, nicht aber gleichzeitig die an ihr belegene Vorstadt St. Pauli ergriffen hat. Es müssen also andere Umstände gleichzeitig eingewirkt haben, wenn das Sinken des Grundwassers die Ursache der Epidemie war, oder ganz andere Umstände für diese verantwortlich gemacht werden. Es liegt ausserordentlich nahe und ist vor allem sehr bequem, auch in dem vorliegenden Falle das Wasser zum Träger und Verbreiter der Epidemie zu machen, man braucht nur "bewährten Vorbildern" zu folgen, auch wenn es diesen nicht gelungen ist, den Beweis für ihre Behauptungen zu erbringen. Thatsächlich bildet die Grenze der beiden Städte auch die Begrenzung der Epidemie und der Wasserversorgungen, wobei es vernachlässigt werden mag, dass die Aktien-Brauerei in St. Pauli ihr Wasser von der Altonaer Leitung bezieht und trotzdem weder bei ihren Angestellten noch bei ihren zahlreichen Abnehmern, welche das mit diesem Wasser in beträchtlichem Maasse in Berührung gebrachte Bier consumirt haben, Erkrankungen zu beklagen gehabt hat. Die auf

PLATE I.


1890
1891
JULI
AUGUST
SEPTEMBER
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUAR
FEBRUAR
MÄRZ
APRIL
Atmosph. Niederschläge.
Grundwasserstände in Eimsbüttel über Normal Null
Typhuserkrankungen in Altona pro Woche auf 10000 Einwohner.
Typhuserkrankungen in Altona pro Woche
Mittlere Temperatur in Graden Cels.
7 m
6 m
5 m
4 m
+30
+20
+10
0
−10
−20

dem Plane der Stadt Altona eingetragenen Erkrankungsfälle ergeben mit unzweifelhafter Sicherheit, dass die Krankheit über das ganze städtisch bebaute Gebiet vertheilt geherrscht hat, doch zeigt der Plan, dass einzelne Theile der Stadt besonders heftig betroffen, andere und zwar beträchtliche Längen bebauter Strassen ganz oder nahezu ganz verschont geblieben sind. Zu den stark betroffenen Theilen gehören diejenigen Strassen, in denen zahlreiche notorisch grundfeuchte Keller vorhanden sind, sowie die mangelhaft entwässerten Strassen des Stadttheiles Ottensen; die weniger betroffenen Theile liegen vorzugsweise auf Sanduntergrund, doch befinden sich auch auf diesem Strassen mit sehr zahlreichen Erkrankungsfällen. Es lassen sich deshalb aus der Verbreitung der Fälle über die Stadt wohl Vermuthungen, nicht aber bestimmte Schlüsse ableiten. Ausserhalb der Stadt Altona versorgt das Blankeneser Wasserwerk die Dörfer Blankenese, Dockenhuden, Nienstedten, Osdorf, Gross- und Klein-Flottbek des Kreises Pinneberg, sowie die seit kurzem zum Altonaer Stadtgebiet gezogenen Dörfer Othmarschen, Oevelgönne und Bahrenfeld. Auch in diesen Dorfschaften sind Typhusfälle vorgekommen, aber nicht allein in ihnen, sondern auch in Orten, welche zum Kreise Pinneberg gehören, aber weit von der Wasserleitung entfernt liegen. Bei dem dortigen Medicinalbeamten sind gemeldet:—

Januar 4. Woche.
1. Tangstedt.

Februar 1. Woche.
2. Rellingen.

Februar 2. Woche.
3. Haseldorf.
4. Gr.-Flottbek.
5. „
6. Osdorf.

Februar 3. Woche.
7. Lurup.
8. Haseldorf.
9. Elmshorn.
10. Schenefeld.

Februar 4. Woche.
11. Dockenhuden.
12. Kl.-Flottbek.
13. „
14. Nienstedten.
15. Clevendeich.
16. Haseldorf.
17. Seestermühe.
18. Eidelstedt.

März 1. Woche.
19. Kl.-Flottbek.

März 2. Woche.
20. Nienstedten.

März 3. Woche.
21. Lurup.
22. Sülldorf.
23. Blankenese.
24. „

April 1. Woche.
25. Lurup.

April 2. Woche.
20. Nienstedten.

Von diesen 26 Erkrankungen sind 14 in Orten, in denen überall gar keine Wasserleitung liegt, 5 in Orten, die theilweise Wasserleitung haben, an welchen aber die weitab wohnenden Erkrankten gar keinen Anschluss besitzen, und 7 in Häusern vorgekommen, die Wasser der Blankeneser Leitung beziehen. Von diesen Erkrankten wohnen 3 in zwei Häusern am Osdorfer Wege, in deren Kellern in jedem Jahre das Wasser fusshoch steht, sodass deren polizeiliche Räumung wegen

Unbewohnbarkeit bereits früher erwogen ist. Es ist doch gewiss auffällig, dass unter den etwa 2,400 Einwohnern des Ortes Blankenese, welche Wasserleitungswasser beziehen, kein Typhusfall vorgekommen ist, während in dem weitab liegenden nicht versorgten Theile deren zwei gemeldet sind; dass ferner in der von mehr als 300 Insassen bewohnten Osdorfer Armenanstalt kein einziger Erkrankungsfall eingetreten ist, trotzdem diese Leute doch sicher nicht besonders gut genährt und widerstandsfähig gegen Erkrankungen sind. Aehnlich ist es in den Dörfern, die jetzt zu Altona gehören: unter den 2,200 Einwohnern von Bahrenfeld sind 2 Erkrankungen vorgekommen, von denen die eine unbedingt von dem Erkrankten, einem Seemann, mitgebracht ist; in Othmarschen sind 2 Erkrankungen in zwei benachbarten Häusern, unmittelbar an dem damals fast wasserleeren Ortsteiche; in Oevelgönne ebenfalls 2 Erkrankungen vorgekommen, von denen die eine ebenfalls eingeschleppt sein soll. Aus diesen Thatsachen ist zu schliessen, dass gleichzeitig mit der heftigen Epidemie in Altona eine sehr geringe Anzahl von Erkrankungen in den dieser Stadt benachbarten Ortschaften vorgekommen, bei diesen, wegen ihrer gleichmässigen Vertheilung über die mit Wasser versorgten und nicht versorgten Ortschaften, Beziehungen zwischen der Erkrankung und dem benutzten Wasser überall nicht zu finden sind. Welche Gründe sprechen dafür, dass in Altona das Wasser der Träger und Verbreiter der Krankheit gewesen ist? Dass es dort Wirkungen hervorgerufen hat, die ihm in den Dörfern versagt blieben?

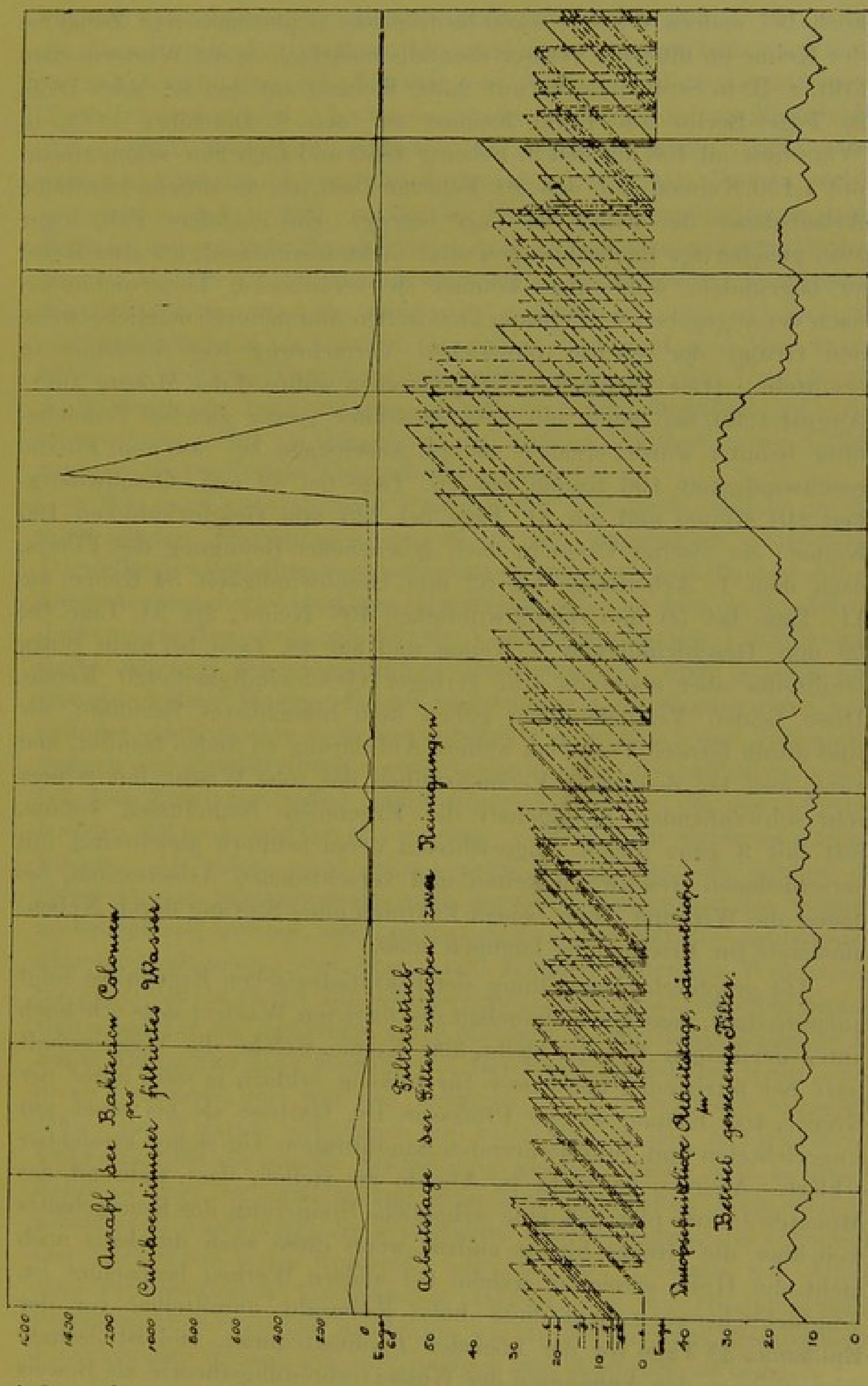
Wir müssen vor Beantwortung der Frage auf den Filtrationsprozess und die bakteriologische Untersuchung des Filtrates eingehen. Die gebräuchlichen Sandfilter werden ganz allgemein in der Weise betrieben, dass man mit möglichst kleiner Geschwindigkeit das Wasser durch die Filterschichten fliessen lässt, wobei sich auf der Oberfläche des Sandes eine Schmutzschicht bildet, die, allmählig stärker und dichter werdend, schliesslich wenig oder gar kein Wasser mehr durchlässt, sodass das Filter sich verstopft und unwirksam wird. Man hat deshalb, ehe dieser Zustand eintritt, die Filter von Zeit zu Zeit zu reinigen, was dadurch geschieht, dass die oberste etwa 20 bis 30 Millimeter starke verschmutzte Schicht abgestochen und alsdann das Filter wieder in Gebrauch genommen wird. Ein solch gereinigtes Filter arbeitet kurze Zeit bakteriologisch mangelhaft, es lässt erheblich mehr Keime durch, als ein schon in Gebrauch gewesenes, doch verliert sich dieser Mangel, je nach der Beschaffenheit des rohen Wassers, mehr oder weniger schnell. Wie lange ein Filter von einer Reinigung bis zur nächsten wirksam in Gebrauch bleiben kann, hängt von der Qualität des Rohwassers und des Sandes, sowie von der Geschwindigkeit ab, mit der filtrirt wird. Im allgemeinen dürfte ein durch thonige oder erdige Beimengungen weniger verunreinigtes Wasser die Arbeitszeit der Filter verlängern, ein stark verunreinigtes Wasser dieselbe verkürzen. Die meisten Flüsse führen während der Frostzeit klareres, weniger getrübtes Wasser, als in den warmen Monaten, in denen nach heftigen Regengüssen häufig sehr erhebliche Trübungen des Wassers eintreten. Dementsprechend können die Wasserwerke in der Regel während der

Wintermonate ihre Filter länger betreiben, als im Sommer, zumal auch fast ausnahmlos in der kalten Jahreszeit weniger Wasser gebraucht, also auch langsamer filtrirt wird, als in der warmen. Die Zeitdauer, während welcher die Filter von einer Reinigung bis zur andern benutzt werden, ist bei den Wasserwerken sehr verschieden; beispielsweise finden sich in den Angaben deutscher Wasserwerke aus dem Jahre 1889-90 folgende Zahlen:—

Berlin	längste Betriebsdauer	90 Tage,	kürzeste	8	Tage.
Breslau	„	70 „	„	13	„
Magdeburg	„	40 „	„	11	„
Altona	„	48 „	„	15	„
Stettin	„	22 „	„	6	„
Bremen	„	28 „	„	4	„
Stuttgart	„	70 „	„	11	„
Braunschweig	„	104 „	„	22	„

Die Schwankungen sind sehr beträchtlich; es scheint aber, als ob bisher niemand in einer Gebrauchsdauer von 70 bis 104 Tagen etwas Bedenkliches gefunden hat, man würde sonst doch wohl öfter gereinigt haben. Vermuthlich lässt man allerorts die Filter so lange arbeiten, als sie bei mässiger Geschwindigkeit und ohne übermässige Druckhöhe zu filtern in Stande sind. Auch bei den Blankeneser Werken ist nach diesem Grundsatze filtrirt, und so treffen hier, wie wohl an allen anderen Orten, die längsten Arbeitszeiten immer in den Winter, weil bei Frost das Elbwasser regelmässig sehr wenig verunreinigt ist. Wie lange ein jedes der 10 in Blankenese vorhandenen Filter von einer Reinigung bis zur andern gearbeitet hat, zeigt die anhängende graphische Darstellung, in welcher jedesmal am Tage der Reinigung die Filterdauer auf den Nullpunkt zurückgeht, und von diesem aus regelmässig bis zum nächsten Reinigungstage wieder ansteigt, sodass aus den dargestellten Linien die Arbeitsdauer der Filter direkt abzulesen ist. Unter diesem Diagramm steht ein ferneres, welches den Durchschnitt der Arbeitszeit aller 10 Filter für jeden Tag anzeigt. Die Figur ergiebt, dass während der Monate Juli 1890 bis April 1891 die Arbeitszeit von 50 und mehr Tagen nur 10 mal, von 40 und mehr Tagen nur 11 mal, die längste Arbeitszeit von 59 Tagen zweimal erreicht ist, während die durchschnittliche Arbeitszeit etwa 15 bis 20 Tage beträgt. Es ist also bei den Blankeneser Werken die in andern Wasserwerken gebräuchliche längste Arbeitszeit der Filter von 70 bis 104 Tagen lange nicht erreicht. Trotzdem aber stieg, als während des sehr kalten Monates Januar dieses Jahres die Arbeitsdauer der Filter von durchschnittlich 20 Tagen auf durchschnittlich 33 Tage verlängert wurde, der durch die bakteriologischen Untersuchungen ermittelte Gehalt an entwickelungsfähigen Keimen ganz ausserordentlich hoch, indem an Stelle der sonst gezählten stets unter 100 bleibenden Anzahl nunmehr plötzlich 1,100 and 1,900, im Durchschnitt 1,500 Keime im Cubikcentimeter Wasser gefunden wurden. Dieser Befund veranlasste, schleunigst einige Filter zu reinigen, und kaum war dies bei der Hälfte der Filter geschehen, so sank die Keimzahl sofort

Plate II.



wieder auf das gewöhnliche Maass, und blieb auf und unter diesem für die ganze fernere Beobachtungszeit bis heute. Es entspricht diese explosionsartige Vermehrung der Keime in ihrem Anfange genau dem Anfange der längeren Arbeitsdauer, während ihr Ende der verminderten Arbeitsdauer etwas voraufeilt. Ist dieses Vorkommen ein zufälliges oder sind ähnliche Beobachtungen auch andrerorts gemacht? In der Litteratur ist nichts darüber zu finden, wohl aber ist es auffällig, dass die auch bei andern Wasserwerken beobachtete explosionsartige Zunahme der Keime im filtrirten Wasser ebenfalls mehrfach in die Wintermonate fällt, z. B. in Stralau-Berlin mit 2,300 Keimen auf den 30. März 1886, in Tegel-Berlin mit 1,500 Keimen auf den 8. Dezember 1885, in Warschau mit 406 auf den 9. Februar 1889 und auch hier schon einmal mit 1,150 Keimen auf den 20. Februar 1886, als die durchschnittliche Arbeitsdauer der Filter 40 Tage betrug. Ein einzelner Fall, sogar zwei gleichartige Beobachtungen sind nicht ausreichend, um eine Regel zu begründen, wohl aber können sie veranlassen, Untersuchungen nach der angegebenen Richtung anzustellen und dadurch möglicherweise den Grund der ebenso plötzlichen Vermehrung wie Abnahme zu ermitteln. Hier angestellte Versuchsreihen während der Monate Juni–August 1890, bei denen ein dem Grossfilter genau gleiches Versuchsfilter benutzt wurde, ergaben am 24. Arbeitstage bei 300 mm. Filtrirgeschwindigkeit 196 Keime, am 26. Tage bei 82 mm. Geschwindigkeit 210 Keime und am 31. Tage bei 225 mm. Geschwindigkeit 190 Keime; ein zweiter Versuch, nach geschehener Reinigung des Filters, nach dem 1. Arbeitstage bei 83 mm. Geschwindigkeit 84 Keime, am 11. Tage bei 50 mm. Geschwindigkeit 408 Keime, am 21. Tage bei 59 mm. Geschwindigkeit 8 Keime und am 48. Tage bei nicht genau ermittelter aber ebenfalls sehr geringer Geschwindigkeit 420 Keime. Diese beiden Versuchsreihen gaben kein brauchbares Resultat; wir sind durch fernere Versuche, weitere Aufklärung zu finden bemüht, und zwar, weil bei den ersten Versuchsreihen das rohe Wasser mit seinem sehr schwankenden Keimgehalt die Ergebnisse beeinflussen konnte, jezt mit 3 ganz gleich eingerichteten Versuchsfiltern gleichzeitig mit verschiedenen Geschwindigkeiten und verschiedenen Arbeitszeiten, bei denen die Wirkung dieser beiden Faktoren ohne Störung durch Nebenumstände zur Erscheinung kommen muss.

Die graphische Darstellung der bakteriologischen Ergebnisse zeigt unzweifelhaft, dass der Keimgehalt des filtrirten Wassers stets erheblich unter derjenigen Grenze bleibt, 300 Keime, welche die Wissenschaft jetzt bei filtrirtem Flusswasser für zulässig erklärt, ja weit unter der Grenze, 100 Keime, welche Professor Dr. Gärtner als bei einer gut eingerichteten und funktionirenden Sandfiltration für sicher erreichbar erklärt. Aber es ist nicht in Abrede zu stellen, dass während des Monates Januar plötzlich eine erhebliche Steigerung des Keimgehaltes weit über die Grenze hinaus eintrat, wenn diese auch durchaus noch nicht die Höhe erreichte, welche bei andern Werken beobachtet ist. Unglücklicherweise liegt diese hohe Keimzahl unmittelbar vor der Epidemie, 33 Tage vor der höchsten Typhusfrequenz, und ist deshalb sehr geeignet, den Anhängern der Wasserverbreitungstheorie als Beweis für die Richtigkeit ihrer Behauptung zu dienen, da ihnen andere Beweise vollständig fehlen. Es war uns bekannt, dass schon zu Ende Dezember die Zahl der Typhusfälle sich vermehrt hatte, und gab dies Veranlassung, sowohl hier wie in Kiel die Untersuchungen, insbesondere die Bestimmung der Arten mit ganz besonderer Sorgfalt auszuführen. In allen Proben sind nur die stets im Elbwasser vorkommenden Arten unschädlicher Wasserbakterien gefunden: Bacillus implexus, B. liquefaciens, B. fluorescens liquefaciens, B. fulvus agilis, B. albus, B. aurantiacus, B. plicatus, B. candicans, Mikrococcus sulfureus, mehrere weisse, eine rothe Hefeart, von denen je 3 bis 9 Arten in jeder Probe zu finden sind. Im Januar traten einzelne der verflüssigenden Arten ganz besonders zahlreich auf; andere Arten, insbesondere pathogene, sind niemals gefunden, trotz der zahlreichen Proben, welche untersucht sind. Nun ist ja das Nichtfinden krankheitserregender Keime durchaus kein Beweis dafür, dass in dem Wasser keine Typhus-bacillen enthalten gewesen sind, aber bis zu geschehenem Nachweis ist die Behauptung, dass sie vorhanden gewesen sein müssen, doch um nichts begründeter, als die vom Gegentheil; während uns doch wenigstens das redliche Bemühen nicht abzustreiten ist, das Unsrige zur Aufklärung des Sachverhaltes gethan zu haben, begnügte man sich anderntheils nichts zu thun, jetzt aber um so kräftiger seine Ueberzeugung als zweifellose Thatsache hinzustellen.

Bei einer unbefangenen Prüfung der Umstände, welche in den vorstehenden Darlegungen, sowie in den angefügten graphischen Darstellungen enthalten sind, erscheint es kaum zweifelhaft, dass Altona durch die mancherlei sanitären Massregeln, welche hier in den letzten Jahren getroffen sind, jahrelanger Verunreinigung des Untergrundes durch Abgänge des menschlichen Haushaltes ein Ende gemacht hat; dass durch diese Massregeln eine wesentliche Austrocknung des Untergrundes, dadurch aber auch eine verstärkte Verwesung der Verunreinigungen und hierdurch weiter eine Vorbedingung geschaffen ist, welche bei dem Zusammentreffen ungünstiger Umstände die gewöhnlichen leichten Erkrankungsfälle bis zu einer vollständigen Epidemie steigern konnte. Als solche ungünstige Umstände sind das tiefe Sinken des Grundwassers, möglicherweise auch der hohe Keimgehalt des Wassers zu bezeichnen, welcher, wenn auch an sich nicht schädlich—das beweisen Hamburg mit seinem weit über 3,000 Keimen haltenden Wasser und die Dorfschaften an der Elbe—doch schädlich wirken konnte bei dem an sich schon für die Aufnahme der Krankheit vorbereiteten Zustande der Stadt Altona und ihrer Bewohner. Bei Hamburg fehlten diese besonderen Umstände, dort war das Reinigen des Untergrundes schon viel früher zur Wirkung gekommen und hatte sich in den Epidemien von 1886 und 1888 die gleiche Erscheinung gezeigt, welche hier in diesem Jahre zu Tage trat, und in fast allen anderen Städten beobachtet ist, sobald nach Ausführung der gründlichen Bodenreinigung die Umstände das Ausbrechen einer Epidemie begünstigten. Deshalb hat Altona eine Typhusepidemie durchmachen müssen, von der Hamburg völlig verschont blieb, weil hier das fehlte, was zu den übrigen Bedingungen hinzukommen musste, um die Epidemie zum Ausbruch zu bringen.

Der greise Meister der deutschen hygienischen Wissenschaft, Dr. Max von Pettenkofer, dem die vorstehenden Thatsachen zur Kenntniss gebracht wurden, schreibt:—

"Ich stehe ganz auf Ihrem Standpunkte, dass die Epidemie nicht vom Trinkwasser abzuleiten ist. Die Altonaer Epidemie erinnert mich sehr an hiesige Erlebnisse. Auch München hatte, solange es noch Typhusboden war, die grösste Morbidität und Mortalität im Winter, wo die Menschen am wenigsten Wasser trinken, wo wir allerdings auch den tiefsten Grundwasserstand hatten.

"Seit unser Boden allmählig reiner wurde, theils durch Reinerhaltung, theils durch Selbstreinigung, wurden die Epidemien immer schwächer und haben wir seit 11 Jahren keine mehr gehabt. In früheren Jahren schwankte die jährliche Typhussterblichkeit pro 100,000 Einwohner zwischen 150 und 330, jetzt zwischen 10 und 12, obschon der Grundwasserstand noch ebenso auf- und abschwankt, wie früher. Jetzt thut uns ein tiefer Grundwasserstand kein Leid mehr an; das kann auch die Ursache sein, warum der Typhus in Hamburg 1891 trotz unfiltrirten Wassers nicht aufgetreten ist, während er in Altona trotz filtrirten Wassers auftrat, obschon der Grundwasserstand für Altona und Hamburg der gleiche war.

"Wenn Sie in Altona so lange mit Assanirung des Bodens fortfahren, wie in Hamburg, wird Ihnen ebenso wie in München auch bei tiefem Grundwasserstand und vielen Bakterien im Trinkwasser der Typhus nichts mehr anhaben.

"Ich weiss recht wohl, dass diese meine Ansicht vom Einfluss des Bodens nicht harmonirt mit den gegenwärtig herrschenden theoretischen bakteriologischen Anschauungen, und dass ich nicht angeben kann, was alles speciell vom Boden dazu gehört um eine Typhus-Epidemie hervorzurufen, aber ich bin nicht schlimmer daran, als meine Gegner, welche eine Epidemie durch Trinkwasser erklären, ohne Typhusbazillen darin nachweisen zu können."

Bei der grossen Erfahrung Pettenkofer's ist seine Meinung um so werthvoller, als ein sicherer Beweis weder für die eine, noch für die andere Behauptung zu führen ist. Jedenfalls zeigen diese Mittheilungen, dass im Filtrationsbetriebe noch immer Räthsel zu lösen sind, und die bakterioskopische Untersuchung des filtrirten Wassers viel regelmässiger und sorgfältiger geschehen sollte, als dies im Allgemeinen üblich ist.

The Water Supply of India.

BY

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The vast importance of the general subject of the water-supply is so fully admitted in the present day that no outlay is deemed extravagant or excessive when the object of it is to secure this first necessity of sanitation. When cities such as Glasgow, Liverpool, &c., in search of this source of health, enter on schemes such as that completed for Glasgow, and that now being carried out for Liverpool, the extent and cost of which it is difficult to realise, it is yet felt that on this one important point a primary judicious liberal outlay is, in the end, the most economical; and perhaps nowhere is this more evident than in the case of cities like Glasgow, Cardiff, Liverpool, &c., which are also large seaports, and where the value of a really good water supply can never be over-estimated, as it is greatly to be feared that much of the sickness experienced on board ship is due, not a little, to the inferior quality of the water taken in at the port of departure being such as to make it unfit for storage.

If all this is necessary in this country, how much more is it so in India, with its population, practically total-abstaining, proverbially like their sacred cows indifferent either to the source or quality of their drinking water, so dense and so migratory. And yet, if the question were asked, What has been done in the matter of the water-supply of India? up to within the last 10 years I fear the answer must be, Practically nothing. True, within these 10 years considerable efforts have been made to improve the water supply of large cities, such as Calcutta, Bombay, &c., but the population of India is not to be found in the cities; 95 per cent. of the people of India are in the villages, and what, I ask, has been done for them? And again the answer is, Nothing, if I may judge from an experience as extensive as that enjoyed by most medical officers of 30 years' Indian service. Take, for instance, the densely populated districts of the upper portion of the Mesopotamia, of the Ganges and Jumna, as embraced in the Agra and Meerut Divisions; or the first sanitary circle of the North-Western Provinces, with a population of over 10,000,000, crowded together to the extent of over 500 to the square mile. For 20 years continuously I was in the sanitary charge of this circle from 1864, and I can vouch for it that nothing has been done by the Sanitary Department with the Government of India during that time to improve the water supply of this circle, and I challenge them to say that it is due to my neglect in failing to bring the subject before them. My annual sanitary reports will answer this, and will further show that the remedies I proposed were not such as would involve a large outlay, but were cheap, simple, and permanent. Not only has nothing been done for the fixed population of these districts, but that most important section, as regards the public health of the community, I mean the migratory and pilgrim population, has also been left worse than unprovided for in the matter of its water supply, as wells which should be closed are left open to tempt the thirsty traveller to his fate, and a regiment on the line of march, when halting for its early breakfast, as I know, ran a great risk of having the seeds of typhoid fever taken up from one of these wells containing, not only stagnant water, but water charged with malarial germs. Through the whole length of this district pass tens of thousands on their way to and from the sacred shrines of Muttra, Bindrabun, &c., and places of pilgrimage on the Ganges and Jumna, from Hurdwar to Allahabad on the former, and from Kalsi (where the Jumna leaves the Himalayas) to the union of the latter with the former, at "Pryag" or Allahabad. The condition of the water in the wells and their surroundings are a disgrace to sanitation from the "Meeta Kooah," the sweet well at Agra, to the filthy well near the sacred steps at Hurdwar. The same, alas, is the case with the wells on the line of railway, with stations such as Etawah, Toondlah, Agra, Gazeeabad, and Saharanpur. Can it, therefore, be a matter of surprise to hear that that country is decimated by sickness, in a great measure preventable. To sum up this terrible account, I have seen the water in the railway well at Saharanpur fouled by "lotahs" (the brass drinking cups a native carries over his shoulder with a cord) covered with unutterable impurities during an epidemic of cholera, and a regiment passed through the station under these conditions. I can point to roadside and encampment wells in which the water was impure from stagnation, and the imperfect way in which the well was emptied in the case of troops coming to encamp on the spot, by which the impurities adhering to the sides of the well were left to be again mixed with the water as it rose in the well. It is from sources such as these that typhoid fever enters the large military cantonments, where, from the defective water supply, it soon spreads, and an unaccountable (?) outbreak of typhoid is the result.

The water-supply of the plains of India, as met with in the Bengal Presidency, may be classed (that from artesian wells being still under trial) under three heads, viz., Well, River, and Tank or Pond water.

Well-water.—The quality of the water from this source varies greatly, from the perfect supply, obtained by the presence of a faultless masonry tube, which brings the water to the surface after a *compulsory filtration*, through suitable soils, where by constant emptying and refilling and the absence of several feet of leaf mould at the foot of the well, owing to the well being covered, the water is, for all practical purposes, as perfect as can be obtained in the plains of India, to the filthy water obtained from wells which are but slightly removed in the rains from cesspools, as is the case with some of the servants' wells in the officers' compounds in the cantonment of Meerut. Between these two extremes as regards quality the well water of the plains of India ranges.

The ideal well I have described is, I fear, far from common in all the conditions necessary to secure a good water-supply; and there is little doubt that the drinking water for the vast majority of the peoples of India, as far as it relates to well-water, is obtained from the most defective system of wells; and it is because I feel that the real sanitary improvement of India must begin at the well, that I have asked to be allowed to draw special attention to it.

Let me start with the village well, or that from which nine-tenths of the population of India draw their drinking water. This is nearly always "kutcha," *i.e.*, dug out of the soil, without any masonry tube, the home, too often, of pigeons and other birds, as a protection from cats and snakes, with but rarely any parapet, and generally a "peepul" (sacred fig) tree over it, whose dead leaves have produced a layer of leaf mould, it may be two or more feet thick, rarely cleaned out except when something valuable falls into the well. Can it be wondered at that malarial germs suspended in this water, and forced through this mould by spring-water-power, are freely drunk by these villagers, to say nothing of the impurities washed in owing to the absence of a parapet, or the young birds falling in from their nests. There is only one source of impurity from which these "kutcha" wells are free, and which in "pucca" or masonry wells is often the cause of the water becoming unfit for drinking purposes; I allude to frogs. These animals, if they have nothing to rest on or hold on to in the well, not infrequently die. In a "kutcha" well they manage to rest in little holes in the sides, but in a "pucca" one the natives always throw in some "bajra" or millet stalks when they see there are frogs in a masonry well, and nothing on which they can rest. In most villages there are generally one or more masonry wells, but the surroundings, as I shall point out, are such as seriously to interefere with the purity of the water. These wells however, are in the enclosures of the head man of the village, and are, therefore, not available to all. There is always a tree shading these wells, and, unless the masonry sides are in good condition, the impurities of the courtyard too often find their way, little changed, into the water in the well by means of the roots of the tree and cracks in the masonry. Near this well often is a most insanitary institution known as a "chawbatcha," which is simply an open receptacle for all kinds of surface impurities, and as this is frequently near the verandah, we cease to wonder how it is possible to become quite indifferent to that which would upset most people. Not a few of these wells are so constructed that a passer-by can dip in his "lotah" and draw up water, but after what I have said of the too frequent state of this "lotah," this must be a dangerous proceeding to the health of the household. In short, it seems almost hopeless under present conditions for the water in a town or city well to be pure, unless situated within an enclosure; but here a fresh difficulty arises, water in India under the ordinary conditions met with in even a fairly good masonry well, cannot remain pure unless regularly withdrawn, and as this is impossible in the case of a large well and a small household, the result too often is that a species of typho-malarial fever breaks out; it may be confined to a house or two, but if the season is unusually dry, the disease sometimes becomes alarmingly epidemic, as happened once at Haupper in the Meerut district. The remedy for this lies in using the water for irrigating the garden, and if this is impracticable then in obtaining drinking water from a well constantly in use.

River-water.—In the plains of India, when we think how little makes a river even temporarily sacred, viz., by its running southward, and when this is the case how it becomes the highway to heaven for the mortal remains of all who can secure this last religious act being performed, I think it requires very little sanitary knowledge to decide that, with but very rare exceptions, it is, unless a most elaborate and careful system of purification is secured, a most hazardous proceeding to use river water in India for a drinking-water supply; and nothing would induce me to use it for this purpose without boiling it first.

Tank or pond water.—This is open, if possible, to greater objections than the river water-supply, because there is no real change taking place in the water, and if bodies are not thrown into it, here is little doubt that many corresponding impurities find their way into these ponds. Some species of water plants are credited in Bengal with purifying the water of ponds; possibly they may, but I prefer 212° Fahr.

Filters at railway stations as a means of purifying the water require so much looking after, that I prefer the plan recommended hereafter. The filter at the cantonment railway station at Meerut, when I once inspected it by lifting off the cover, only required the regimental band to convert it into an object for an aquarium, and if this happened at Meerut, what may we not expect at smaller stations.

In some parts of India, where the water-supply is apt to become very impure from the heavy rains, the rain-water is collected and carefully stored in large jars. The mode of this collection is as effective as it is simple, viz., by means of a very large cotton sheet, tied at the four corners to poles, about four feet high, and to secure the collection of all the rainfall a smooth clean stone is thrown on the sheet, and as it rolls into the centre and remains there, the water gathers here, and passes into the collecting jar below. This, when full, is taken away and emptied into the large storage jars; thus, a supply of very pure water is obtained, and when carefully stored in a cool place, is no doubt in many districts very valuable.

After this practically universal condemnation of all the ordinary sources of the water supply, as at present met with in India, the least I can do is to recommend some measures for securing a good water supply, if such are practicable; and fortunately they are not only practicable, but simple and feasible. During my entire Indian service the improvement of the water-supply was my constant endeavour, and with, I trust, justifiable pride and satisfaction I can point to that at the hill sanatorium of Mussooree in the Himalayas, as the crowning of all my labours, for here is a water-supply, perennial and incapable of pollution, delivered at three different parts of the sanatorium, and all attained without the addition of a penny to the amount of the local taxation. This entire scheme was carried out quite independently of the Sanitary Department with the Government of India, for, as an elected not officially nominated member of the Municipality of Mussooree, I designed and superintended the whole scheme; and to this municipality is due the entire credit of having a water-supply unequalled in any other station in India, on the hills or in the plains, at an entire cost of Rs. 30,000, or about 3,000*l.*, spread over six years.

At my first station in Orissa, in 1855, by using the ordinary baked clay rings, I sunk new wells where I found the locality of the old ones defective; and when I came to the North-Western Provinces in the special Sanitary Department, I saw from some cases of typhoid fever at Mussooree the absolute necessity of a good water-supply, and that scheme just alluded to was the outcome of these cases of typhoid fever. When marching through the first sanitary circle in 1864, I saw the condition in which the supply of drinking water for the troops on that line of march and for the weary traveller or pilgrim was in the roadside wells, and in those in the encamping grounds, and after various trials and experiments, decided on one which seemed cheap, simple, and effective. When the railway system spread through my circle, I felt that, unless some steps were taken, the water at the railway stations would prove a serious source of danger to the public health, and accordingly I suggested the following measures for remedying the defects complained of.

First.—Roadside wells. In my circle there were about 200 of the "cos kooahs," or two-mile wells, and the simple plan I suggested was to let out these wells to the cultivators of the fields near, on the single condition that the water, before it passed into the irrigation channels, should fill a trough for the cattle, and also admit of a lotah being filled as the water came fresh from the well. Where this was carried out, it answered admirably, and cost the Government nothing; but the Sanitary Department paid no attention to the suggestion at the time, and who can tell how much of the present typhoid prevalence in the North-Western Provinces and Oudh is due to this indifference?

Second.—Wells in encamping grounds. My suggestions, similar to the above, were carried out by some magistrates, and appeared to work so well that one wonders how the system was not universally adopted. While on the subject of water-supply when in camp, I think my experience of this is as varied and extensive as that of most medical officers, and perhaps the following may prove useful. As a rule, when in camp, I generally obtained my drinking water from an irrigation well *at a distance from* the village, preferring this to the water from the well in the encampment. From these irrigation wells the water was not only fresh and cool, but remarkably free from impurities, as these are drawn into the large bag by which the water is lifted, and thus, after the withdrawal of a few bags of water, *the surface impurities* blown into the well were removed. Further, in these wells there is no layer of leaf-mould, as the means taken to keep the well deep enough for irrigation purposes effectually remove this injurious deposit. However, as a rule, except I was quite sure of the water, I invariably boiled it, and cooled and re-aërated it by pouring it from one vessel into another.

Railway Station Wells.—When we think how largely the railways are now used, not only for travelling, but for purposes of performing a pilgrimage, and how dependent the locked in passengers are on the water supplied to them by the water-men at every railway station in India, thanks to the wise forethought of that Solon of Indian Viceroys, the late Lord Dalhousie the importance of procuring pure water and of securing this purity will be self-evident; but if I may judge from the state of this public water-supply in my late sanitary circle nothing could be more disgraceful. True, I made suggestions on this subject, but they were unheeded, and for all I know to the contrary the railway station wells in this year's (1891) "Khoomb," or twelfth year festival at Hurdwar, may be in the same state they were in in 1879; and if water can contain in suspension the cholera germs, then I should think the railway wells at Saharanpur, Gazeabad, Toondla, and Agra have much to answer for. My suggestion was to cover the wells, and use a pump on them; or, better still, when the water was being drawn up to the "Williams" towers of defence for filling the engines, to let a large tank be filled, and *two* taps attached to this will, as I know, meet all requirements, and overcome all difficulties about caste, &c., as I proved at Mussooree.

Cantonment wells should have no trees over-shadowing them, and should have thatch covers, as all these wells once had at Meerut. All wells should be carefully examined, and those in which the water cannot be kept pure and good should be closed. The wells for the servants should receive the same attention as those used for the master, as, without doubt, if the truth were known, the water is often very indiscriminately drawn and served out. The locality of the latrine should be more carefully selected with reference to the servants' wells, and the Meerut cantonment is a very serious offender under this head.

City wells.—Favourite wells, such as the "Meeta Kooah" at Agra, should be carefully protected, and a pump used to raise the water. The "lotah," in its first dip into the well is generally very dirty, and, in bringing up water for its own cleansing, fouls that from which it is drawn.

There is, however, in nearly every Indian well one great source of impurity more overlooked than anything I know of, and that is what I have alluded to before as *the leaf-mould deposit* at the foot of the wells. Now this deposit is the very substance in which is generated the germ which is credited with the production of malarial fever, viz., the product of decomposing vegetation, chiefly of leaves. The germs in this deposit when acted on by a tropical sun, pass into the air with the fluids raised by evaporation, or, as in this case, when suspended in the water, are taken into the system, when the water of wells with a deep layer of this deposit is used for drinking purposes. To anyone who has watched the cleaning of a well with the object of bringing up something which may have fallen into it, the true character of this deposit is clearly evident; and it seems to me that, in a masonry well with a good tube, every drop of water withdrawn from the well *must* have passed through this layer of leaf-mould, and in its passage must surely bring away some of the malarial germs present in this decomposing vegetation. Indeed, I believe that of the two great trains of symptoms in true malarial fever, one, a hot dry skin, relieved by a free perspiration, is due to the malarial poison, whatever it may be, having been inhaled; while the second, a sensation of cold, with an intense desire to be sick but inability to vomit, is due to this germ having been taken into the system when suspended in water which has been drunk, in much the same way that the train of symptoms differ in spontaneous and in inoculated small-pox. In spontaneous small-pox the eruption is, in many cases, present not only internally on the various mucous membranes, but also externally; this is doubtless due to the inoculation by the virus, both as suspended in the air and breathed, and in the food or water taken into the stomach. Now, when the virus is scientifically inoculated, as practised till lately in the Himalayas, where I studied it, no general eruption appears at all, everything is confined to the site of the small-pox virus insertion; on the other hand, when this inoculation is carelessly, or, rather, unscientifically practised, and small-pox crusts are swallowed as pills mixed with flour and coarse sugar, or these crusts in a very fine dry powder are blown into the nostrils, and thus inhaled, then the most serious results follow, the mortality is very high, and the eruption often confluent.

Now, as the native method of cleaning a well is not only expensive but very ineffective, hearing of Bull's dredger, I called on Mr. Bull when passing through Cawnpur in 1879, and at once saw that his dredger was the very thing I wanted to remove this deposit and to work down to the clean sand. I accordingly made a special report to the Government on the subject, and suggested a plan by which a Bull's dredger, placed on wheels, with a set of shears for working it, could be used in a group of stations, and transported by bullocks or horses from one station to another, in much the same way that a portable engine is made available in this country; but no notice whatever was taken of the suggestion, and I have little doubt that an examination of the deposit in the wells in most Indian cantonments, and particularly at Lucknow, would reveal conditions of insanitation which would raise the question, not why so many suffer from fever, but how it is that any escape.

When writing on the subject of the late alarming increase of enteric fever in India, I found on inquiry that the cost of a Bull's dredger, such as I have described, would be in India, complete with derrick, windlass, and 100 feet of chain, suitable for conveyance in a cart, and capable of erection in 15 minutes, 180 rupees.

And now I have done, and in conclusion would only repeat that everything here stated or suggested is to be found in my official sanitary reports for the first circle North-West Provinces, extending over 20 years, from 1864; and I can only state that, as regards this circle, with its large military cantonments in the plains, and its hill sanatoria in the Himalayas, the conclusion arrived at by the Sanitary Department in India, and in this country, to the effect that the value of the European soldier's life has greatly increased, owing to the improved sanitation of his surroundings, is just one of those delusions which, like a pricked air-bag, collapse before the sharp point of any careful inquiry.

The increased value of the soldier's life is due to a moral, not a physical sanitation, and total abstinence and its accompaniments have had more to do with this than all the sanitation which India has seen for the last 25 years. Take, for instance, the sanitary condition of the first circle as regards the work of the strictly sanitary department; it was worse in 1884 than it was in 1864, as I am prepared to prove, for the defects of 1864 were allowed to go on unheeded and unremedied till 1884, when a wide-spread epidemic of typhoid fever was the penalty of years of the grossest violation of the first principles of sanitation in the matter of the water-supply; and the cases of typhoid fever in the large hill sanatorium of Chuckrata in the Himalayas, and the increasing unhealthiness of Roorki, Meerut, Muttra, and Agra are evidences that neglected sanitation in the point of water-supply must bring a terrible retribution.

DISCUSSION.

Mons. Maignen said that Mr. Kümmel had been asked to explain the reason for the sudden rise shown in his diagram, and he had explained that it was intended to represent what he termed a sudden explosion of microbes, owing to the filter having been overworked. The same sort of thing had happened in England in the case of sand-filtration. Berlin engineers had found that sand was not capable of arresting a microbic organism until it was ripe, that was, in fact, not until a sufficient quantity of sediment had been deposited on the fine sand to form a filter in itself. What would become of the microbic organisms that had passed through that thick layer of sand before the filter became ripe? There was really plenty of room for them to remain where they were, and they would never be removed. Therefore, sand-filtration was open to great question, and they had in the case of Hamburg an explanation of why, at one particular moment, sand-filtration might bring about the evils of which they complained. With regard to boiling water, they had been told in a previous discussion that water might be considered to be safe if it was boiled at 130° C. for 10 minutes in a closed vessel. There was one point he wished to suggest, and that was that the longer the water was boiled, the more quickly would it become putrid. Water boiled for five minutes would become putrid in three days, but water boiled for a quarter-of-an-hour would become putrid in one day. He wished to say a word on the question as to what was to be done under the present emergency. In the first place, water coming from the best of sand-beds was a little coloured. This colouring was due to fine particles, so that it showed that the filtration was not perfect. But water contained other things, and they had been told that, besides sediments in suspension, there was also organic matter in solution. In some waters there was too much life. For the future they would have to deal with water, not by means of filters—which left behind things which might be a source of danger—but water must be treated chemically. He would tell them half a secret which would not be a secret next year, namely, that for the last year in Paris experiments had been made, which he was not yet authorised to divulge, which showed that the chemical purification of water entailed a bacteriological purification. He could not divulge it at present because it was necessary to find out how this was taking place, at what particular point, and for what particular reasons; but the fact was that water which had been thus chemically purified had not a living germ in it. He had seen this done in four or five laboratories in Paris, and it was found that the water was completely sterile if properly treated by chemistry. The re-agents employed were no source of danger, and they completely precipitated lime, organic matter, and organisms. He believed that this would be the treatment applied to the impure water of the future.

Dr. Simpson (Calcutta) said the last speaker on the subject had laid great stress on the purification of water; but he himself looked at it from a different point of view, and thought they should see that the water was not contaminated, and therefore would not need purification. Dr. Pringle had told them the condition of the water-supply in India, and had shown that there was some difficulty in keeping that water pure, especially when the water was collected in tanks. Quite recently, some of the gentlemen connected with the Sanitary Department in Bengal had got over that difficulty, in a way, by using tube wells. They had introduced a number of tube wells, such as were used in the Abyssinian Expedition, and put them down near the tanks, and in that way were enabled to obtain pure water. He quite agreed with Dr. Pringle that the sanitary condition of India in regard to the water-supply was the most pressing need. He had had an illustration of that last February, when, owing to a very large festival where the people collected on the Ganges for bathing purposes, outbreaks of cholera had taken place. When those pilgrims went home they took the cholera to their villages; and, following them up, he had inquired into the matter, and found that wherever pilgrims went and polluted the water-supplies (which they did so easily, as Dr. Pringle had told them), there cholera broke out, so that there were epidemics all over the country, which he attributed entirely to the water-supply. In another Section he had mentioned what had occurred in Calcutta on the introduction of the water-supply, and he thought it was a fact worth repeating. In Calcutta the water-supply was introduced at the end of 1869. In the five years prior to that date there were 21,000 deaths from cholera; in the five years after the water-supply was introduced, there were 5,000 deaths. Now, the supply at first was a street supply—standposts were introduced at certain distances along the streets and lanes. The people soon began to see the value of water, and were clamorous for the introduction of that water-supply into their houses. A number of house connexions were made, and the consequence was that in a very short time the street supply, instead of being constant, became intermittent. The cholera death-rate immediately ran up, and in the next five years, instead of an average of 1,100 deaths a year, the average was 1,400. That matter was not remedied; a great deal of controversy went on, and another five years passed away without any remedy. The consequence was that more house connexions were made, the water was allowed to go to waste, and in certain sections became so scarce that it was almost impossible to get any. The result in those five years was that the deaths from cholera further rose from 1,400 to an annual average of 1,800. Then a partial remedy came in, more water was brought, but it was not so well distributed until the last year of the last quinquennium. The intermittency was not done away with, but the supply was better. The cholera death-rate immediately ran down again to 1,400. During the past two years the supply, though still intermittent, had been very much improved, and the cholera mortality had fallen to 1,000. After his experience in India, from the inquiry into local outbreaks and from the knowledge of what had occurred as the result of sanitary measures in regard to water-supply, he was convinced that once Calcutta, which was called the home of cholera, had a constant water-supply as well distributed as in some of the English towns, there would be no cholera excepting that which was imported from the villages. From that illustration they would see the importance of the water-supply to villages. Ninety-five per cent. of the population of India lived in villages, and it was really in the villages that so much ill-health occurred. He had mentioned cholera simply because it furnished a good illustration; but he was convinced that much of the fevers, of which they had probably heard, were due to the condition of the water that was drunk. India was such an immense country, and the people were so poor, that they could not have very large drainage works, but they could introduce a proper water-supply; there was no doubt of that, and he was sure some system of drainage could be devised by the eminent engineers who had to do with sanitary science, which would be of an inexpensive nature, and would meet the requirements of the country.

Mr. Binnie said he thought they must feel very much indebted to Dr. Pringle and Dr. Simpson for the remarks which had fallen from them on the subject of water-supply in India. That was a matter about which he had some little experience, and in which he could corroborate very fully all the statements of those gentlemen. The great bulk of India was without a water-supply in the sense in which they now used the words. Nothing could be more filthy or disgusting than the ordinary village well, and it behoved them to do what they could to improve the water-supply in that country. Of couse, in the large towns and municipalities they had to a certain extent an unlimited amount of water. Calcutta, as they had heard, was doing its best; Bombay was certainly far in advance of all the other towns in India, for not only was it getting a larger water-supply than any other town, but it was getting water from an undoubtedly pure and uncontaminated source, and from uncultivated and, he believed, unculturable areas. The importance of this they had seen in the paper on Altona. That town derived its water-supply from a river at a point below that at which sewage was discharged into it. They saw from the diagram that in that particular case the people drank the water with perfect impunity and immunity as regarded that particular outbreak of disease. At a certain period—in the month of February 1891—that disease increased at a great rate. They saw also that about the same time, or rather, in the previous month of January, the filters gave indication of a very sudden rise in the number of microbes detected. Going back another month, they saw that the month of December was one in which there had been little rainfall. Putting those things together, he thought they confirmed a remark he made the other day, that they might for a long time continue to drink comparatively clean and healthy sewage, but the time would sooner or later arrive when epidemics of that kind would break out. It was most instructive to have such facts brought before their notice in the very clear way that the diagrams did, and they had seen what had been noticed in other places, that sand-filtration was not a perfect protection against those diseases.

Herr Kümmel said he did not see how the filter could be overworked, but he had said in his paper, and repeated it now, that it was possible that there existed some relation between the working days of the filter and the number of microbes. The other things which had been mentioned were all to be read in his paper, but he wished to say that Mr. Binnie's remarks were right.

Aperçus sur l'Assainissement du Sous-sol des Villes.

BY

Señor Don Pedro Garcia Faria.

Parmi les lois qui regissent tout ce qui a été crée, une des plus notables est certainement la relative à la circulation continue de la matière, laquelle se présente à nous sous divers aspects, selon la phase que nous observons du cycle fermé où celle-ci évolutionne.

Cette loi a reçu de très importantes applications depuis le Congrès International de Bruxelles de 1856 où Mr. Ward la formula par cet aphorisme : "Circulation or stagnation," formule savante dont l'application renferme le système complet de l'assainissement des villes. Les eaux de pluie pénètrent dans le fond bas des terres et, de là, on les achemine vers les grandes cités, et servent à l'approvisionnement, en leur assignant les divers services qu'elles sont appelées à rendre ; dégénerant bientôt en déjections urbaines extrêmement toxiques, il faut en faciliter l'éloignement par des moyens naturels ou artificiels, obligeant ces substances putrides à se purifier par l'action filtrante et régéneratrice du sol, de l'oxigène de l'air, et des végétaux, dont l'effort contribue à transformer ces substances en d'autres inertes qui, plus tard, devenues assimilables à l'homme, serviront à son alimentation.

La même circulation s'établit au sujet de l'air, dont la régénération par rapport à l'air vicié s'accomplit d'une manière analogue, et en général on peut dire que là où la vie existe, on observe la transformation de la matière.

Les procédés employés à l'assainissement des villes varient selon l'importance qu'ont ces villes. Dans les petites, l'action régénératrice des agents naturels, est réellement efficace, tandis, qu'au contraire, dans les grandes cités, cette action est si faible qu'elle est insuffisante pour combattre les multiples causes d'infection qui se présentent.

La formation des villages a lieu généralement par l'agroupation de demeures plus ou moins distantes entr'elles, qui réclament la construction de nouvelles habitations, et c'est alors que se forment des rues rudimentaires, comme rudimentaires sont aussi les services qui s'etablissent en elles. Ainsi dans la plupart des hameaux, les rues sont de véritables torrents qui deviennent le réceptacle des eaux de pluie et des eaux sales, même des ordures de toutes sortes ; mais par cela même prétant plusieurs services, ceux, en effet, d'expulser les eaux excédentes et les excreta du village.

Les résidus qu'il convient d'enlever le plus promptement possible sont les matières fécales, les plus toxiques pour l'homme, et pour que leur évacuation soit rapide, il importe d'établir des canalisations qui les transportent avec célérité en des lieux n'offrant aucun péril à la santé publique ; il conviendrait aussi évacuer en elles toutes les eaux contenant des matières organiques, en un mot, tout ce qui est susceptible de décomposition et qui peut être emporté par la véhiculation aqueuse. En faisant cela, il faut rendre convexe le profil transversal des rues, car les égouts sont destinés à remplacer le lit du torrent tracé dans les rues rudimentaires ; par lui la chaussée se perfectionne, et de naturelles separations s'etablissent entre la circulation pédestre, la roulante et la ferrée, qui peuvent encore s'exécuter souterraiment, ainsi qu'y établir les canalisations et les tuyaux de distribution.

L'assainissement des villes de peu de ressources ; celles d'exiguë population, et, enfin, celles dont les conditions topographiques ne comportent point l'installation de galeries où l'homme puisse pénétrer, s'obtient par le système tubulaire formé par des conduits cylindriques, en grés, eprouvés sous 10 atmosphères, et rendus ainsi inattaquables aux eaux sales et industrielles, dont l'évacuation a lieu par ces conduits.

Le réseau sera nettoyé au moyen d'ondes recueillies dans des reservoirs à echappées automatiques, fixées à la tête de chaque tuyau et semblables à celles que l'on emploie pour le nettoyage des égouts. En cas d'obstruction des tuyaux alimentaires des réservoirs, ou que l'obstruction du drain fût dificil à éviter, le nettoyage se pratiquera alors au moyen de baguettes flexibles introduites dans le drain principal par le secours de trois autres tuyaux mis en communication avec lui, lesquels émergent du fond des ouvertures ou puits d'inspection et dont l'équidistance est un peu moindre que le double de la longueur de la baguette.

Les unions des conduits entr'eux se réalisent au moyen de courbes à raccordement tangentiel, évitant toujours les unions anguleuses, les parties entrantes ou sortantes qui peuvent motiver des obstructions et des depôts de substances putrides.

Dans les villes où les conditions différent de celles plus haut énoncées, l'adoption d'un réseau souterräin d'égouts est conséquemment préférable, car il prête ainsi tous les services incommodes, insalubres ou périlleux possibles, dont il convient de débarrasser les rues et l'habitation de la gent urbaine.

La canalisation, qui doit obéir à un plan général, doit être de plus imperméable, et permettre la sortie rapide de toutes les eaux et bien avant que la décomposition putride ne se soit initiée en elles.

Les matériaux employés en œuvre doivent résister à l'humidité oxigénée et aux charges qu'ils sont appelés à supporter; et ceux employés comme les revêtements, être complètement inattaquables par les eaux qui sur eux courent; ils doivent être bien lissés, et, s'il est possible, polis, afin d'éviter ainsi l'adhérence des matières putrides et augmenter en même temps la vélocité des eaux sales.

Les sections transversals des galeries doivent présenter des formes arrondies; les formes de l'ovale convenant en général aux égouts de petites dimensions qu'un faible volume d'eau parcourt, car alors l'eau acquérant une suffisante hauteur augmente par cela même la vélocité de la nappe liquide; dans les autres cas il est bon de recourir aux formes circulaires et semi-circulaires qui, à périmêtre égal, ont une plus grande aire; d'ailleurs pour que l'homme puisse les parcourir et qu'elles rendent les divers services qu'on attend d'elles, leurs dimensions ne doivent pas être moindres de 1.60 mts. en hauteur et 0.80 mts. en largeur, dimensions qui doivent aller en augmentant dès les dernières ramifications, jusqu'à la zone inférieure où s'accumule un plus grand volume d'eau; les augmentations de sections seront toujours rendues insensibles.

Les unions des branchements avec les galeries et de ces galeries entr'elles, doivent se faire au moyen de courbes tangentielles dont le rayon soit de vingt fois supérieur que la largeur du radier; les pénétrations des différentes parties d'égouts s'obtiennent en prolongean leurs surfaces jusqu'à leur respective rencontre, disposant des arcs sur lesquels reposent les voûtes; quelquefois on construit une seule voûte en la zone d'union, et cette voûte, qui couvre les galeries qui s'unissent prend la forme d'entonoir qui oblige d'établir une cheminée de ventilation en sa partie haute afin d'éviter que l'air infecté s'accumule en elle; cette solution ne saurait être prodiguée car étant très coûteuse, elle est aussi plus difficile à construire que la précèdente.

Les sections des galeries devront être étudiées de manière que chacune de ses parties répondent à de déterminés services; ainsi on calculera la cunette de façon à suffire à l'évasion de toutes les eaux sales; la totalité de la section sera suffisante à l'évacuation des eaux de pluie; sur les arêtes de la cunette, c'est-à-dire au bord de la banquette ou bien sur celle-ci, on empôtrera les rails où courront les vagonnets destinés au transport des résidus solides, et sous la voûte on aménagera les tuyaux et les conduits de distribution d'eaux et des divers fluides.

Pour pouvoir faire le calcul de la section totale des égouts des multiples rues d'une ville, on doit examiner en cette dernière les bassins affluents à chacun des talwegs, en tenant compte que ces talwegs sont déterminés par la topographie du terrain d'asseoiment; par l'urbanisation établie déjà, et par les points ou zones où se practique le déversement des eaux. Le cube d'eaux qui afflue aux égouts est de trois catégories distinctes; de pluie; d'industrie; et les eaux sales, considérant comme telles celles excédents de l'arrosement, lavage et autres usages. Pour fixer le debit correspondant aux eaux de pluie de chaque galerie, il faut connaître l'aire de la région affluente en un point de cette dernière; la hauteur d'eau tombée dans les grandes averses et leur durée, documents qui doivent se déduire de la Météréologie locale de la ville à laquelle on destine le projet; on doit encore tenir en compte que l'eau met à se réunir dans les égouts le double ou le triple du temps qu'elle met à sa tombée, et que, non plus, toute cette pluie arrive au réseau souterrain, car il se perd par évaporation, filtration, imbibition, le tiers ou la moitié de cette pluie, proportion que croît avec la perméabilité des pavages et du terrain. Au volume d'eau de pluie il faut ajouter celui des eaux sales, et de celles qui excèdent, dont la quantité est variable selon la densité des habitants par hectare et selon la dotation par jour et par personne, pouvant considérer aussi que la moitié ou les deux tiers de la dotation qui correspond aux habitants qui s'en servent, arrivent à l'égout, les pertes étant toujours plus petites à mesure que la dotation est grande. En résumé, il faut aussi tenir en compte la dotation relative aux eaux industrielles dont la quantité et régime sont encore plus variables, parcequ'elles dépendent de la situation et nature des établissements industriels de la cité; il est par consequent nécessaire de calculer dans chaque région la proportion relative à cette cause, et, (faite la somme des trois affluences correspondant à l'hectare du terrain et multipliant cette somme par le nombre d'hectares de la région dont le talweg forme la galerie,) on obtient le debit Q, soit le volume auquel il faut donner passage; connaissant de plus la pente du radier J et le rayon moyen R du type de section qui s'adopte et la valeur qui correspond au coefficient a selon l'adhèrence de l'eau par rapport au revêtements qui peut se considérer égal à 52 si le revêtement est bien lissé;

On peut alors faire l'application des formules connues :

$V = a\sqrt{RJ}$; $Q = \frown V$, déduisant de la première la velocité moyenne V, et de la seconde l'aire $\frown$ nécessaire au déversement, on recherche parmi les sections adoptées, celle dont l'aire libre ait cette valeur comme minimum.

Quant à la vitesse des eaux sales, il importe que ce soit la plus forte possible et pour ce motif la cunette doit se construire de formes circulaires dans lesquelles R acquiert la valeur maxima et la surface intérièure de celle-ci doit être parfaitement lisse et, s'il est possible, polie avec soin, car alors augmente la valeur de a, et par tant celui de V ; le même résultat s'obtient en augmentant la pente J qui a ses limites determinées par les pentes mêmes de la rue, pentes qui dans les parties basses des villes sont généralement fort réduites. La pente minima admissible pour un réseau, d'égouts depend du volume d'eau affluant à ce réseau, diminuant celui-ci en raison égale des autres circonstances, à mesure que l'autre augmente ; cependant pour ne pas exiger de grands volumes d'eau ou moyens spéciaux de nettoyage, il ne convient pas d'admettre de pentes minimas très petites ; la limite de 0·001 est très acceptable, bien que, parfois, de grandes villes ont été en bessoin d'en admettre de plus petites, pour l'exiger ainsi la topographie du terrain.

Quant à la limite minimum de la vitesse, ou doit tenir en compte, que, dans aucun cas, elle doive jamais descendre de la nécessaire à l'entrainement de toutes les substances putrides apportées par les eaux, pouvant fixer cette limite de vélocité en soixante dix mètres par seconde, au cas de n'admettre aucuns solides trop denses ou volumineux, laquelle au contraire on augmentera si l'on doit donner accès à ces derniers.

Obeissant aux principes exposés plus haut, il se déduit, comme conséquence logique, qu'il convient d'extraire toutes les ordures des maisons et des rues par l'interieur des égouts, bien qu'il faille les doter de moyens ad hoc que permettent de pratiquer avec efficacité ce nouveau service ; si le courant d'eau des égouts etait continue, s'il était suffisant à entraîner les ordures, qui sont moins denses que l'eau, par la flottaison, il est clair qu'on pourrait adopter ce système ; mais il est si difficile de reunir toutes les circonstances, qu'il est préférable, en général, d'extraire les ordures au moyen de vagonnets légèrement perfores dans leur fond.

A cet effet, il faut disposer les rails empotrés sur les arêtes de la cunette, c'est-à-dire à la naissance de la banquette ou sur celle-là, et de façon à ce que la marche des vagonnets soit rendue facile dès les dernières ramifications jusqu'à l'emissaire, et vice-versa ; les ordures se jetteront dans les vagonnets dès les dépôts souterrains qui fonctionneront par un mécanisme très simple et qui ne devront point ressauter sur la voie publique ; ils s'ouvriront automatiquement au moment de jeter les ordures, sans pouvoir, dans aucun cas rester ouverts.

Les dépôts d'ordures auront des formes arrondies et seront exempts d'arêtes et d'angles rentrants ; et dans l'intérieur on construira les bouches d'égout semi-circulaires, qui doivent donner l'entrée aux eaux de pluie et qu'on pourra visiter et nettoyer facilement ; tous ces ouvrages seront revêtus intérieurement d'un matériel résistant et parfaitement lissé, empêchant ainsi toute adhérence des ordures, et on les nettoyera journellement avec une forte quantité d'eau, mais seulement après en avoir extrait les ordures.

Le transport des résidus solides s'etant opérè par la manœuvre des vagonnets, comme aussi ceux des cunettes des galeries par le moyen des vannes que ce vagonnets portent avec eux, il faudra prendre certaines précautions pour éviter les effets d'une grande agglomération d'eau, et pour la prévenir, on doit disposer d'un réseau téléphonique et de timbres d'avis qui transmettront les ordres au service, et, entr'autres, ceux nécessaires à conduire les vagonnets hors des égouts, ou bien aux parties élevées de ceux-ci, ainsi qu'aux galeries de refuge qui se construiraient.

L'illumination des galeries doit être électrique pour plusieurs raisons, et, entr'autres, celles d'eviter par ce moyen les explosions du gaz d'éclairage, ouvrant le courant électrique là seulement où ce fluide devra prêter les services qui lui incombent. La bonne exploitation du reseau réclame qu'on signale avec clarté les galeries par des écriteaux qui empêchent de les confondre entr'elles, consignant sur ces plaques toutes les indications de longueur, pentes et sections qui peuvent intéresser.

On établira une ventilation si complète qu'en aucune part l'air ne pourra se détenir ou se vicier, et l'on recourra pour cela faire, aux ouvertures des bouches des égouts, aux regards, aux dépôts aménages pour les ordures et surtoût aux tuyaux de descente des eaux de pluie; enfin tous les conduits portéront directement l'air saturé des égouts aux couches atmosphériques supérieures, au-dessus des toitures. Si en un point quelconque, ou pour des circonstances exceptionnelles, les moyens indiqués ne suffisaient pas, on recourra à l'emploi de cheminées d'aspiration ou à d'autres moyens artificiels dont l'emploi doit se restreindre autant que possible.

L'assainissement du sous-sol des villes requiert que les conduits privés de descente des eaux de pluie des latrines, de cuisine, et de lavage qui sont des ramifications de la canalisation publique, réunissent telles conditions, que jamais, ni sous aucun prétexte, se détiennent en eux les matières putrides, et pour obtenir ce résultat, il faut disposer les tuyaux des maisons de façon à ce que l'évacuation de tous les résidus s'opère avec promptitude et rapidement, par des déversoirs expeditifs, et les siphons qui se placent à leur naissance pour incommuniquer la maison et le conduit privé, évitant ainsi à ces maisons les conséquences fâcheuses que les imperfections du reseau pourraient leur causer. Les tuyaux seront droits et faciles à examiner; ils auront le diamêtre strictement nécessaire que réclament les services qu'ils doivent rendre; ils seront exempts de parties rentrantes ou saillantes, seront construits en grès, plomb ou en d'autres matériaux résistants et inattaquables aux eaux sales et aux agents atmosphériques.

Tous les tuyaux de descente devront se prolonger de 2.00 mêtres au-dessus des toits afin que les germes qui ascensionnent par leur secours, atteignent la partie haute de l'atmosphère et s'oxident et minéralisent les matières organisées.

Dans la partie inférieure, les unions des tuyaux de descente avec les égouts seront faites sans recourir à l'intermédiaire d'un siphon quelconque, qui pourra se tolérer seulement dans les cas où les égouts ne réuniraient pas les conditions définitives qui en assure l'immunité.

Pour favoriser l'amélioration de la santé publique dans beaucoup de grandes cités, on ne doit pas compter seulement sur l'évacuation des eaux de pluie, sales et d'industries, car les fluctuations de la couche aqueuse souterraine originent des décompositions putrides sur les matières organiques qui pénètrent dans le sous-sol; pour déjouer es inconvenients que produit cette cause, on recourt au draînage perméable, lequel déverse son contenu en des endroits des égouts appropriés à l'effet; cette canalisation peut-être établie par des tuyaux de terre cuite poreuse, sans le secours d'aucun matériel en ses unions, le tout placé dans la direction et avec la pente rationnelle qui lui correspond.

Les drains peuvent se placer dans le fond même de la tranchée preparée à recevoir le réseau des égouts, et par ce moyen on réalisera avec une grande économie, l'abaissement de la couche d'eau souterraine ainsi que la neutralisation des matières putrides et toxiques qui auraient pénétré dans le sous sol.

C'est dans l'intérieur de la canalisation souterraine et spécialement sous la voûte qu'on place tous les tuyaux des conduits d'eau et des fluides qui doivent être distribués dans la ville, faisant en sorte que le côté destiné au passage des préposés aux divers services, reste entièrement libre, afin d'éviter les contusions et les accidents qui pourraient survenir à ces gens. Quant au mode de pratiquer les prises pour les établissements privés, on simplifie considérablement la chose en se servant d'une galerie ou branchement incommuniquée avec l'égout, la même que celle qui contient les tuyaux de descente des eaux de toutes espèces.

Quand les eaux sales arrivent au point inférieur de la canalisation, il se peut qu'en ce point même commence l'émissaire qui doit conduire ces eaux sales en un lieu désigné pour leur dépuration, ou bien encore qu'il soit nécessaire d'user du moyen d'une élévation; en ce cas des machines font fonctionner des pompes qui portent les eaux à l'endroit qui leur est destiné.

Sur ce sujet nous ne pouvons aussi que faire des indications générales, car plusieurs villes sont entourées de hautes montagnes, sans aucuns champs dans leur voisinage, et alors il faut lancer les eaux à la mer ou recourir aux moyens spéciaux de dépuration, moyens qui ne laissent point d'avoir beaucoup d'inconvénients. Dans les autres cas, ou use du système des irrigations agricoles et des filtrations dans le terrain, procédé qui garantit la plus complète depuration des eaux sales au bénefice de la cité d'où elles proviennent, ainsi qu'aux bourgs, hameaux et champs dont les propriétaires obtiennent d'excellents résultats de ces mêmes substances toxiques dont l'état stagnant est si préjudiciable aux êtres humains.

Les résidus urbains, et principalement les matières fécales, constituent le plus riche des engrais, représentant une richesse considérable qui, perdue une fois, ne peut plus se reprendre; et pouvant produire autant de maux que de bénéfices, étant judicieusement utilisée.

SOMMAIRE.

1. L'assainissement du sous-sol des villes sera d'autant plus complet et perfectionné, qu'on saura faciliter d'avantage et la circulation continue et la transformation de la matière, dans le circuit où celle-ci évolutionne.

2. Les services prêtes par les rues des villes augmentent d'importance à mesure qu'elles s'accroissent et se perfectionnent. Dans les cités de peu de ressources, et dans les zones déprimées on recourt au système tubulaire dont la conservation et nettoyage deviennent faciles au moyen des courants d'eau.

3. Dans les autres cas, on construit un réseau souterrain où sont établis les services incommodes, insalubres ou périlleux, et les galeries servent à l'expulsion des eaux sales, à l'extraction des résidus solides, ainsi qu'à l'installation des canalisations et conduits de toutes espèces.

4. Les sections des galeries seront de forme arrondie et leur aire suffisamment grande pour permettre au personnel de les parcourir librement et d'y prêter leurs services.

4. La pente des réseaux doit diminuer de la partie supérieure à l'inférieure, en raison de l'augmentation du volume d'eau, et des difficultés que présentent les zones basses; les limites de l'inclinaison des pentes oscillent, si cela est possible, entre cinq pour cent et un pour mille; les pentes petites réclament l'emploi d'abondants volumes d'eau pour leur lavage.

6. Les unions des galeries entr'elles devront toujours se faire tangentiellement, et le rayon des courbes être en général vingt fois plus grand que la largeur du radier destiné à évacuer les eaux sales.

7. L'extraction des immondices et des résidus solides urbains pourra se pratiquer dans l'intérieur de la galerie au moyen de vagonnets courant sur des rails empotrés dans les maçonneries. Les trains formés dans l'intérieur des grands collecteurs se dirigeront à l'exterieur pour fertiliser les champs avec ces riches ferments.

8. La ventilation du réseau souterrain devra être grande et complète afin d'éviter l'infection de l'air, sans qu'il y ait jamais aucune partie de galeries, branchements, siphons où manque cette ventilation nécessaire.

9. Le nettoyage des égouts se pratiquera au moyen de la vehiculation aqueuse par courants d'eau continus, s'ils sont abondants, ou bien pas ondées intermittantes qui parcourront une fois ou deux par jour au moins chaque galerie. Pour que la circulation continue s'effectue en bonnes conditions, il faut que la vitesse minimum soit de 0·70 mètres par seconde et que la dotation d'eau ne baisse pas de 200 litres par jour et par personne.

10. Les branchements particuliers s'enlaceront avec le réseau des égouts d'un mode facile et simple au moyen de galeries qui permettront d'inspectionner les branchements et d'y placer les ramifications et tuyaux de prise, s'unissant aux canalisations et conduits de toutes espèces.

11. L'excessive humidité du sous-sol s'évitera dans les villes qu'aient cet inconvénient au moyen du drainage perméable disposé sur les côtés du réseau des égouts.

12. La dépuration agricole complète l'assainissement du sous-sol des villes, constituant, quand on peut l'appliquer opportunément, le moyen le plus higiènique et économique de tous les systèmes connus.

DISCUSSION.

The President said they must now close their proceedings for the day and for the Session. He should like to express the thanks of the committee to those gentlemen who had come so far and rendered such valuable services in the presenting and discussing of the several papers. He should be sorry for them to dissolve without according to their invaluable secretary, Mr. Middleton, their best thanks for the services he had rendered. There was no member of the Organising Committee or of the Council, or of the Sectional Committee, there was no gentleman in the room or out of it who was so able to judge as he was, owing to the peculiar circumstances in which he had been placed as President of the Section, or who could form an adequate conception of the value of Mr. Middleton's services from the very commencement of the work, several months ago, until the present time. He hoped they would give him a vote of thanks by acclamation for the services he had rendered.

A vote of thanks to Mr. Middleton for his services as secretary was then carried by acclamation.

Mr. Middleton said he was exceedingly obliged to them for the manner in which they had received the remarks of Sir John Coode. He could say that, although the duties of the secretaryship of that section had been heavy, they had been a labour of love. He only hoped that his work had been properly done, and that they were satisfied with it; if so, he was well repaid.

The President said the next stage would be that in course of time members would receive the report of their proceedings in print. He thought he was justified in saying that the result of that gathering in London had not been surpassed in value by those of any other meetings of the Congress in any other city in Europe.

Mr. Middleton said that in the absence of the vice-presidents he hoped he might be allowed to propose a hearty vote of thanks to Sir John Coode, who had given up an immense amount of his valuable time to presiding at the meetings, much more even than could have been expected from him. They were very much obliged to him for the trouble he had taken in attending not only these meetings, but the meetings of the committee. The organisation of the scheme could not have gone on in the way it had, if Sir John Coode had not given so large an amount of attention to it.

A vote of thanks was then passed to the President by acclamation.

The President said he had endeavoured to do that, as every other matter which he took in hand, to the best of his power, not putting his hand to the plough and looking back. He thanked them for the recognition they had tendered to him for so doing.

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