PRESIDENTIAL ADDRESS.

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(Read before the Sydney University Engineering Society, on June 28th, 1911.)

Gentlemen,—My term of office having expired, and my successor having been elected, it now remains for me to give the usual Presidential Address, and then vacate the chair.

Before entering on the subject chosen by me I should first of all say that the Society may be congratulated on a fairly successful year. We had, during 1910, six papers read at our regular meetings, which were well attended, and with the exception of Mr. Littlejohn's, which was not open for discussion, all the papers provided considerable discussion.

1.—"The Frome Dam," by A. J. Debenham, B.E.

2.—"Diving and Diving Appliances," by R. S. Littlejohn.

3.—"Rapid Route and Topographical Surveying," by J. H. Cardew, M. Inst. C.E.

4.—"The Wolgan Valley Railway," by H. Deane, M.A., M. Inst. C.E.

5.—"The Water Supply of Singleton," by H. H. Dare, M.E.

6.—"Recent Departmental practice in the Design of Steel Railway Bridges, required for the Waterways of the North Coast Railway, New South Wales, including some notes on their manufacture," by J. W. Roberts, B.E.

In view of the fact that such valuable papers are read and discussed at our meetings, and subsequently published in the "Proceedings," it seems strange that so small a proportion of the Engineering Graduates are members. On looking up the figures, I find that of 215 graduates, 116 only are members, or 54 per cent.

It has been freely stated that we aim at being the principal Engineering Society in Australasia. This can only come to pass if practically the whole of our graduates keep in active touch with the Society.

At present our graduates are widely scattered, and are rising to important positions, so that it is within their power to supply papers in such numbers and quality as to make this Society the leading one if they sincerely wish it to be so. I hope the time is at hand when we can confidently claim that we have attained our desire in this matter. I would strongly urge on the new Council that immediate steps be taken to largely increase the proportion of graduate members.

The undergraduates supply a much better proportion, viz.: 82 per cent. are members.

Turning now from ourselves let us look at what has been done in engineering matters in the State during the past year.

I had intended to give a short account of the many important railway, water supply and sewerage works that have been under construction during the past year, but I found that the subject chosen for my address proper demanded more space than I expected, so that I must content myself by simply mentioning the North Coast Railway, the Barren Jack Storage Dam and Murrumbidgee Irrigation Scheme, and Long Bay Outfall Sewer as examples of large and important works, which any man might well be proud of being connected with.

Another great scheme that is being most seriously designed is the Warragamba Water (for Sydney) and Irrigation Scheme.

Public works have never been so vigorously pushed on in New South Wales as at present, and there must be, for some few years at least, many good openings for our civil engineering graduates.

I now come to the subject of my Presidential Address:—

THE BIOLOGICAL PURIFICATION OF SEWAGE.
ITS POSITION AT PRESENT.

Sewerage generally may be said to consist of a mixture of saline matter in solution and nitrogenous and carbonaceous organic matter in solution and suspension, together with a certain amount of grit and mineral matter. The objects to be aimed at in its purification are the removal of the suspended matters and the oxidation of the remaining organic matter and ammonia.

It is now clear that the purification is effected by bacteria of different kinds, some of which liquify the solids present in sewage, producing putrefaction accompanied by offensive gases, while others oxidise the contents; the former are known as anaerobic and the latter as aerobic bacteria. The object of all artificial treatment of sewage consists in allowing these bacteria the greatest scope to perform their work under the most favourable conditions.

These bacteria abound in sewage but they are also present in surface soil, in water, and in air.

The first sewage commission, appointed in the year 1857, reported in 1865 that—

"The right way to dispose of town sewage is to apply it continuously to land, and it is only by such application that the pollution of rivers can be avoided."

Another commission, appointed in 1882 to report upon the discharge of sewage into the Thames, reported in 1884— "That by chemical precipitation a certain part of the organic matter of sewage would be removed, and that the liquid so separated would not be sufficiently free from noxious matters to allow of its being discharged at the present outfalls as a permanent measure. It would require further purification, and this, according to the present state of knowledge, can only be done effectually by its application to land."

Since the publication of the last-mentioned report, it has been the practice of the Local Government to require, save in exceptional cases, that "any scheme of sewage disposal for which money is to be borrowed with their sanction, should provide for the application of the sewage or effluent to an adequate area of suitable land, before its discharge into a stream."

In 1898 a Royal Commission on Sewage Disposal was appointed, and in their first interim report, published in 1901, they reported as follows:—

"After carefully considering the whole of the evidence, together with the results of our own work, we are satisfied that it is possible to produce by artificial processes alone, either from sewage or from certain mixtures of sewage and trade refuse, such, for example, as are met with at Leeds and Manchester, effluents which will not putrefy, which would be classed as good according to ordinary chemical standards, and which might be discharged into a stream without fear of creating a nuisance. We think, therefore, that there are cases in which the Local Government Board would be justified in modifying, under proper safeguards, the present rule as regards the application of sewage to land.

"No general rule as to what these safeguards should be can be laid down at present, and, indeed, it will probably always be necessary that each case should be considered on its own merits."

Modern sewage purification may be divided into two stages—

1. Clarification.
2. Oxidation.

The first stage, consisting of the reduction of suspended solids by screening and various systems of tank treatment; the second stage consists of the removal of the dissolved impurities and part of the remaining matters in suspension.

"Although each of these two stages of purification may be effected by the four distinct methods of treatment mentioned in the following classified list, the works required for complete disposal of sewage will usually consist in a combination of several methods to suit the special circumstances of each case."

CLASSIFICATION.

1. Clarification Processes.	2. Oxidation Processes.
(a) Removal of grit, etc.	(a) Broad irrigation.
(b) Screening.	(b) Land irrigation.
(c) Sedimentation.	(c) Contact beds.
(d) Precipitation.	(d) Percolating filters.
(e) Liquefying.	

1. CLARIFICATION PROCESSES.

(a) Removal of Grit—

Where septic tanks are to be used which will only be cleaned out at long intervals of time, fairly thorough preliminary settlement of grit is generally desirable. The removal of the sludge which has accumulated over a long period in a septic tank is, as a rule, a matter of difficulty, as the sludge is often so thick that it cannot be pumped unless sewage or water is mixed with it. Much mineral in the sludge increases the difficulty.

Where precipitation or sedimentation tanks are to be used, and especially if the district is sewered on the combined system, it will, we think, generally be found better to settle out a considerable proportion of the mineral detritus before allowing the sewage to pass into the tanks. The necessity for a thorough preliminary settlement of the grit is not, however, in these cases of so great importance, for the presence of grit in sludge renders the latter more amenable to pressing and drying.

Detritus tanks are usually designed so that the speed of flow will allow the mineral matters to settle out of the sewage, while the bulk of the organic suspended matters are carried forward.

The capacity of detritus tanks should be about one hour's dry weather flow.

(b) Screening.

Before passing on to the septic or other treatment tanks the sewage should be passed through coarse screens for the purpose of removing the grosser suspended matters, such as sticks, cloths, paper, rags, corks, etc.

The removal of such suspended matters is almost essential where the sewage has to be pumped, and in other cases it is usually considered an advantage. Although the amount of suspended matter which is removed by coarse screens bears only a small proportion to the total suspended matter, the screenings have some manurial value, and in England there is usually no difficulty in getting farmers and others to take them away. Screens are of various kinds, some are fixed bars, and some are movable; in many cases the latter being driven by the sewage flow, as at Birmingham. At Leeds, with a screen of a mesh 30 to the inch, rather less than 10 per cent. of the total of the suspended matters was removed. The use of fine screens is always attended with difficulty, as they choke readily.

Some screens are provided with automatic apparatus for clearing them, but, in small works in particular, it is usually done by a man with a hand-rake standing on a platform above the screens. In any case the screens must be cleared at frequent intervals, as the matter collected soon blocks them and causes sewage to back up in the main outfall sewer.

(c) Sedimentation—

All tanks are sedimentation tanks, but it is convenient to limit the expression to tanks in which the sewage is allowed to settle, without the aid of chemicals and from which sludge is frequently removed. This system was formerly used to a very considerable extent for removing both organic and mineral matters in suspension, but it is now almost entirely confined to detritus tanks for removing the heavy solids, chiefly of a mineral character, while the organic matters are carried forward for bacterial treatment.

Experiments which were carried out at Leeds and Sheffield showed that, with the sewages of those cities, quiescent settlement for two or three hours was sufficient to remove a large proportion of the suspended solids entering the tanks, and to produce a fairly good tank liquor. Certain kinds of sewage contain more solids, which settle very slowly, than other kinds. For example, a large proportion of the solids in sewages which contain brewery or tannery waste, or wool scouring liquor, are difficult to settle.

(d) Precipitation—

Precipitation consists in the artificial acceleration of natural or mechanical subsidence by the addition to the sewage of certain chemicals to form a precipitate which, in settling to the bottom of the tanks, entagles the solid matters in suspension and carries them down with it, so that it is possible by this means to remove nearly all the suspended matter from the sewage and to produce a comparatively clear tank effluent, which in the early days of sewage purification was freely discharged into inland water-courses, and which may still be considered unobjectionable when it can be readily diluted with a sufficiently large volume of water, as in the case of an outfall into the sea.

(e) Liquefying—

Liquefying crude sewage in septic tanks partially clarifies it, but it also effects a certain amount of purification also, and that without the aid of expensive chemicals, viz.: by means of anaerobic bacteria contained in the sewage itself. It is now almost universally adopted in place of precipitation. In addition to being better and cheaper there is less smell arising from septic tanks than from precipitation tanks. Another great advantage is, that the volume of sludge is very much less, as the chemicals used for precipitation represent a considerable quantity of sludge, seeing that 95 per cent. is water.

By liquefying a certain proportion of the suspended solids with the production of gases, the quantity of sludge is still further reduced, and at the same time is reduced to such a form that it can be much more readily oxidised on land or bacteria beds.

Mr. Cameron, of Exeter, was the first to propose the adoption of septic tank treatment on a large scale. At that time it was claimed that the septic tank possessed the following, among other, advantages:—

(1) That it solved the sludge difficulty, inasmuch as practically all the organic solid matter was digested in the tank.

(2) That it destroyed any pathogenic organisms which there might be in the sewage.

(3 That sewage which had passed through a septic tank was more easily oxidised than sewage from which the solids had been allowed to settle, either with or without the aid of chemicals, in tanks which were frequently cleaned out.

(1) It is now known that all the organic solids are not digested by septic tanks, and that the actual amount of digestion varies to some extent with the character of the sewage, the size of the tanks relative to the volume treated, and the frequency of cleansing.

As to the proportion of solids digested in a tank, an exact figure cannot be given. It may, however, be given as 25 to 30 per cent.; the remainder becomes sludge or scum, chiefly the former in England, the latter in Australia, because of the higher temperature rendering the fermentation action greater.

As to the character of the sewage there is nothing further to be said.

As to the size of tanks, it is generally considered desirable to provide space equal to one day's dry weather flow. The particular shape of the tanks is of importance. They are generally rectangular both in plan and section, the length three to four times the width.

There should always be two tanks, so as to have one always in use while one is being emptied. There are generally not less than four tanks.

The tank capacity given above is for a fairly large installation; for private houses the capacity might be 1½ day, and for small village installations 1¼ day.

The inlets and oulets are over weirs and under scum-boards reaching to a depth of not less than one-fourth the depth of the tanks. Average depth of tanks is six to seven feet.

Assuming that a detritus tank has been used, the bottom of septic tank should have a fall of, say, 1 in 100 towards outlet to facilitate removal of sludge by gravitation. As a further means of facilitating the removal of sludge the bottom may be divided by dwarf walls into longitudinal bays with a special sunk pit in centre for catching heavy detritus.

(2) As regards the second claim, it is found that as a result of a very large number of observations, the sewage issuing from septic tanks is, bacteriologically, almost as impure as the sewage entering the tanks.

(3) As regards the third claim, it seems clear that experience has not borne out the claim. At the same time, septic tank treatment as a preliminary process is both efficient and economical.

The liquor issuing from a septic tank contains, on an average, 15 to 20 parts per 100,000 of suspended solids, though it seems impracticable to maintain the amount at an approximately uniform level for any length of time, and the amount has a tendency to increase as time goes on.

Cleansing of Septic Tanks.—There is no doubt that the longer a tank is run without cleansing, the less volume of sludge there will be per million of gallons of sewage treated. Sludge from a tank cleaned out at short intervals may contain 90 to 95 per cent. of water, while if allowed to run for say two years, the water in the sludge may be only 80 to 85 per cent.

There are other important considerations, viz.:—

The amount of suspended matter, issuing in the tank liquor, which greatly increases as time goes on.

The fact that at a large sewage works it would usually be less easy to deal with very large quantities of sludge at long intervals of time, than with smaller quantities at short intervals.

It does not seem desirable to entirely remove the sludge from a septic tank.

Such of the sludge as has had little time to undergo digestion should, if possible, be left in the tank.

If some sludge is left in the tank fermentation is hastened when the tank is restarted, whereas if it is cleaned out completely, some weeks may elapse before the fermentation is in full progress again.

Rate of Flow Through Septic Tanks.—The main objects in passing sewage through septic tanks must be looked on as being—

The settlement of the suspended matter in the sewage.

The digestion of as much sludge as possible.

The equalisation of the sewage as regards strength.

The most advantageous rate of flow, therefore, is that which gives the maximum settlement and the maximum digestion of sludge, without producing any serious nuisance from smell.

Should Septic Tanks be Open or Closed?—As regards digestion of sludge and quality of tank liquor, the closed tank possesses no advantage over the open tank. Where it is important to avoid nuisance from smell, the closed tank is generally preferable.

2. OXIDATION PROCESSES.

(a) Broad Irrigation.

(b) Land Filtration.

I do not propose to go into a discussion of these two methods of dealing with the clarified and partly purified effluent obtained after the clarification processes, as these subjects scarcely fall within the scope of this address.

(c) Contact Beds. } Bacteria Beds.
(d) Perolating Filters }

The final oxidation of the organic matter in sewage is brought about by aerobic bacteria, and the object aimed at in designing bacteria beds is to supply the bacteria with the best conditions for working to the best advantage. Bacteria beds produce the same results as land treatment much quicker and on a much smaller area.

Contact beds are tanks filled with filtering medium. In this type of filter the sewage is held up before it is discharged. The bed, after it is emptied, is allowed to remain empty for some time before receiving the next filling. The length of time during which the sewage is allowed to stand in the bed is spoken of as the period of contact.

In percolating filters the sewage is not held up, but is allowed to percolate through the filter.

There can be no doubt that the organic matter in solution can be oxidised by either type of filter, provided the filter is properly constructed and properly worked; but the question of the relative merits of the two types is one of some difficulty.

Before discussing the relative advantages of "Contact Beds" and "Percolating Filters" the class and size of material used in the body of both may be considered.

The materials in general use for contact beds are clinker or coke.

Preference must always be given to those materials which present the roughest and most irregular surfaces. Coal is also frequently used.

As to size, the smaller the material the greater is the total internal surface area of the medium exposed, and consequently the more intimate is the contact of the liquid with the material, the greater the purification, and the more efficient the arrest of the suspended and colloidal matter. The efficiency of a contact bed, however, depends very largely upon the admission of air to all parts of the filter during the time the bed is resting empty. Thorough and rapid drainage is therefore of the utmost importance. For this reason, it is important that the material in a contact bed should not be too small, especially if the liquid to be treated contains an appreciable quantity of suspended matter, as some of the suspended matter will find its way into the interstitial spaces and prevent proper drainage of the bed.

For filtering purposes the following definitions may be accepted:—

Coarse Material.—3in. diameter and upwards.
Medium Material.—½in. to 1in. diameter.
Fine Material.—¼in. diameter.
Very Fine Material.—⅛in. diameter.

(c) Contact Beds—

Contact beds are vessels filled with some filtering material such as coke, clinker, coal, etc., to a depth of about 4ft. In shape they are generally rectangular. They may be built of concrete rendered with cement, or of brickwork, but must be water-tight. While being filled with sewage from surface channels, the outlet from a tank is kept closed. As the sewage sinks through the filtering material, it displaces the air from the interstices until the tank is full. They are then allowed to stand full for about two hours generally, "in contact" with the filtering material, and hence the name. As the sewage escapes during emptying, fresh air is drawn into the interstices again.

In fixing the size of a contact bed it may be assumed that the water capacity when filled with filtering material and new is about one-third the original water capacity of the tank itself. The depth is the first thing to decide upon. This should not be greater than 6ft. nor less than 2ft. 6in., and the limits may be narrowed still further, viz.: 4ft. to 3ft.

Then, knowing the quantity of sewage to be dealt with per day, and the number of fillings (generally three per day), the area of bed required is obtained.

It is desirable that the greatest possible time should be allowed for aeration, and the following cycle may be taken as typical:—

1 Hour filling.
2 Hours standing full.
1 Hour emptying.
4 Hours standing empty.

And there are generally four beds.

It is usually found that where the beds are not worked automatically, two fillings per day is sufficient if the capacity and efficiency of the beds are to be maintained.

Thus, if beds are 4ft. deep, two fillings per day represent 150 gallons per super. yd., and three fillings 225 gallons.

Assuming that the sewage had been settled in detritus tanks, then tank liquors containing 10 parts of suspended matter per 100,000 could be treated upon medium filtering material at this rate for four or five years, when the material would probably require washing and renewing. These figures refer to single contact.

In order that a contact bed may drain properly, it is necessary to have a few inches of large material on the floor of the bed, and this, with the under drains themselves, would occupy 6in. of depth.