In general, after a bed is once "mature," the period of rest is more important than the time of contact, and the total time, in 24 hours of filling, standing full, and emptying, should not exceed the total period of rest.

The liquid should be passed on to the filtering material fairly evenly over its whole surface, so that the suspended solids may, as far as practicable, be spread over the whole surface and be prevented from entering the body of the bed.

Automatic gear is more economical at small works than large ones, because at large works there are always men available for controlling the operation of the beds.

The loss of capacity of contact beds during work is due to several causes:—

(1) Disintegration of material.
(2) Consolidation of the filtering material.
(3) Deposition of collodial matter.
(4) Growth of organisms.
(5) The volume of liquid passed on the bed.
(6) Insufficient rest.
(7) Inefficient drainage.
(8) The amount of suspended matter in the liquid passed on to the bed.

(6) Insufficient Rest—

"A gain in capacity in contact beds during rest of, say, two weeks has been commonly noticed ever since they were first brought into use. For some time the cause of this gain was assigned to the biological digestions of the suspended matter caught in the material of the filter. A part of the gain in capacity which takes place during rest is no doubt due directly to this cause; but we think that much is due directly to the digestion tending to make the organic matter in the bed of a more granular and less spongy character."

The gain in capacity which results from a short rest, say, a fortnight, serves for little more than to shrivel up the spongy and gelatinous matter in the interstices of the bed. In many cases it has been observed that such matter returns to its original spongy state soon after the bed had been restarted. If a bed could be rested for a very long time, the sewage matter would become permanently granular through oxidation; but it is not practicable on a large scale, and as it would possibly result in the bed losing its maturity, it is important not to allow a contact bed to become so seriously clogged as to necessitate a prolonged rest.

It may here be mentioned that at Chatswood and Mosman, where there are four contact beds, each bed has a week's rest in turn, so that three only are at work at any one time. No trouble has yet been experienced at either of these places through clogging due to want of rest.

(8) The Amount of Suspended Matter in the Liquid Passed on the Bed—

The access of suspended matter to a contact bed is, in most cases, the chief cause of loss of capacity, and no doubt the rate of loss can be greatly lessened by carefully eliminating the suspended solids from the sewage before filtration.

Washing of Filtering Material—

The total cost of removing, washing, screening, and replacing in beds and making up to original level with new material at Manchester is 1/6 per cube yard. This does not include the cost of the washing machinery.

The total cost by hand is 2/- per cube yard.

These prices might be doubled in estimating the same work in Australia.

"Maturing" of Contact Beds—

Contact beds mature in anything from six weeks to six months.

(d) Percolating Filters—

The depth of percolating or continuous filters is a difficult thing to determine. At most places the depth has usually been determined by levels. If plenty of fall has been available, deep filters have been constructed, while at places with little fall, the material has usually been laid out in the form of a shallow filter. In other words, percolating filters have usually been constructed as deep as levels would allow. In some cases the advantage of deep filters over shallow filters has even been considered sufficient to justify the adoption of pumping.

After making a considerable number of experiments, the Royal Commission on Sewage Disposal found as follows:—

Coarse Material.

"For practical purposes we think the conclusion is justified that, within somewhat wide limits of depth, and given ample aeration and good distribution, the same amount of work can be got out of a cube yard of coarse material whether it is arranged in the form of a deep or of a shallow percolating filter."

Medium Material.

"On general grounds, we should think it better to arrange a given volume of medium-sized material in the form of a shallow rather than of a deep percolating filter.

"In this way better aeration would be maintained throughout the filter and the suspended solids in the liquor treated would be spread over a greater quantity of the filtering material."

Very Fine Material.

"It is clear, therefore, that percolating filters of very fine material can only be worked for a certain limited time without being rested, and, in order to obtain the maximum amount of work out of a given quantity of fine material, it would seem better to arrange it in the form of a shallow rather than in the form of a deep filter, provided the distribution is efficient."

Fine Material.

"The results show that, with the amount of sewage liquor being treated, the extra depth in the deep filter was not required; or, in other words, that passage through the first half of the deep filter was sufficient to oxidise almost the whole of the oxidisable matter in the liquor put on the filter."

The average depth of percolating filters appears to be about 6ft. 6in.

On the question of actual depth of filters, the Royal Commission find as follows:—

(1) "That the deeper the filter the better the effluent. This holds both for the fine and coarse material, assuming good distribution and aeration."

As to area of percolating filter required, it may be assumed that properly constructed filters dealing with ordinary domestic sewage, 200 gallons per super. yard, or one million gallons per acre per 24 hours may be taken as a fair average rate of filtration for permanent work, and though this rate may be doubled for short periods during storms without permanent injury to the filters, this variation is usually accompanied by a corresponding temporary deterioration in the purity of the effluent.

The chief advantage claimed for coarse grain filtering media is that when the tank effluent contains a considerable quantity of suspended matter which can only be very slowly decomposed, it is better to let it pass right through the filter with the effluent, rather than allow it to accumulate in the interstices of fine media, where it will tend to reduce the space available for aeration, but with efficient preliminary treatment in tanks the suspended matter should be reduced to from 5 to 10 parts per 100,000, and if this matter is capable of decomposition by the action of aerobic bacteria, the surface layers of a well-aerated filtering medium would seem to be the best place for this to be effected. If it is found that the surface layer becomes clogged with material that cannot be decomposed, it is a far less expensive matter to remove two or three inches at the top, as in the case of a sand filter for water, than to renew or wash the whole contents of the filter, which is very likely to become necessary if the medium is not fine enough to intercept the suspended matter near the surface.

It seems, therefore, a reasonable conclusion to come to that a few inches of the surface of a percolating filter should be of fine material and the remainder coarse.

Distribution on Percolating Filters.

The method of distribution to be adopted very largely decides the shape of the filter. Fixed distributors generally result in rectangular filters. Rotary distributors generally require approximately circular shape.

Efficient distribution is the most difficult problem in connection with percolating filters. The main object to be aimed at is to deliver the liquid uniformly over the whole area in such a way that each particle of material receives an equal quantity of liquor.

A distributor should comply with the following requirements:—

It should distribute the liquid uniformly over the whole area.

Its working should not be effected by atmospheric conditions such as wind, frost, etc.

It should be capable of adjusting itself to large variations of flow, i.e., it should deliver well the small flow of the night and the increased flow during storms.

The distribution should not be liable to be affected by the stoppage of small holes by the suspended matter of the sewage or tank liquor.

It should be easy to clean.

The points at which the moving parts of the distributor are in contact with the stationary parts, or with the parts which have a different motion should, as far as possible, be separated from the liquid which is being distributed.

In selecting a distributor, it would be necessary to consider the head of water or other power required to work it, and, of course, the question of cost.

Forms of distributors may be classified as follows:—

(1) A sprinkler, which moves either automatically or by applied power, dropping or spraying the liquid as it rotates or travels backwards and forwards, over an area of filtering material.

(2) A stationary form of distributor in which the liquid to be distributed is carried over the filter by means of pipes, and forced under head of water through a large number of orifices, so that it is broken up into fine jets.

(3) A form of distribution, in which definite volumes of liquid are automatically delivered in flushes.

(4) Distribution by means of a very fine material laid on the surface of the filter, the liquid being by this means spread over the whole, or the greater part of the filtering area.

(5) Dripping trays; a stationary form of distributor, mvented by Mr. F. Wallis Stoddart, by which the sewage liquid is carried over a filtering area in perforated trays of corrugated iron, from which it falls upon the filtering material in a succession of drips.

(6) Tipping troughs; a stationary form of distributor, consisting of troughs balanced on pivots in such a way that, when filled with liquid, they tip and then return to their original position.

Risk of Nuisance.

All forms of distribution on percolating filters are liable to give rise to nuisance from smell if a strongly smelling liquor has to be dealt with. In the case of trays or tipping troughs the smell is confined more or less to the immediate vicinity of the filter, and it may be largely done away with at small works by providing an inexpensive form of cover for the filter. The nozzle form of distributor is naturally the most liable to give rise to smell, but moving sprinklers are almost equally bad in this respect.

Construction of Percolating Filters.

It is now usual to provide some kind of wall to enclose the filtering material, whether the filters are above or below ground.

It is absolutely necessary to provide an impervious floor under the filtering material, as it is essential that the effluent should be drained off as rapidly as possible. Concrete at once suggests itself as the best material for the floor, since it can easily be finished with a smooth surface to the gradients decided on and in concrete it is easy to form the necessary channels and drains to carry off the effluent after passing through the filter.

Under-drainage in bacteria beds not only affords outlet for effluent, but also provides a means of drawing off the heavy carbonic acid gas which is formed in the filter, and which, if allowed to accumulate in the interstices of the filtering material, will prevent thorough aeration, and thus greatly impede the activity of the bacteria, good ventilation being the first essential for their efficient working.

In order to serve both purposes the effluent drains should be far larger than the size actually required to carry off the effluent water.

Comparative Cost of Purification by Contact Beds and Percolating Filters.

For treating septic tank liquor there is little difference between the cost of single contact treatment and treatment by percolating filters, but for double contact as generally adopted in England the cost is double. In Australia, as far as I know, single contact only has been adopted in all cases of contact beds. With the comparatively weak sewages to be dealt with in Australia up to the present, the final effluent is very satisfactory.

General Summary as to Contact Beds and Percolating Filters.

(1) The amount of sewage which can be purified per cube yard of contact bed or percolating filter varies—within practical limits—nearly inversely as the strength of the liquor treated. This statement is based on the assumption that the size of the material of which the filter ist composed is, in each case, suitable to the character of the liquor treated, and that the material is arranged at the proper depth to secure maximum efficiency.

(2) Taking into account the gradual loss of capacity of contact beds, a cubic yard of material arranged in the form of a percolating filter will generally treat satisfactorily nearly twice as much tank liquor as a cubic yard of material in a contact bed.

(3) In the case of sewage containing substances which have an inhibitory effect upon the activity of micro-organisms, the working power per cubic yard of filter of either type may be more nearly equal. This point is not clearly established.

(4) Percolating filters are better adopted to variations of flow than contact beds.

(5) The effluents from percolating filters are usually much better aerated than the effluents from contact beds, and apart from suspended solids, are of a more uniform character. On emptying a contact bed, the first flush is usually very much more impure than the average effluent from the bed.

(6) The risk of nuisance from smell is greater with percolating filters than with contact beds.

(7) It is also found that with percolating filters there is nuisance from flies especially with filters constructed of coarse material. In the warmer months of the year such filters swarm with members of the Psychodidae which, though appearing to breed and develop in the filters, may usually be seen in large numbers on the walls of houses and buildings close to or on the works.

As showing the thorough and exhaustive treatment which sewage is subjected to in England in order to produce an

effluent fit to be discharged into small rivers inland, Birmingham may be cited.

Detritus pits.
Screens.
Roughing filters or sedimentation tanks.
Septic tanks.
Silt tanks (Dortmund tanks).
Percolating filters.
Sedimentation (separating Dortmund tanks).
Thence to River Tame.

The excess flow in time of rain is treated as follows:—

Detritus pits.
Sludge bays.
Percolating filters.
Thence to River Tame.

For the years 1907-8 and 9, the following are the average chemical analyses:—

BIRMINGHAM.

In Parts per 100,000.

	Suspended Solids.	Free Ammonia.	Albuminoid Ammonia.	Nitrites and Nitrates.	Oxygen absorbed in four hours
Crude Sewage ..	47·8	4·01	1·43	·27	27·7
Effluent	2·0	3·47	·33	2·11	2·52
CHATSWOOD, NORTH SYDNEY AND BALMORAL.					
Crude Sewage ..	26·97	3·20	1·63	·03	4·44
Effluent	1·61	1·68	·23	·50	·71

It will be seen from the above figures that the sewage from our Northern Suburbs is very much weaker than the Birmingham sewage, as shown by oxygen absorbed in four hours.

They also show that, whereas our effluent is not so highly nitrified, it is much purer by oxygen test.

SCHEMES OF BIOLOGICAL PURIFICATION

Now in operation in New South Wales. Under the control of the Board of Water Supply and Sewerage, there are three schemes:—

Chatswood.
Mosman (Balmoral).
North Sydney.

In the two former the means adopted are:—

Detritus pits.
Septic tanks.
Contact beds (of coke).

In the case of North Sydney the filters consist of 8 acres of sand about 5ft. in depth. Because the rate of filtration is now too slow to deal with the ever-increasing flow, it has been decided to instal a percolating filter about 1 acre in extent. The distribution will probably be by means of fixed pipes perforated.

The Public Works Department have already carried out schemes for Narrandera, Hay, Lismore, and Parramatta. In each case the means adopted for Chatswood have been used.

In the case of Narrandera, additions have been recently made. The recently constructed filters are shallow, percolating filters, the distribution being effected by double tipping troughs.

In the case of Parramatta the stone wall reticulation pipe lines are laid with mastic joints, this being the first drainage work in New South Wales where such joints have been used. The mixture is:—

2 Parts partly refined Trindad bitumen.
1 Part coal tar pitch.
1 Part blue-stone dust.

Katoomba Sewerage Scheme is now being carried out and is nearly complete. Septic tanks have been built above the Falls, and tank effluent is conveyed in cast-iron pipes to filters below the Falls beyond the tourist resorts.

Overfed sprinklers are used, the nozzle being in bottom and not top of supply pipe. Drop pipe is ½in. in diameter. The flow impinges on a drop plate suspended by hangers and held between lock nuts.

The distributors are supplied from a dosing chamber fed by the overflow from the septic tanks.

Schemes have been prepared for the following country towns:—

Lithgow.
Goulburn.
Albury.
Bathurst.
Orange.
Wagga.
Tamworth.
Wollongong.

In all these cases the means adopted are as mentioned for the other towns. In several cases the tank effluent has to be pumped in order to get it high enough to command the surface of the filters.

In these cases the filter effluent will generally be used for irrigating adjoining land.

Inspections have been made and schemes outlined for—

Grafton.
Tumut.
Dubbo.
Coonamble.

Several public institutions have also been provided with septic tanks and filters, viz.:—

Liverpool Asylum.
Rookwood Asylum.
Newington Asylum.
Jenolan Caves House, etc.
Penitentiary, Long Bay.

In the case of the asylums the tank effluent is pumped into tanks and used for irrigation purposes.

The biological system of purification is thus seen to be specially suitable for our inland towns, and the municipal authorities are eagerly seeking the assistance of the Government Engineers in this matter.

This concludes my address as retiring President, and I regret very much that I cannot be with you to-night to instal my successor.

I can and do wish him a prosperous year of office; and, further, I hope he will have the same constant and unselfish assistance from the Secretaries, Committeemen, etc., as I had during the past year. The valuable assistance I always received was of great service to me, and I take this opportunity of thanking the officers who, one and all, gave me their hearty co-operation.