pied by the pores, we have what is termed air capacity. When a soil has a water retaining capacity almost equal to the volume of the pores, then air capacity almost ceases to exist; and purification or oxidation practically ceases to exist.

Now it must be obvious, that, the greater the effective size and uniformity coefficient value of the filter particles the less becomes the water retaining capacity in proportion to the total volume, and the greater becomes the air retaining capacity in proportion to the water retention volume.

With a low effective size and uniformity coefficient it means, that, a dose of sewage is capable of being held up by capillary attraction in every pore of the filter, and, that, pracically all the air is driven out of the filter.

Now, the greater the supply of oxygen throughout a filter, the greater is its efficiency, therefore, the higher the effective size and uniformity, coefficient of the material, the greater becomes the volume of oxygen, which the filter is capable of retaining. There must, however, be practical limits to the increase in the size of the filter particles, as it has been shown that it is not only a question of oxidation (or nitrification); but, it is a question of the ability of the filter to retain and hold up, within itself, matter in suspension, as well as absorb from the sewage organic matter in solution. These matters are not oxidized even after they have been retained, or absorbed, in the space of a few minutes, or even of a day. The oxidizing process of nitrification is no sudden effect, but intricate and prolonged.

How can the difficulty be got over? We must have a filter, the air retention capacity of which is high with a consequent low water retention capacity; and yet, it must be possible to retain within the filter pores practically the whole of the organic matter both in suspension and solution, until such time as they are fully acted upon by the process of nitrification, so that the effluent will show not albuminoid ammonia but its oxidized equivalents of nitrites and nitrates.

It was very early shown that the purifying process in sewage by land was not due to any peculiarly inherent attributes of soil; nor, was the purifying process due to any plant life grown on the soil surface; as plant life has no use for the organic compounds contained in sewage until they are mineralized or oxidized. Filters composed of pebbles, stone, or, in fact, most hard material in cubes, were found to be as effective in purifying sewage as soil. The whole problem became, therefore, one of substituting some other filtering material, rather than soil; the latter providing too small an air retaining capacity in proportion to its water retaining capacity. With the water carriage system, the total amount of sewage proper as compared with the volume of water is small. By substituting a material which will retain within itself sufficient oxygen to treat the sewage and yet pass off the large volume of water at high rates is the problem of artificial treatment.

The earliest experiments in the above lines which were carried out in England were in connection with the London County Council. The Massachusetts observations and results were the basis of the experiments; which, were conducted with settled London sewage at Barking. The work was under the direction of Santo Crinip (engineer to the County Council) and Mr. Dibden (chemist). The first experiments in 1890 were conducted with four tanks giving a superficial area of 1-200 acre. The tanks were respectively filled with coke breeze, sand and gravel, stones and burnt clay of the size of peas. These tanks were filled with sewage, which was allowed to stand for eight hours, so as to give ample opportunity, as was thought, for nitrification to take place. The sewage was then drawn off, and air allowed to take its place in the filter. During the three months that these tanks were in operation, non-putrescible effluents were obtained. The results being considered, so far satisfactory; an experiment was commenced in 1892 with a larger filter, an acre in area and 3 feet 3 inches deep, of 3 feet coke breeze and 3 inches gravel on top. This filter, at first, was not a success. It was operated precisely as the smaller tanks had been, viz., an eight hours period, standing full of sewage, followed by a period for oxidation or rest. After six weeks the effluents showed a diminution of nitrates and nitrites. In fact, the filter became clogged, the sewage standing on the surface; clearly showing, that, an equilibrium between retention, absorption and oxidation had not been obtained. The filter was retaining more matter than it was capable of digesting.

Although, the above were based on the Massachusetts observations, the experiments were not analogous. Intermittency was more frequent at Massachusetts; where, in fact, the sewage was supplied in doses at periods of twenty to thirty minutes. The results, even with the preliminary experiments at Barking never equalled those made in the States. Dibben acknowledged, that, the experiments failed through lack of intermittent treatment, and, because, of a too high rate of filtration; consequently, in 1894, the filter, having recovered after a prolonged period of rest, it was again put in operation, being allowed to stand full for two hours instead of eight. Good results were now obtained. The filter, showing every promise of maintaining an equilibrium, Dibden advised the Sutton authorities, after some preliminary experiments with the sewer there, to adopt the system.

This system, first adopted in 1894 at Sutton, Surrey (England), came to be known as the Contact Bed System, because, of the period of contact allowed, during which the sewage was supposed to undergo purification. An illustration of these beds is given in our issue of August 6th. The beds were alternately filled with and emptied of sewage. The filtering material was composed of coke breeze on the same principle as the London experimental filter. The sewage was successfully treated at a rate of 750,000 gallons per acre per day, with the result, that an oxygen absorbed efficiency of 86.5 per cent. reduction was obtained; the effluents being rendered non-putrescible.

Sutton abandoned, altogether, chemical treatment, and land filtration; and many other towns commenced to follow its example. It was calculated at Sutton, that, 77 tons of sludge were retained in seventy-six days by the biological contact beds, and it was believed, that, this sludge was changed to gas and water and harmless mineral salts.

Contact beds were accepted, for the time, as the final solution to the sewage disposal question. It was argued, on every hand, that, these beds provided perfect homes or workshops in which the nitrifying organisms could carrry out and maintain their work of decomposing and changing the chemical organic combinations in sewage liable to putrescibility. Instead of an acre of ideal land (perhaps impossible to obtain) treating sewage at the rate of 30,000 gallons per day, here was an acre of filter, which could be constructed anywhere, independently of the porosity of the land, capable of treating 750,000 gallons per day, or at twenty-five times the rate on land.

At first, it was the custom to measure contact beds, with reference to rate of treatment, by their superficial area; now, however, all artificial biological methods of filtration are generally measured by their cubic capacity. With land, it was a question of acreage, with tanks enclosing the filtering material at certain depths, lengths and breadths, it is a question of capacity. Accordingly, the Fifth Report of the Royal Commission on Sewage Disposal have departed from the old custom and now use the cubic yard as the unit of measurement of capacity with reference to rate treatment. This applies to both contact beds and percolating filters.

At the time of (and for a considerable time after) the introduction of contact beds at Sutton, it was taken for granted that the period of contact was utilized by bacteria for breaking up the organic compounds in the sewage. The period of rest was looked upon as one of recuperation and for supplying the necessary oxygen required for nitrification. This explanation of the working of a contact bed is, however, not in accordance with recent investigation and knowledge.

It will be apparent to anyone giving a moment's consideration to the matter, in the light of newer knowledge, that, while the contact bed is standing full of sewage, conditions are provided exactly similar to those in the septic