The latter are artificial conditions and as they are not in any way comparable with the experiments previously mentioned they will not be considered. The results are given in the following table and have been calculated in several different ways. It should also be mentioned that several samples were taken daily so that the criticism offered with regard to the Washington experiments does not apply in this case.

TABLE IV.

September to December of the year 1909.

Rate. Millions of gallons per acre per day.

	5.	10.	15.	20.
Bacterial efficiency as recorded in report	95.3	91.2	89.9	96.2
Calculated from recorded average bacterial content of raw and filtered waters...	94.9	95.4	98.4	95.1
Calculated from average of all individual bacterial counts of raw and filtered waters.	93.9	95.5	96.7	97.0

These results appear to show that the purification is practically independent of the rate of filtration. This table also shows the serious errors that can be made by the use of different methods of calculating results. The first line is presumably obtained by taking the average of the average efficiency of each run, the second by calculation from the recorded average bacterial counts which are again presumably the averages of averages and the third by calculation from the averages of all the individual counts. The author believes the third method to be the only accurate one.

The average length of run and volume of discharge, as recorded, are as follows:

Rate. Millions of imperial gallons per day.	Average length of run in hours.	Average volume of discharge in million gallons per acre.
5	167.0	34.7
10	101.9	42.4
15	72.2	45.8
20	49.3	38.0

These figures appear small compared with those obtained at the filtration plant on Toronto Island in 1912 with water from the same source.

Considerable attention is devoted in this report to abnormal and irregular bacterial counts in the filtered water, but a study of the detailed results shows that these were all obtained during the period when chlorinated tap water was being used as the influent and that the abnormalities were pronounced when the rates of filtration were reduced. The author has previously pointed out (Jour. Soc. Chem. Ind., July 15th, 1912) that the effect of chlorine upon filter sand is to disturb the organic equilibrium and to produce a pabulum which is available as food supply for water bacteria. This may account for the abnormalities reported.

The author's experience at the Toronto filtration plant and elsewhere has been that, after sand filters have matured and consolidated, the variations in the filtered water count are small and follow the variations in the raw water after an interval dependent upon the volume of water in the filter. The Albany results given in the report are in accordance with this experience. Several hours' reservoir capacity are essential to a filtration plant for various excellent reasons, such as maintaining a constant rate of filtration, and for fire purposes, but it is not necessary on account of irregularities as they do not exist in well-managed plants. In the gravel layer at the bottom of a bed where there is a region of very small velocities, it is possible that some bacterial development takes place and that this may be disturbed by variations in the rate of filtration. This is minimized or entirely eliminated by avoiding sudden changes in the rate. Pennick, by means of self-registering filter gauges, showed that at the Leiduin waterworks (Amsterdam) the velocity of flow alternately increased and decreased. With a low filtration rate the intensity of the oscillation is low with as many as eight maxima per minute, but as the rate increases the iintensity also increases, the difference between maximum and minimum reaching as high as 10% at 20 million gallons per acre per day.

Whilst the author was in charge of the laboratory of the Toronto filtration plant a series of experiments was made on the effect of rate of filtration on purification. These differ from most of those previously referred to inasmuch as they were carried out with filter units such as are used for purification purposes. The 12 beds of 4/5 acre each were divided into three groups, these three being operated at nominal rates of 2.5, 4.5 and 6.0 million gallons per day. By this method of working, the author considered that if the results on a large scale were in accordance with the Washington experiments the plant as a whole would benefit as regards purity of output, whilst no harm would be done if the bacteria passing were directly proportional to the rate. In other words, there was everything to gain and nothing to lose by making this experiment. It was commenced in March, 1912, and continued until the end of May. The only objection that may be taken to these experiments is that the filters had not matured, only having previously been in operation for about two months, but the results show that during the period of operation the maturing did not affect the relative results.

These are shown diagrammatically in Fig. 1, and Fig. 2 shows the average results compared with the Lawrence and Washington figures.

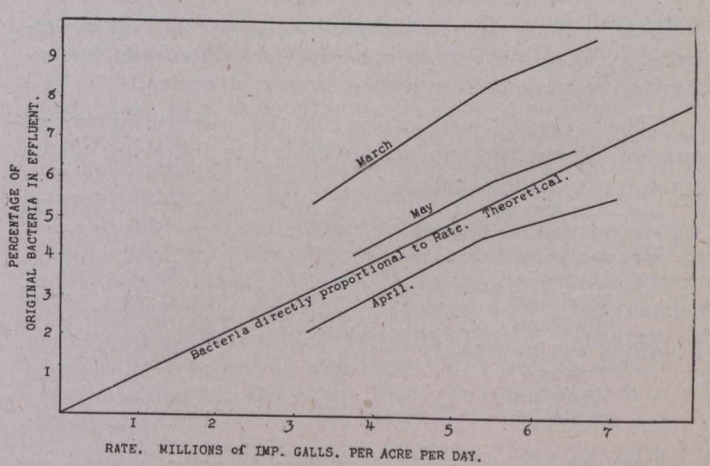

Fig. 1.

These experiments show that the number of bacteria in the effluent of a filter, other things being equal, is directly proportional to the rate of filtration. The sand in all the filters used in these experiments was identical and the depth of sand, although varying a little in each bed, averaged the same for each group.

In the following table the results of the turbidity determinations are given for each group of filters. As it is impossible to determine turbidities of less than one part per million, those effluents showing less than that quantity were assumed to have an average value of 0.5. This method of calculation is not accurate and detracts from the value of the quantitative expression of the results