Correspondence.

Mr. Don. Mr. JOHN DON observed that the Authors' experiences should be of great interest to water-engineers, and their success in rendering potable, at moderate cost, water so highly charged with the finest silt as was the river Nile in flood time, was an asset to others who might have similar difficulties to surmount. The problem was mainly a colloidal one, seeing that the suspensoids in Nile water were to a large extent microscopic and ultra-microscopic. Such water passed through a sand filter without leaving an appreciable quantity of its colloids on the sand, for the granules could not arrest them by adhesion, and their minute dimensions enabled them to pass easily through the interstices of a filter. The failure of colloidal particles to adhere to stones, gravel, and sand was thus explained. Each particle carried its own electric charge, which assured its permanence as an individual, resisting coalescence with neighbouring particles and adhesion to the material of the filter, which had naturally the same kind of electric charge as the raw water. That was the chief reason why the Authors found that without coagulant the final effluent from the strainers was very turbid. Further consideration on the same lines would show why the first attempts failed, and why the final arrangements brought about success. The key to the problem lay in the reaction of the raw water with the coagulant. Seeing that most waters behaved quite differently with alumina in respect of the period required for coagulation, the correct procedure would always be to determine the time-factor by experiments in the laboratory or on a small scale out of doors. The action of alumina (with lime added, if necessary) was first to neutralize the individual electric charges and so to permit the colloidal particles to aggregate into larger masses or flocks of sediment, which not only failed to traverse the interstices of the sand, but were also enabled to attach themselves to sand, gravel, or stones. However, an interval of time must elapse before the particles were sufficiently coherent, after being adequately neutralized, to become amenable to filtration, whether by the Puech-Chabal system or by the Jewell or other type of mechanical filters. The process of coagulation and sedimentation in water charged with fine clay might be followed in the laboratory by the use of tall cylinders, noting the time that elapsed after mixing with the coagulant before sedimentation was under way. This occurred when the top layer of water in the cylinder became clear to a depth

of, say, 2 inches. In his own laboratory the time required ranged from 3 or 4 minutes to ten times that interval. Nevertheless, the burden of proof that the interval so deduced was sufficient for practical purposes rested on an actual test to be made with a filter. Such a test might conveniently be made in a glass tube 1½ inch wide and about 6 feet in length, contracted below and closed with a pinch-cock or other regulator. If the coagulation was satisfactory, the filter filmed readily, and the effluent after a little was perfectly clear. The improvement obtained by the Authors upon annexing the first scrubber to act as a settling-tank indicated that at first the coagulation was not far enough advanced when the water entered the scrubbers. A further advantage was secured by working the two remaining scrubbers in parallel, thus permitting the rate of flow to be reduced. The substitution of finer material in scrubbers and strainers largely increased the total surface exposed to the impurities to be removed. How the alterations made on the strainers operated was not quite evident, as their number was stated to have been three, then four, and afterwards two, and finally one, of four compartments working in parallel, and so giving good results, as perhaps was to be expected. The final adjustments produced limpid water from a most unpromising source, more difficult to deal with than almost any supplies in Europe. It was true that the waters of the Nethe, from which Antwerp derived supplies, and of the Seine at Suresnes, were more polluted with bacteria, but the total sediment was much less than in Nile water, and the colloids were less refractory. It might be of interest to state an opinion as to why the alumina was preferably added in two doses, that was to say, if the total dose was 90 parts per million, it was advantageous to add two-thirds of that to the raw water and the remaining third to the effluent of the settling-tank. Now it was well known that precipitates had the property of absorbing electrolytes as aluminium sulphate,[1] so that it was more than likely that part of the coagulant was lost in the copious precipitate first formed. The second application dealt the final blow, completing the coagulation of the more refractory colloids which were disposed to "hang fire." The Authors' experiments with sand-washing were very interesting, especially the means adopted to discover the stream-lines in the filter-bed, thus furnishing an example that might with advantage be followed at other waterworks. The classic researches of Dr. J. M. K. Pennink on stream-lines in filters,[2]

Mr. Don.

[1] S. Ghosh and N. R. Dhar, "Absorption durch frisch-gefälltes Bariumsulfat während und nach Entstehung," *Kolloid Zeitschrift*, vol. xxxv., p. 144.
[2] "Grondwater Stroombahnen," Amsterdam, 1915.

Mr. Don. were the chief source of information available regarding the action within the filter-bed, and the additional light thrown on the subject was now welcome. It was further to the credit of the Authors that they had devised an effluent-regulator easily and cheaply constructed and reliable in its action. The regulators commonly employed, such as the Weston, Didelon, and Burton, were probably not readily adaptable to small installations at a moderate cost.

Mr. Temple. Mr. F. C. TEMPLE remarked that the water to be clarified appeared to resemble in many respects the upland water of the central Indian plateau. In particular, it appeared to carry a fine sediment which did not settle without the use of a coagulant. He believed that the sediment was of a colloidal character, and he had dealt with it in many water-filtration plants, but he had never used anything quite similar to the apparatus described. He had also found that the addition of the coagulant could best be made in two separate doses when there was a large quantity of silt in the water, but must only be made in one dose, and that at the very entrance to the filters, when the water was nearly clear. It was essential not to make the first dose too small. There was always a minimum dose necessary to produce the required action; if less than that minimum were given in the first dose, the addition of the second dose, unless it were of itself more than the minimum dose, would not produce any effect, and the whole of the coagulant used in the two doses might just as well have been thrown away. The difficulties described in washing the filtering medium were precisely the same as the difficulties which Mr. Temple had experienced in washing mechanical filters, if once they were allowed to fall into bad condition. As long as a filter was kept evenly washed, further washing was easy. As soon as a filter was left with patches unwashed, a vicious circle was set up, the well-washed parts of the bed being more and more washed and the unwashed parts being less and less washed, the result of which was to reduce the effective filtering-area of the bed.

Dr. Thresh. Dr. J. C. THRESH observed that during the last 2 years he had been experimenting with water from small rivers, which so often yielded a turbid water, and which required both clarification and decolorization as well as purifying both chemically and bacterially. The results would probably be interesting to engineers, as one of the chief troubles was "clarification." For a long time it was necessary to wash the filters every 5 or 6 hours. Now the water was so clean before it reached the filters that the same filters, working at 500 gallons per hour per square yard, would run for 2 or 3 or more days without washing. As the result had lead to a good deal of corre-

spondence, and visitors from all over the world had been to see "how it was done," it would not be wise to say more at present. In Egypt he would not recommend any chlorination process, such as the Authors seemed to recommend, since the chlorine did not remove any organic matter. The Authors gave no information about the quality of the water before or after filtration, so that the effect of their processes could not be judged. He had only examined one sample of Nile water, and the conditions there might be so very different that the Nile water would not yield to the same treatment as that of smaller rivers. Dr. Thresh.

Mr. R. C. S. WALTERS remarked that he had just come across an interesting instance of the well-known effect of storage of water upon *B. coli*. Generalizing, the water was found to contain *B. coli* in 2 cubic centimetres, even after passing through two open reservoirs, in parallel, of 30 million gallons each. When the water was stored, without being drawn off, in one reservoir, *B. coli* were present in about 50 cubic centimetres after 1 week, in 100 cubic centimetres after 2 weeks, and were not present after 3 weeks. The observations were made during the summer of 1924, in the absence of sun. The method of drawing-off silt from a tank seemed to influence the quality of the effluent. A sewage filter-effluent, which might resemble the water of the Nile, was passed through humus-tanks of the Dortmund type; and it was found that, when a large amount of humus was allowed to remain in the tank, filling it to about a third, the quality of the effluent was increased by about 25 per cent., as indicated in a colorimeter. It seemed likely that the humus which had settled in the tank had acted as a colloid upon the incoming water. He would be interested to have the Authors' views on the relative merits of sulphate of alumina and permanganate of potash as coagulants. Mr. Walters.

The AUTHORS, in reply, remarked that Mr. Don gave a very interesting analysis of the working of the coagulant. With regard to the laboratory tests he described, the Authors had never tried the test with the 6-foot tube 1½ inch in diameter. They gathered that the tube was used as a section of a sand filter, and in that case small stones would be placed at the bottom and filter sand on the top of the stones to the full depth proposed to be used in the actual filter under consideration. The general difficulty with results obtained from laboratory tests was that, when the same test was carried out on a large plant, in order to confirm the experimental test made in the laboratory, entirely different results were often obtained. In this case if, as Mr. Don considered, the simple test he described would give a fair indication of what the test might be expected to do in The Authors.

The Authors. practice, it would be invaluable in the case of a water-supply of such a nature that coagulation was necessary, since the use of the correct quantity of coagulant was important. If enough coagulant were not added, the filtrate would be poor, even though it might appear clear; and, if too much were added, the filter head would increase with unnecessary rapidity, entailing more frequent washing. In the case of most water-supplies the amount of sediment in the water to be filtered varied throughout the year, and the proportion of coagulant to be added should be varied in accordance therewith.

With regard to the strainers, the compartments were first worked in series and finally in parallel. When all the compartments were thus worked in parallel, they together formed one filter, and the partition walls dividing the strainer into compartments might equally well have been removed, as regarded any effect they had on the filtering process. They were retained to render the wash effective. They would not be required with a water with much less silt in suspension, as the whole area of the strainers washed fairly evenly without them.

The washing of the scrubbers and strainers was most effective even after they had become badly choked by running them for long periods without washing. The Authors' experiments on the sand filter were all carried out with a view to obtain a cheap and efficient method of washing it. The false floor finally evolved and described had proved very satisfactory. Mr. Temple's experience had been universal, and had led to the use of mechanical rakes or compressed air. The Authors' object had been to find a design of false floor which would give such free and good distribution of the wash-water that a foul filter would be satisfactorily washed without the use of compressed air or rakes.

The Authors' experience with permanganate of potash had not furnished any new data.