

DISCUSSION.

Dr. G. Senter asked whether there was much difficulty in removing the last traces of ozone from the water. He remembered Nernst had once expressed the view that when ozone had stood for some time in contact with water it was difficult, if not impossible, to remove it completely by passing a current of air through the solution. In the portable ozone machines described by the author there did not appear to be any arrangement for the removal of the ozone.

Dr. T. M. Lowry said he had been more impressed with the possibilities of the portable apparatus than with the large sterilisation plants. He thought that a cheaper and simpler way of dealing with town drinking water was to soften it and bring down the bacteria incidentally in the precipitated chalk. This had the advantage of improving the water for steam-raising purposes, and though the process was only in use in chalky districts where the water was so hard as to be a source of annoyance and danger, in domestic hot-water installations he believed it might be extended with very great advantage to waters of slight or moderate hardness.

Dr. V. H. Velej stated that when engaged in attempting to prepare the purest nitric acid possible he had found that the best method for removing the last traces of nitric oxide was to allow the distilled acid to drop through an atmosphere charged with ozone generated in the usual manner. As to the results of the bacteriological examination of water purified by ozone, it was perhaps fortunate for the human race that pathogenic bacteria were, as a rule, the most readily destroyed. Investigations had shown that there were both bacteria and *hypomyces* (moulds), which were more persistent in their survival, but these were harmless. The speaker thought it was most useful to have on record a careful account of the sterilisation of water by ozone on a manufacturing scale, more especially as in certain processes now before the public they were induced to believe that merely passing an electric current of 30-40 amperes through water brought about ozone sterilisation.

The Chairman: Dr. Perkin has given a very interesting account of the ozonising process, in particular in relation to the purification of polluted water for drinking purposes. I should like to bring before your notice the result of an experiment which I witnessed during a visit last year to Philadelphia. I saw a complete ozone plant for the purification of water, the process being worked by the United Water Improvement Co., at Philadelphia. The plant was erected to treat the foul water obtained from the river Schuylkill, in West Philadelphia, which is described as being nothing but diluted sewage and is estimated to contain as much as 2,500,000 bacteria per square centimetre according to the testings made by the official bacteriologists of the cities of Philadelphia and New York. After a rough straining to remove the coarser particles of suspended matter the water was treated by the ozonising process, and after treatment the bacteria were reduced to an average of about 25, mainly of hay bacillus, which is supposed to have no effect on human organism. The *Bacillus coli*, indicating the organic pollution of water, was claimed to have been completely killed by the ozonising process. The offensive odour was also destroyed and the discoloration of the water was to a great extent removed. The important part of the process of water purification is that it is entirely mechanical and automatic. A pressure of 10,000 volts and 100 cycles was used, and by the operation of re-actant coils and condensers voltaic arcs and sparks are prevented, the current passing as a pencil of blue light from each of some millions of metallic discharge points across a short air-gap to nickel receivers. Atmospheric air is

92 THE INDUSTRIAL USES OF OZONE, PARTICULARLY

drawn across this gap by means of an air-pump, and in so doing is partially converted into ozone. The ozonised air is then forced into a stand-pipe, in which it meets a current of water flowing in the opposite direction. It is claimed that the cost of erection of ozonising plant is not greater than that of the usual method of sand filtration; and it has the undoubted advantage that it only takes a few months to build a large ozonising plant, whereas sand filtration often takes many years to complete. The space occupied is also very small. The plant which I saw in Philadelphia, estimated to be capable of treating for about 30,000 inhabitants, took only 30 by 50 feet of ground against many acres of land which would have been required for sand filters.

The ozonising process has received attention from a very large number of manufacturers, and several processes apart from that so fully described by the author and illustrated with lantern slides are now in use, amongst which may be mentioned also the processes adopted by Messrs. Lahmeyer Co., the Ozonair Syndicate, &c. The size of plant now in use varies, some being capable of treating as much as 5,000,000 gallons per day, like the one erected at Nice. According to the claim made by the inventors the cost of energy for sterilising purposes is very small indeed. It would be interesting to know whether any experiments were carried out in London, and if so, with what results. An important point in favour of the use of ozone for sterilising purposes was the fact mentioned that small complete plants are now available which can easily be transported from place to place, being very useful during military manoeuvres or in time of war, &c. The ozone plants can also easily be increased in capacity with the requirements by simply increasing the number of batteries of ozonisers as shown by the author.

It is interesting to notice that this ozonising method is being employed in very small towns, and its future development ought to be carefully watched by all those who take an interest in the purification of water and wish to have it as wholesome as possible for drinking purposes. A simple and compact sterilisation equipment was recently shown by the Lahmeyer Co., at the Municipal Building and Public Health Exhibition held at the Agricultural Hall from May 1st to 12th, and I understand that at the Franco-British Exhibition the Ozonair Syndicate are showing a complete plant in actual operation, indicating the many uses to which ozone could be put. The many recommendations which have been and are constantly being made to boil water before drinking are not as a rule carried out; and although household filters have also been largely recommended, yet these require a great deal of attention and frequent cleansing if they are to answer their purpose satisfactorily. The ozone treatment, it is claimed, kills the dangerous bacteria, and therefore makes the water quite wholesome for drinking purposes. The work of the electrochemist, in improving these processes, is a very useful one, and a great deal may be expected from the extensive use of suitable ozonising apparatus. Time alone will prove their practical value.

Dr. H. Borns would have been glad if Dr. Perkin could have given some information on the French high-tension ozone plants. We had not of late heard anything about the plants of Abraham and Marrier: were they still in existence? It was interesting to learn that the flour process was worked on a large scale by Leetham and Cramp; Alsop, Andrews, and many others had, of course, tried to treat flour with ozone. The figures as to bacteriological tests which Dr. Perkin had quoted went back to 1901 and 1902. A lively controversy had subsequently arisen as to the efficacy of the ozone treatment of potable water, but, so far as the speaker remembered, the result had been favourable to ozone. Paderborn was a town of about 25,000 inhabitants, in

which Charlemagne had held a Diet in 777. Wiesbaden had itself more than 100,000 inhabitants, he believed, and sheltered at least as many visitors every year. The thermal springs of both these places had been known to the Romans, but the actual Wiesbaden was very modern, also in its claims as to water supply.

Mr. W. Pollard Digby (*communicated*) thought that Dr. Perkin's paper, setting aside the preamble about filtration and its pleas for sterilisation, resolves itself into telling a little more than can be gleaned in *Science Abstracts* upon this subject save for the affirmation "that purification by means of ozone may be said to be electrical, chemical, and mechanical." But the sentence is hardly worthy of a scientist of Dr. Perkin's high standing unless he was jesting. To affirm that purification by ozone is electrical or mechanical has nothing to do with the actual problem of purification. One might as well affirm that in some cases the purification was gaseous and leathery because in certain cases belt-driven centrifugal pumps driven by gas-engines are used in pumping the sewage.

Upon the subject of the purification of impure waters, purification being understood as meaning sterilisation, he had perhaps as close an experience with the problems of water sterilisation as any member of this Society, having worked at this problem under the late Professor Kanthack and under Dr. Rideal in 1897-98; the medium then being used was an electrolytic hypochlorite of soda. These and other experiments were reviewed in a Paper by Mr. H. C. H. Shenton and himself read before the Society of Engineers in 1906.

It would perhaps not be improper in discussing a paper on Ozone to put forward a few figures relating to a product also electrochemical, viz., sodium hypochlorite, which was equally efficacious and far cheaper than ozone.

Dr. Perkin tells us that 13·5 to 27 grammes of ozone are produced per h.p. hour. Taking the higher figure, we thus have a yield of, say, 36 grammes per kw. hour. Now "the water at Paderborn and Wiesbaden requires an average consumption of 1·3 grammes of ozone per cubic metre" (say 230 gallons), so that for a consumption of 1 kw. hour 28 cubic metres of water (of whose composition bacteriologically and chemically nothing is known) can be sterilised. One would probably be wrong in assuming that it was a very bad water, high in organic impurity, akin to the effluent from a sewage settling tank.

Now, it has been established beyond question that 1 gm. of available chlorine in the form of the hypochlorite will sterilise 1·21 cubic metres of settling tank-sewage effluent or 1·5 cubic metres of filtered sewage effluent. In any good electrolyser 1 kw. hour will produce from 150 to 200 grms. of available chlorine. To avoid any imputation of special pleading he would take the lower figure. This, then, gives a sterilisation of 181·5 cubic metres of unfiltered effluent from a settling tank as against a maximum of 28 cubic metres of drinking water of unknown but presumably not greater organic impurity from consumption of 1 kw. hour of electrical energy.

What, then, is to be said of ozone against sodium hypochlorite? Obviously the cost of salt in the latter case. Ignoring the respective capital outlays required, and taking the running costs only, calculating the cost of electrical energy in each case at 1d. per kw. hour and of sodium chloride for the hypochlorite solution at 1d. per 10 lbs. The cost of sterilising Paderborn and Wiesbaden water then becomes 3·57d. per 100 cubic metres.

In 1896-98 his notebooks showed that sodium hypochlorite was being produced at an inclusive charge upon the basis stated of 15d. per kilogramme of

available chlorine. The cost of sterilising unfiltered sewage-tank effluent was thus 1'24d. per cubic metre.

Dr. F. M. Perkin, in reply to Dr. Senter, said there was no great difficulty in removing the last traces of ozone from the water by simple aeration, and it was possible that the last portion might be removed by coming in contact with organic matter of bacterial nature. Dr. Senter remarked that Nernst considered that when ozone had stood for *some time* in contact with water it was difficult to remove it. In the case in question the ozone was not in contact with the water any length of time, only sufficiently long to destroy bacterial matter.

Dr. Lowry referred to the softening method by precipitating the chalk, which incidentally removes a large amount of the bacteria, but it was doubtful whether bacterial removing action was as efficient as when ozone was employed. He was very much interested in Dr. Veley's remarks, in which he stated that he was able to remove the last traces of nitric oxides by allowing the acid to drop through an atmosphere charged with ozone. He quite agreed with him that the passage of an electric current through water had very little sterilising effect.

Mr. Gaster's experience in America was of interest, and he understood that the Americans are now considering the matter of ozone sterilisation to a very considerable extent, and he was quite in agreement with him that it was very difficult to get householders to filter or boil their water in case of epidemics, and therefore the ozone treatment was much more preferable, especially if the apparatus was fitted to the water supply so as to work automatically.

In reply to Dr. Borns, he was not aware whether the Abraham and Marrier plant was still in existence. The historical facts in reference to Paderborn were very interesting.

In reply to Mr. W. Pollard Digby, he would point out that the ozone processes to which reference had been made were used for the sterilisation of potable water, and he had in no case referred to the sterilisation of sewage effluents. Mr. Digby appears to be wedded to the use of sodium hypochlorite rather than to the use of any other form of sterilisation. Now, sterilisation by means of hypochlorites was an electrochemical process, and sterilisation by means of ozone was also an electrochemical process. For one class of work hypochlorites might be the better and for another class of work ozone; and certainly as far as the sterilisation of potable water was concerned he thought that ozone was very much superior to the use of hypochlorites. When ozone was employed the resulting product was simply oxygen, the extra atom of the oxygen in the ozone being used for oxidising and sterilising purposes. By using hypochlorites sodium chloride was introduced into the water. The quantity, indeed, was small, but at the same time he held that water for potable purposes should have no substance added to it other than oxygen, which is practically the same as giving it a slight excess of aeration. He had often spoken in favour of the employment of hypochlorite for purposes of disinfection, particularly in the case of the very successful Poplar plant, and for treatment of sewage it undoubtedly had shown very good results.

Ozone has not so far been employed to any great extent for the sterilisation of sewage effluent, but provided this were filtered there seems no obvious reason why it should not be used. It would simply be a question of whether hypochlorite or ozone were the cheaper material to use. He was quite willing to admit that Mr. Digby had a large and varied experience in connection with the sterilisation of waters, but his remarks showed that he had had very little experience in sterilisation by means of ozone.