Mechanical and Engineering Section.

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Direct and Indirect Methods of Electrical Purification of Water.

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It is about a century since the results of electrolysis began to attract attention, but the commercial exploitation of the processes was impossible until the economic production of the processes practical. So far as the purification of water is concerned, but little result was expected from electrolytic methods until the discovery of the microbic life in water and its relation to disease. The latter discovery was promptly made the basis of a rapid and brilliant, but in some respects untrustworthy development. Water analysts, and sanitarians generally, were often misled by the statements emanating from bacteriologic laboratories. Even to-day, we must receive with caution publications from such sources, especially tabulated results of experiments.

It is not necessary to review the history of the application of electrical currents to water purification, nor to describe even briefly the numerous patents that have been granted for such purposes. I propose to refer here only to some that have come under my own observation, in consequence of having been asked to make expert investigations. Some attempts have been made to remove the mineral impurities from water by taking advantage of the electrolytic powers, but most processes have been intended to kill the microbes. The ordinary inventor has proceeded upon his (generally superficial) knowledge that the disease-carrying power of water is dependent upon bacteria, and that electricity in sufficient strength is fatal to living matter.

In some of the processes the method has been the crude one of simply passing electric discharges through the water, hoping to kill the bacteria by direct shock. Thus, in one patent which was submitted to my consideration a few years ago, the inventor pro-

Fig. 1. Scheme of arrangement of tower for mixing ozonized air with the water.

poses to have electrodes passed into the water-main through insulated sockets and discharge a succession of sparks across the stream. The impracticability of the method, on anything but the most minute scale, seems not to have appeared to him, but what I consider much worse, the absurdity was unregarded by the patent office. It has seemed to me that ~~there are limits beyond which the authorities of the patent office should not allow the sanction of their protection.~~ I am well aware of ~~the fact that many~~ processes ridiculed by experts, have been ~~successfully~~ applied, but a limit of permissibility can be set without working injustice. Too many patents are granted that are inoperative and are, or should be, known to be so by the examiners who have experience in such matters.

I have seen in operation several methods of water purification by means of electrolysis. In these aluminum electrodes have been used, and more or less loss of the metal has occurred, it being converted into aluminum hydroxide. This produces its usual effect, that of combining with the organic matter and entangling the suspended substances so that the water, after treatment, can be subjected to a rapid filtration and will show material improvement in microbic content, especially if the amount of suspended matter and microbic content were previously high. On waters containing but little suspended impurity, living or dead, the purifying action is relatively low. The constant loss of the electrode is, of course, a most serious item of expense, generally overlooked in the experimental plants.

Two of the plants in which aluminum electrodes were used may be described with advantage in some detail, as some incidental features are of interest. In one, large aluminum plates two feet long and several inches wide were immersed in the water in a tall jar and the current passed through. The experimenters selected (probably with a view of more profoundly impressing inexperienced observers) very muddy water from the street gutter in front of the building in which the plant was located. The current seemed to cause the mud to collect and settle rapidly and the water became soon fairly clear, but analysis showed ammonium compounds and nitrates in abundance, and it was evident that the purification was nominal. The parties had but little money and were trying to interest a Philadelphia business man, but I could not make any but an unfavorable report.

Fig. 2. View of exhibition mixing tower at Philadelphia plant.

In another case I was asked to examine a plant that was in operation near Eighth and Chestnut Streets, Philadelphia. One of the parties operating the plant claimed that the scale-forming ingredients could be removed from Schuylkill water as well as the other impurities. As this was a very broad and seemingly unwarranted claim, I was much interested in the basis for it. The promotor furnished me with a sample of water, said to be Schuylkill (city) water so treated and purified, but on taking the total solids I found the dissolved fixed matter to be just about that of the amount in the city water. It was evident that no material diminution of the dissolved solids had occurred. At the urgent request of the promoters, I visited the plant and found a very elaborate installation, mostly of closed vessels, some of which were taking the street current through ammeters and voltmeters, and from others of which a clear water could be drawn in considerable amount. The operators showed me specimens of water containing a large amount of sediment, mostly in flakes, which they claimed to be the "scale-forming ingredients." I was at first much puzzled by this sediment, as I had not been informed as to the construction of the electrifying apparatus, but when I learned that aluminum electrodes were used I recognized at once that the precipitate was aluminum hydroxide. The process was, of course, entirely unsuited to the purposes for which it was devised.

In the operation of the Anderson process of purifying water by agitation with metallic iron, attempts have been made to get more powerful action, that is, more rapid solution of the iron, by making it the positive pole of an electric system, but no practical advantage seems to have been attained. Recently, a process has been patented in which an electric current is passed from an inner to an outer pipe, the water flowing through the annulus, but I have no practical knowledge of this method.

It seems to me that the most practical benefit of the application of electricity to water purification will come from the indirect methods in which the electrical energy used to produce an active disinfecting agent, and this is then applied to the water. Of all the processes of this type, those which produce ozone seem to be most useful. The material from which ozone is obtained—air—is in unlimited supply and the addition to water cannot be re-

Fig. 3. Diagram of Vosmer system. T, step-up transformer; C, high-tension condenser; L, high-tension choking coil; O, ozonizing apparatus.

garded as being dangerous, since if present in excess it soon reverts to the condition of ordinary oxygen.

The principal problem in this method is the economic production of ozone. This modification of oxygen can be obtained by several methods of different types, but those in which electricity is employed seem to be alone applicable to the processes in question here. For the purpose, high-tension currents are most economical, and the best yield is obtained by the so-called "silent discharge." It is now known that a spark or arc discharge will produce nitrogen oxides which are corrosive. It has also been determined that the air intended for production of ozone should be dry, otherwise hydrogen dioxide will be formed. The principal mechanical difficulty encountered in producing ozone on the large scale by means of the electric discharge is to secure a suitable dielectric. Glass, porcelain, rubber and other materials have been tried but are so liable to fracture or perforation that serious interruptions of operation frequently occur. Continuity of action is very important in commercial processes, such as the purification of water, and when a large unit of the plant is out of use in order to install a new dielectric, the condition is annoying.

The inventions of Vosmaer seem to overcome the difficulty, for he avoids the use of a special dielectric, employing only the dry air which is to be ozonized. The discharge takes place from thin metal strips on which are saw-like teeth. These strips are held by insulating (porcelain) sockets, firmly in the center of metal pipes. Many of these pipes are combined in parallel, the strips being all connected with one pole and the pipes with the other. An alternating current of high potential is allowed to flow through the arrangement, almost all the current passing by silent discharge, although at times a spark passes, but as there is no permanent dielectric, no damage is done. The sparking is too seldom to produce damage or any appreciable amount of objectionable gases. The drying of the air may be done by any of the known methods; preference is given by Vosmaer to refrigeration, by means of an ordinary ice machine.

A plant capable of purifying many thousand gallons in twenty-four hours has been for some time in operation on the west bank of the Schuylkill River at the foot of Locust Street, Philadelphia. The cuts will show the general arrangements, but a brief description will aid in understanding the operation.

Fig. 4. Longitudinal and end-view of tubes of ozonizer.

The water is first roughly filtered. This operation is merely intended to remove the grosser suspended matter, as the ozone process proper does not accomplish this. As the main part of the operation is the destructive action of the ozone on the bacteria, it is not necessary for the preliminary filtration to be nearly so close as when the latter is the sole reliance (as in ordinary filter plants), hence the filter area in the ozone plant is relatively very much smaller, the rate of filtration being so much greater. The filtered, or, perhaps, we may call it strained water, is passed into aërating towers. These are tall, narrow vessels, into which the water enters at the top and the ozonized air at the bottom, the latter under considerable pressure. In the experimental plant above mentioned, an exhibition mixing tower has been installed. This is a glass tube about sixteen feet high and ten inches in diameter. In this the admixture of the ozone current with the water current is well seen. Upon the thoroughness of this mixing depends, in large part, the thoroughness of the purification. The water escapes at the foot of the mixing tower, clear and practically sterile. It sometimes contains a small amount of ozone in solution, but this is not objectionable and soon disappears, either by conversion into ordinary oxygen or by combination.

The advantages of the process may be summarized as follows:

No objectionable chemical is introduced into the water.

Large filter beds are not required.

The operation expenses are not high.

The plant occupies a limited area and the operation is simple and easily comprehended.

The plant may be enlarged by the addition of new units without disturbing the original units.

The sterilization is rapid and certain.

The plant may be placed at any convenient point.

The process seems to me to find even more valuable application to the purification of sewage than to ordinary water supply. Both of these problems are now among the most urgent questions of sanitation. The extensive use of water in our domestic life, with the increasing sources of pollution, give importance to every method of purification, and processes that seem to be founded on scientific principles and seem capable of practical operation on a large scale, and to involve low operative cost, limited land area

and freedom from dangerous chemicals deserve careful investigation.

Many tests of the bacteriocidal efficiency of the plant have been made. Some made by myself showed that the water as discharged from the ozonizer is practically sterile. The following more elaborate tests, extending over many weeks, were made by Dr. Rivàs, official bacteriologist of the City of Philadelphia, supplanted by independent tests by Drs. Jackson and Hale, city bacteriologists of Greater New York.

DR. RIVAS.					
Bacteria					
Date	Sample	Before	After	Organic Matter	
		Ozonization	Ozonization	in Solution	
		(includ'g disease germs)	(no disease germs)	Before	After
May 15, 1905	1	720,000	16	15.21	7.7
May 15, 1905	2	253,000	37	13.33	8.89
May 18, 1905	1	500,000	55	11.96	7.51
May 18, 1905	2	500,000	38	19.92	7.11
May 19, 1905	1	700,000	5	10.07	6.52
May 19, 1905	2	700,000	0	12.64	6.72
Average		562,100	25		

DRS. JACKSON AND HALE.					
B. Coli after Ozone.					
May 19, 1905	1	665,000	15		0
May 19, 1905	2	648,000	13		0

More recent tests confirm the foregoing.

The following figures show a series of tests with statement of operative cost:

Date	Quality of Water gals. per hr.	Bacteria		Electrical Expend'g K.W.hr.	rate per million gals. in K.W.hrs.
		Before Ozoniza'n.	After Ozoniza'n.		
Dec. 14, 1905	31,200	1,500	2	6.1	196
Dec. 14, 1905	30,000	2,000	2	6.0	200
Dec. 14, 1905	30,300	2,600	4	6.0	198
Dec. 15, 1905	30,900	2,100	2	5.5	178
Dec. 15, 1905	31,300	1,000	2	5.9	188
Dec. 15, 1905	30,000	1,300	5	5.8	193
Dec. 18, 1905	29,900	5,600	4	5.6	172
Dec. 18, 1905	31,000	1,000	5	5.6	181
Dec. 18, 1905	28,500	1,200	1	5.5	193
Dec. 19, 1905	30,000	750	2	5.5	183
Dec. 19, 1905	29,000	550	4	5.6	193
Dec. 19, 1905	27,000	9,900	19	5.6	208

Dec. 19, 1905	28,000	6,000	3	5.5	197
Dec. 19, 1905	30,000	3,700	4	5.5	183
Dec. 20, 1905	29,000	2,900	1	5.5	190
Dec. 20, 1905	28,400	4,100	2	5.6	197
Dec. 20, 1905	28,400	7,100	5	5.6	197
Dec. 20, 1905	28,000	5,700	5	5.8	207
Dec. 21, 1905	29,000	8,600	13	5.5	190
Dec. 21, 1905	28,000	8,700	11	5.5	197
Dec. 21, 1905	27,000	16,400	15	5.8	215
Dec. 21, 1905	26,000	2,700	6	5.5	212

FOREST SERVICE TIMBER TESTS.

Extensive tests to determine the strength of the commercial timbers of the United States are being made by the Forest Service. Such information is of great value to architects and engineers in that it enables them to use more economically the products of the forest. The tests are made on large beams. The material is generally tested while green, since timber is weakest in the green condition. The strength of a beam is indicated by the greatest fibre stress developed during the test. Technically speaking, this breaking strength is termed the modulus of rupture. By using it the load that any beam will carry can be calculated. In the table below the first column gives the green breaking strength of our principal commercial timbers. The second column gives the greatest load that a timber five inches wide and twelve inches high, with fifteen feet between the supports, would hold if the load were concentrated midway between the supports.

Species.	Breaking strength in bending, lbs. per sq. in.	Breaking load concentrated mid- way between sup- ports, for a beam 5 x 12 in. x 15 ft. lbs.
Longleaf pine.....	7,772	20,700
Douglas fir.....	7,500	20,000
Western hemlock.....	5,783	15,400
Loblolly pine.....	5,580	14,900
Tamarack	4,562	12,300
Norway pine.....	3,975	10,600

If instead of being concentrated at one point the load were uniformly distributed over the entire length of the beam the beam would hold twice as much. In order to insure safety, in practice beams are seldom allowed to carry more than one-sixth their breaking loads.