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THE STERILIZATION PLANT OF THE JERSEY CITY WATER SUPPLY COMPANY AT BOONTON, N. J.

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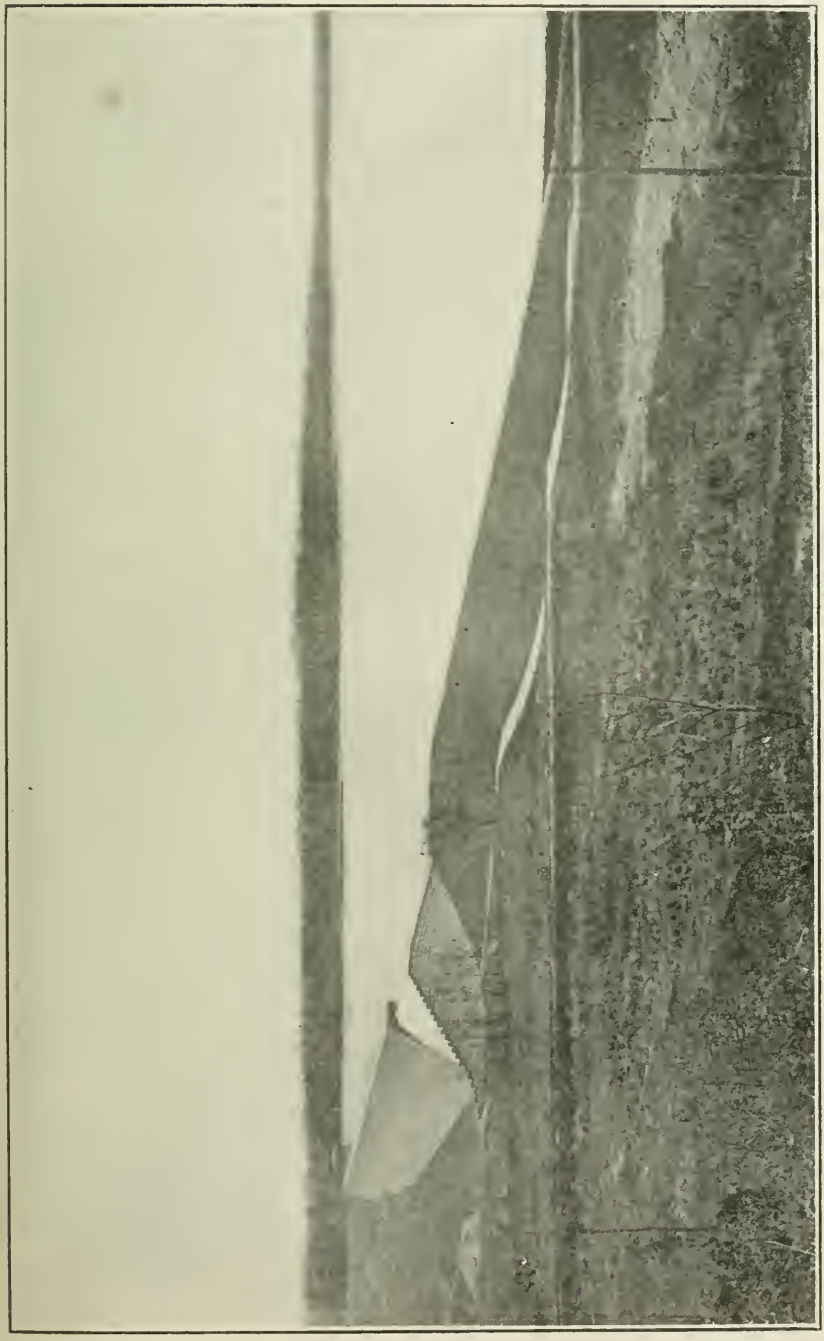
Since the latter part of September, 1908, a process of water purification has been in operation at Boonton, N. J., which I believe will be of great interest to scientists and to purveyors and consumers of water. The water treated is the supply of Jersey City, N. J., and is controlled by the Jersey City Water Supply Company. The process employed has been called a "sterilization" process, but is properly one of disinfection. It consists in the addition to the water of so-called "bleach," used in very minute quantities. It is the first time, to my knowledge, that such a process has been applied, as a permanent one, to a water supply. There is one instance on record in which the same process was used, as a temporary expedient, during a typhoid fever epidemic due to infected water supply. This was at Maidstone, England, during the 1897 typhoid epidemic, when a solution of bleaching powder was used by Sims Woodhead for sterilizing the Maidstone water supply. During an outbreak of typhoid fever in Lincoln, England, in 1904–1905, a solution of "chloros" (a commercial preparation of hypochlorite of soda) was used by Drs. Houston and McGowan, to sterilize the water going to the filters, and also to sterilize the reservoirs. In both these instances good results were obtained.

Dr. Rideal has also used solutions of bleach in connection with the Guilford, England, water supply, but only experimentally.

Somewhat similar processes have also been tried, with more or less success, on the waters of the rivers Seine and Vanne in France and at Middlekerke and Ostend in Belgium.

Rather extensive experiments were made with solutions of bleach and soda, in the early nineties, by Mauritz Traube,



BOONTON RESERVOIR

Alois Lode, Sickenberger, Kaufmann, Bassenge, Hunermann, Deiter and Ballner, their object being to obtain practically instantaneous sterilization or disinfection of water for the use of travelers or troops in the field. Their results, although not attaining the end sought, were successful in establishing the efficiency of both calcium and soda chlorides as disinfectants of water.

Electrolytic solutions of sea-water or salt have been used in a number of instances, as at Worthing, England; Nice, France, and at Poplar, England, for general disinfecting purposes, including street watering; for application to sewage effluent at Maidenhead, England; by Rideal, for application to sewage effluent at Guilford, England, and by Woolf for the disinfection of sewage effluent at Brewsters, N. Y., the disinfection of Jerome Park Reservoir of the New York City water supply, and for general disinfection purposes at Havana and Vera Cruz.

Solutions of bleach have been used for the disinfection of sewage or sewage effluents on the river Brent in England; at Hertford, England; on the Hooghly River, India; at the Tittagurh installation near Calcutta, India, and at Guilford, England; by Schultz of Hamburg in connection with the effluents of hospital sewage works; by Phelps at Baltimore, Md., and Red Bank, N. J.; by Pratt and Kimberly at Camp Perry and other points in Ohio, and by others at numerous places, with generally successful results.

No especial discovery, therefere, is claimed in connection with the process in operation at Boonton, N. J.

I do claim, however, that it is the first time that it has ever been used on any such scale, or as a continuous or permanent system of water purification, and I also claim that as a result of the investigations made by us, certain facts in connection with the process have been obtained, which had not been heretofore recognized.

The Jersey City Water Supply is obtained from the Rockaway River, a tributary of the Passaic. The supply is impounded in what is known as the Boonton Reservoir, having a capacity of 8500 million gallons, and is conveyed by a line consisting partly of concrete conduit, partly of tunnel and partly of steel pipe, a distance of 23 miles to Jersey City; the average draft being 40 million gallons daily.

In order to understand the causes which led up to the adoption of this system of purification, it will be necessary to go, very briefly, into history. In the year 1899 the city of Jersey City entered into a contract with a certain contractor for this water supply. Said contractor at once transferred the contract to a corporation which he had organized for the purpose, called the Jersey City Water Supply Company. Work was started by said company, but, becoming financially embarrassed, they were forced to stop. Various attempts were made to finance the project, but all proved failures until in the spring of 1902 the New Jersey General Security Company was induced to assume control of the Jersey City Water Supply Company and to fulfill its contract obligations. The work was at once resumed and pushed vigorously to completion in the latter part of the year 1904.

In the meantime, however, the city had started suit in the Court of Chancery against the company, claiming that the work was not being done according to the specifications and contract. The specifications in said contract with regard to the quality of the water were as follows:

> The water to be furnished must be pure and wholesome for drinking and domestic purposes; and the works shall be so constructed and maintained by the contractor that the water delivered therefrom shall be pure and wholesome and free from pollution deleterious for drinking and domestic purposes.

The opinion of the court, rendered May 1, 1908, was in favor of the company on all the points raised, with but three exceptions, namely: (1) A penalty was imposed for some one hundred and forty odd days' delay in the completion of the works; (2) a deduction of some $16,000 was made on account of the lining of a certain tunnel not being strictly in accordance with the contract, and (3) the court's finding as to the quality of the water was, briefly, as follows:

> (*a*) That during most of the time the water was pure and wholesome, free from pollution deleterious for drinking or other domestic purposes, according to the contract; (*b*) that owing to certain combinations of circumstances, occurring perhaps two or three times a year (meaning times of high water or flood) the water as delivered at Jersey City contained too high a bacterial count and that B. coli were present in too small quantities of water and was therefore of "doubtful" quality; (*c*) that the company was obliged under the contract to deliver a water that was on these few days of

the year pure and wholesome, free from pollution deleterious for drinking or other domestic purposes: (*d*) The purification of the water could be effected by means of a filter plant. To construct it and to convey the filtered water to Jersey City, at the head contracted for, would involve a great expense. It would have been so important a part of the scheme that had it been contemplated, it would, naturally, have been mentioned in the agreement. The bill does not pray for any deduction grounded upon its absence. It may, therefore, be dismissed from consideration unless the evidence shows that it is indispensably necessary to a complete performance of defendant's contract obligation. I do not think it does.

The court then goes on to suggest, not as its own opinion, but on account of certain evidence given by the city in the case, that the water on these certain days could he made to comply with the contract by the construction of sewers and sewage disposal works for various towns in the watershed.

I was firmly convinced that such a course would not prevent the conditions criticised by the court, but that after the expenditure of the very large sums of money required to perform such work, the company would be left in the same position as indicated by the opinion; believing, as I did, that by far the greater percentage of bacteria and B. coli found at the point of delivery in Jersey City was due more to the washings of soil, roads, streets, manured fields, etc., than from any sewage contamination, it being understood that there are no sewerage systems in any of the towns in the watershed.

I therefore advised strongly that the court be requested to allow the company to suggest to it its own method for the complete fulfillment of the contract requirements. This prayer was made and granted by the court in the decree filed June, 4, 1908, as follows:

> In lieu of and as a substitute for all or any of the sewers and sewage disposal works above referred to in this paragraph, the defendant company may, within ninety days from the date hereof, present other plans or devices for maintaining the purity of the water delivered by the company to the city throughout the year, under present conditions, and estimates of the cost of the works now necessary therefor; and both parties may present evidence touching the efficiency of such plans or devices to produce the necessary results, and the cost thereof; and the defendant company may, pending the taking of testimony, with the leave of the Court, upon notice, present amendments and modifications of such plans and devices.

Upon the rendering of the opinion, May 1, 1908, I began to consider the means necessary to accomplish the objects indicated

in said opinion. Under all the circumstances, it seemed to me that the method indicated was one of sterilization or disinfection. I had made rather extensive experiments with electrolytic solutions of salt and also with solutions of bleach, as early as 1897 or 1898, in connection with the proposed purification of another water supply. The results were most favorable from a bacterial standpoint, although the method was not used because it did not fulfil all the requirements of the water under consideration. My first idea therefore was to use an electrolytic solution of salt in connection with the Jersey City supply. I was unable, however, to find a proper cell, and as time pressed, after the rendering of the decree, June 4, 1908, I decided to recommend to the company the use of chloride of lime. Before doing so, however, I was firmly convinced in my own mind of the following facts, as they have since been proved, although at that time there was a good deal of difference of opinion upon some of them, namely:

1. That bleach on being added to water ceases to be bleach, and therefore that criticisms which had been hitherto applied to such addition were without foundation.

2. That on the addition of bleach to water the loosely formed combination forming the bleach splits up into chloride of calcium and hypochlorite of calcium. The chloride of calcium being inert, the hypochlorite acted upon by the carbonic acid in the water, either free or half-bound, splits up into carbonate of calcium and hypochlorous acid. The hypochlorous acid in the presence of oxidizable matter gives off its oxygen; hydrochloric acid being left. The hydrochloric acid then drives off the weaker carbonic acid and unites with the calcium, forming chloride of calcium.

3. That the process was wholly an oxidizing one, the work being done entirely by the oxygen set free from the hypochlorous acid in the presence of oxidizable matter.

We have used, during our investigations, the term "Potential Oxygen" as expressing its factor of power. When set free, it is really nascent or atomic oxygen, and is in its most active state entirely different from the oxygen normally in the water.

4. That no free hypochlorite or hypochlorous acid would be left in the treated water in the presence of oxidizable matter. It is true that at times in the treated water at Jersey City we

have been able to obtain the reaction for so-called available chlorine, according to the method of Wagner as modified by Shultz, there being always oxidizable matter present in such water, and it has been a matter of a good deal of discussion as to the true explanation of this. In my opinion, however, the matter has been definitely settled by the experiments and findings of Prof. Franklin C. Robinson of Bowdoin College, who first found such reaction in untreated Boonton Reservoir water, and afterwards in over seventy-five natural waters. It is but natural, then, to conclude that this test for so-called available chlorine is simply a test for an oxidizing agent present in the water, be that what it may.

5. That any of the atomic oxygen left after the first explosion, by which the more easily oxidizable substances are destroyed, unites with those not so easily oxidizable and more slowly accomplishes the same results.

6. That no free chlorine could possibly exist in the treated water, the existence of free chlorine being impossible in an alkaline solution.

7. That there could be no material change in the quality of the water after treatment, such as would in any way interfere with its use for potable and manufacturing purposes.

8. That it could in no way injuriously affect piping, fixtures, etc.

Justified in my own mind by the above convictions, I therefore made the recommendation above indicated. The recommendation was approved and on June 16, 1908, I engaged the firm of Messrs. Hering and Fuller to design the necessary works, and Mr. George A. Johnson of said firm to operate the same.

I shall not enter into a description of these works, nor of the technical details of the process, as my friend, Mr. Fuller, who follows me, will do both; neither will I go into the details of operation or the results, which will be covered by my friend, Mr. Johnson, who was in immediate charge of the works.

I will, however, briefly sum up such results and their application.

The plant was started September 26, 1908. The results, chemically, have been that the water is practically unchanged in character by treatment. the hardness being very slightly increased from one to two parts per million, the solids slightly increased

and the carbonic acid lessened. The differences, however, are only such as would result in samples taken at different periods or through the personal equation of different analysts. Bacterially the results have been most gratifying. For weeks at a time the water taken at a point three-fourths of a mile below the works has been practically sterile, and the count at Jersey City has been from sterile to an average of 20 or 30, with B. coli present in 10 cc. only three times up to April 27, 1909. The bacteria in the raw water have run from 200 or 300 to 20,000, with B. coli frequently present in .1 cc.

The oxygen seems to have a selective effect upon bacteria in general, but especially upon the intestinal group. We have at times, while experimenting, obtained counts of as high as 1000 in treated water with no B. coli present, whereas B. coli were present in one-tenth cc. in the untreated water.

Many experiments have been made by means of putting in the treated water typhoid bacilli, B. coli., etc., with the result of their rapid destruction. Fecal matter and also fecal matter of typhoid patients has been treated by solutions of bleach, resulting in the rapid destruction of all typhoid and colon organisms. The greatest surprise we have experienced, however, has been the small quantity of the chemical necessary to accomplish the required results. I use, as a rule, 0.2 parts per million of so-called available chlorine. There have been two or three occasions when, on account of very high water, I have, in order to be absolutely sure of results, increased the amount to 0.35 parts per million. I am perfectly satisfied that it will never be necessary to increase beyond the latter amount. Of course, we started with much larger amounts, but have gradually reduced them, as we found that we could accomplish the same results.

The cost is almost nominal, being about 14 cents per million gallons of water treated. Mr. Johnson will enter into this feature fully.

Mr. Johnson was able some time in December to discover an electric cell with which we can accomplish most satisfactory results, so that at the present time we have the option of proceeding as we are now doing, or of installing a plant of these cells and using an electrolytic solution of salt. As we have water power, therefore electric current costing us practically nothing, the cost of operation would be a little less than the cost of the

bleach process. The efficiency seems to be just the same, as shown by a number of experiments made by Mr. Johnson and myself in which we treated the Jersey City water supply for 49 hours with electrolytic solution of salt, obtaining practically the same results as we had obtained with the bleach process.

This system, however, whether by the use of bleach or an electrolytic solution of salt, is not by any means applicable to all waters. It does not, in most instances, take the place of filtration, except under certain conditions. It answers the purpose better than anything known, from a sanitary standpoint, but it does not remove suspended matter, nor does it remove color except to a very slight degree. It is applicable to waters from large reservoirs where the water has received sufficient sedimentation and bleaching, and to the waters of large lakes if such waters be satisfactory from the æsthetic standpoint.

I believe that one of its most important uses in the future will be in conjunction with filtration. It will certainly effect any bacterial results required, thus making greater rates possible than with ordinary sand filtration and diminishing the cost, and in mechanical filters making less sulphate of alumina necessary and also allowing greater rates. I know of several mechanical filter plants now about to use bleach in connection with their existing systems, and I also know of a plant building in which it is planned so to do. I personally have used it for a period of several weeks in conjunction with a mechanical filtration plant of the highest type, in which, although the bacterial efficiency was satisfactory, yet on account of the large numbers of bacteria in the raw water, the number in the filtered water was anywhere from 300 to 800. By the addition of the bleach in the amount of 0.35 parts per million, I was able to reduce the amount of sulphate of alumina used and secure an effluent containing anywhere from 2 or 3 to 40 bacteria, the numbers averaging the same in the raw water.

This process will also be used in cases where towns or companies are financially unable to build filtration plants, but are forced for sanitary reasons to adopt some means of purification. It will be used also, I believe, in cases of emergency, where water supplies have become infected and where it is impossible to cease using such supplies. In many such ways the practical application of the use of bleach for the disinfection of water sup-

plies seems to me to be a great advance in the science of water purification. It is so cheap, so easy and quick of application, so certain in its results, and so safe, that it seems to me to cover a broader field than does any other system of water purification yet used. It cannot but conduce to the economic and physical benefit of mankind.

Associated with me in this undertaking have been Mr. Rudolph Hering, Mr. George W. Fuller, Mr. George A. Johnson, Mr. E. G. Manahan, of New York; Mr. John H. Cook, Hydraulic Engineer of the Jersey City Water Supply Co., Prof. H. B. Cornwall of Princeton University, Mr. A. W. Cuddeback, of the Jersey City Water Supply Co., Mr. J. W. Ellms, of the Cincinnati Filtration Works, Prof. Leonard P. Kinnicutt of the Worcester Polytechnic Institute, Prof. Wm. P. Mason of the Rensselaer Polytechnic Institute, Dr. George E. McLaughlin of Christ Hospital Laboratory, Jersey City, Prof. W. H. Park of Bellevue and the New York Research Laboratory, Prof. Franklin C. Robinson of Bowdoin College, Prof. Thomas B. Stillman of Stevens Institute, and Prof. F. F. Westbrook, Dean of the University of Minnesota.

Assisting in the work were: Mr. Frank W. Green, Superintendent of Filtration Works of the East Jersey Water Company, Mr. H. C. Stevens, Mr. L. R. Whitcomb and Mr. Guy Britton.

To these gentlemen I wish to express a debt of gratitude for the intense interest in and devotion to the work which they displayed. The services rendered by them could only have been dictated by a scientific interest and confidence in the results hoped for.