PROCEEDINGS

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chlorite of lime. This is in no sense true for the reason that free chlorine cannot be liberated from hypochlorite of lime or soda in a natural water. To do so it would first be necessary to decompose all the alkaline constituents in the water with an excess of strong mineral acid. Again, even if free chlorine could be liberated from hypochlorite of lime in a natural water, the chlorine would immediately combine with the hydrogen of the water and liberate atomic oxygen.

DISCUSSION

Prof. H. B. Cornwall: *Mr. President and Gentlemen:* When Dr. Leal called on me sometime ago to speak about this process which he has just described to you, and which it appears to have been his notion to put into regular effect as a means of sterilizing a water suitable for treatment, he asked me two or three questions. One was whether I thought that water could be sterilized in this way. I told him that I thought that it could. He asked whether I thought there would be any objectionable results from the process? I told him that I thought there would not; but I must confess that when I was giving him these answers, although there was not any doubt in my mind upon first looking into it that they were correct enough answers, I was basing them all on a somewhat different assumption, than what has turned out to be the truth. He told me they were going to use bleaching powder. Of course, the first idea that occurs to anyone in connection with bleaching powder is that it is a very powerful sort of substance. All the manufacturers of bleaching powder and the people who are using bleaching powder invariably refer to its strength in terms of what they call "available chlorine;" and every chemist working in a laboratory knows what happens when some of his chlorine gets beyond the bounds that he has set for chlorine. He knows that it is not a pleasant neighbor to have in a laboratory.

But on looking the subject up afterwards more thoroughly I found that under the conditions in which this agent is used, whether as a solution of calcium hypochlorite made from bleaching powder, or obtained electrically as a solution of hypochlorite of sodium from common salt, it was not a question of free chlorine at all.

At the beginning of the discussion, which I am not going to prolong very much, I would say that this term "available chlorine" applied to bleaching powder is quite similar under the conditions in which it is used in the water as described by Professor Leal, to the use of the term horsepower as applied to a steam engine. There are no horses around. This is simply a way of measuring oxidizing effect. This "available chlorine" is simlpy a way of measuring oxidation. The result may be brought about in different ways.

The real agent in the wonderfully efficient process that has been laid before you is oxygen. If you will look through the standard and most up-to-date works on chemistry, you will find nowhere any other statement with regard to hypochlorites, whether of soda or lime, calcium or sodium, under the influence of weak solutions of carbonic acid—and that is what is present in all natural waters. The only acid that is present in a free state is carbonic acid. You will find the statement invariably made that a very weak carbonic acid solution does not liberate chlorine from bleaching powder or from any similar compounds. I have tried the experiment myself and could not find that any chlorine was liberated. Then on the other hand, hypochlorous acid, which is present in hypochlorite, is a very feeble acid indeed. Hypochlorous acid is a feeble compound which is pretty easily split up. It consists of hydrogen, cholrine and oxygen, an atom of each; and in the presence of anything oxidizable the oxygen splits off. The printed paper very thoroughly discusses this aspect of the case, and I will not deal with that part any further than to say that the residual hydrochloric acid reacts with the calcium carbonate that is present in the water, or there may be carbonate of sodium present in the water, very often is—almost certainly is. So it is disposed of, and we get a perfectly neutral calcium chloride and sodium chloride.

Now it has been part of my connection with this whole subject to make quite numerous tests of the raw Boonton water, and of the same water after it had been treated with the bleach. The tests were quite as full as analyses that are made to determine from a chemical point of view whether a water is suitable for drinking purposes and for manufacturing purposes. These tests were carried along with analyses to see what

the result would be of this very small quantity of bleaching powder put into the water up at Boonton and how it manifested itself. Each of these tests showed exactly what you would have expected. That is, we were putting in a small quantity of soluble calcium compounds, calcium chloride, calcium hypochlorite, calcium hydroxide, which is present in the bleach, and also very small quantities, indeed quite inconsiderable and not worth noticing, of impurities present in the bleach. We found that the nitrites, which you know are present in almost any natural water to a very small extent, disappeared under the oxidizing action of the hypochlorite. The nitrates were increased very slightly. The total solids increased a little exactly in proportion as these things were put in. I do not suppose that a process like this, as Dr. Leal has very properly said, would be applicable for too impure a water even if it were to be prepared for drinking purposes. I can imagine that under such circumstances as that you would find that you had to put in a very considerable quantity of bleach. Now if for any reason, considerable rain or something of that sort—we know that rain water is at times a very pure water—you might be likely to find yourself putting in an excess of this bleaching powder, because you would not know just exactly what effect the large additional amount of rain water might have upon your water supply; but that would not be a matter of any moment when you were putting in very small quantities. You are never in any danger of getting an unwholesome excess even in the first place.

I can see that it is suitable for a water which, even without this treatment or without any treatment is devoid of taste of of any unwholesome odor. We know that the surface water that comes down from our granite mountains has no odor. This Boonton water has no odor. I have again and again tried it, and it has no odor whatever under the conditions in the summer when we are looking for it.

If you take a half liter of it and heat it, as we do in our analyses, and apply your nose to the lower part of the retort, you will notice a very slight odor; but it is not the odor of putrescence at all, it is an odor more like wet hay than anything else. It is the odor that you get with any such surface water that you collect in most parts of the country. Now to such a water as that this treatment is I believe perfectly applicable.

I am not going into the bacteriological aspects of it. The paper goes on to prove that it takes very minute quantities to sterilize the water and render it no longer harmful from any specific disease. The germs are killed.

What I would like to speak of a little bit is the question of the conceivable injury done to a water to be used not only for drinking purposes but for ordinary technical and industrial purposes by putting in a small quantity of bleaching powder or of hypochlorite.

I would remind you that when I was first examining the question, I thought of the decomposition of this bleach as giving out chlorine which would kill germs. It would, I suppose, but I do not believe it would kill them because of free chlorine. Anyone that wanted to raise objections to this process might do so on the assumption that there was free chlorine, but there is not. If there were you might expect to find a deleterious effect on metals; for instance, you will find that no iron that has come in contact with this treated water is going to be affected or corroded. Now what is the truth in regard to that? Well, after treatment the water runs through some seventeen miles of supply pipes. I have made perhaps a dozen tests of the raw water, and also of the treated water discharged at the lower end of these seventeen miles of mains; and I never found any more iron in the water at the end of the line than I did in the raw water. Generally it was just about the same amount of iron in the one case as in the other. Not infrequently there was a little more iron in the raw water than there was in the water after it had been treated and then run through seventeen miles of pipe. When you come to think of it, the corrosive action of water on metals like lead or iron is due probably to the combination of two different things; and this corrosive action will manifest itself in the test. We did not find any evidence of such effects. In order to produce this effect we must have oxygen present, also carbonic acid and carbon-dioxide and then you are likely to get considerable corrosive action.

They are putting in a bleach which contains about twenty per cent of calcium hydroxide. It contains calcium oxide; and when you put in the bleach you are putting in something that combines with the free carbonic acid. The less free carbonic acid there is, the less the corrosion.

There is no marked effect on the Boonton water in destroying color. Sometimes I have been able to observe a little less color in the water, and sometimes not any difference. When the water stands a few days in the bottle and deposits sediment, there is no difference in the character of the sediment.

My conclusion in regard to this is that the process is just what Dr. Leal has said about it, that it is just suitable for a water that is pretty nearly good enough anyway, and where you just want to make sure that you are getting rid of any possibility of dangerous germs. It is not suitable for a very impure water which you would have to treat in some other way before you could subject it to treatment with the bleach, unless you wanted to run the risk of putting in too much bleach.

I am very glad to have had a chance, Mr. President, to address the members of the Association.

Vice-President Alvord: We also have with us Professor Flather, of the University of Minnesota.

Prof. J. J. Flather: *Mr. President and Gentlemen of the Association*: The hour is getting late and I will not impose upon your time. The subject is one of very great interest to me, as it doubtless is to you, as being something new in the purification of water on a large scale. My attention was first called to this process during the winter when my friend and colleague, Dr. F. F. Westbrook, was carrying out some experiments on the Mississippi water at Minneapolis. I was surprised to learn of the wonderful results that were obtained in reducing bacteria with such minute quantities of bleach. I was familiar with the use of alumina, and of lime and iron in reasonable quantities of from one to three grains per gallon; but when it comes to the use of a quantity of one-hundredth of a grain per gallon, I did not think it could be much good; but I was very much surprised to find that the bacteria were practically eliminated. So when I had the opportunity of inspecting this plant at Boonton a few weeks ago, I was prepared to find a duplication of these laboratory experiments on a much larger scale and was very glad to find them.

It was my privilege to be able to examine the records there for several months, and it was astonishing to find how the

bacteria had been reduced from several thousands in some cases to zero, two, three, four, eighteen per cc.; very small indeed in number. In one case during the month of April, I think it was, there were nine days in which the bacteria shown was zero, something very interesting because of the very minute quantities which were used, not more than two-tenths p.p.m. up to perhaps four-tenths p.p.m. I expected to find the use of this chlorine producing possibly an odor and taste; but at that plant there was no such odor manifest, nor any taste so far as I could determine.

The use of this agent has been very well suggested as being applied to a water which is fairly good in itself. That suggests, as Dr. Leal has mentioned, a use for it in waters which have been treated by filters. I was not surprised to find in other places that this bleach is now being used for that purpose. I was informed that it was being used in the Croton Reservoir at New York; but from the records that I was able to obtain there from Dr. Park, I am sure that the bleach was not used during the month of May of this year, for the bacteria as determined from water taken from the tap ran anywhere from 200 up to 500 per cc. and I was satisfied that the bleach had not been used, because if it had been they would not have run up to such high numbers.

In other places visited I found them using the bleach very satisfactorily in connection with a filter, so as to be sure that the bacteria were reduced to the desired number.

For this purpose it is being used both with mechanical filtration and with slow sand filtration. In one case which I had the opportunity of visiting I found the bleach was applied just before the coagulated water was led on to the mechanical filter. In that case it was applied in a small quantity, about one-tenth of a grain per gallon every other day, and the bacterial content was reduced to a very satisfactory figure.

In another case the hypochlorite was applied to the effluent from a slow sand filter as it passed to the clear water reservoir.

One great advantage of the process which was utilized in this case was the ability to start the sand filter at full rate immediately after cleaning. It was found that by so doing the time out of commission was reduced from eleven to seven per cent. Another marked advantage is the ability under fav-

orable conditions to operate the filters at much higher rates, and still have the finished water free from bacteria.

In one plant which is notable in many ways, I found the bleach being used to an extent that produced a decided odor and a very strong taste of chlorine. That was the Bubbly Creek plant in Chicago, where they were treating the sewage and rendering it practically pure. The sewage came from a sewer twenty feet in diameter discharging into a canal alongside of another sewer about four feet in diameter, and still another two feet in diameter. Some 500 or 600 feet distant the canal was tapped, and the water treated and run through a filter. Just before being led to the filter 2 p.p.m. of the active agent was introduced to the water, sufficiently purifying it to make it a drinkable water. I confess as I drank the water I had the sewer in mind back of me; but it was pure, and I had sufficient confidence in scientific results to be able to drink it with satisfaction; but there was a chlorine taste, and ordinarily I would hardly like to have that odor and taste. When the hypochlorite of calcium is used in a proper way, and when the condition of the water itself is satisfactory except for possible bacterial pollution; or when the water has already been treated in a mechanical or slow sand filter, this treatment ought to give most satisfactory results.

Prof. W. P. Mason: *Mr. President:* I can scarcely add anything to what has been already said excepting perhaps this word, that when I first came in contact with this process I was a very strong disbeliever; in fact, I am on record in print as not approving of the process. I have been converted, however, and I have been converted because of the results of many experiments. I found, very greatly to my surprise, that the dose was exceedingly small that was required to produce satisfactory treatment.

Of course there is nothing new whatever about the use of bleaching powder as a disinfectant. If we throw in enough bleaching powder all germs are killed. But I was by no manner of means prepared to find that three one-hundredths of a grain per U. S. gallon of bleaching powder, measured as available chlorine, was sufficient to do good work and reduce the number of bacteria from a high figure to nearly zero. Water containing about 100,000 per cc. was used and after the treat-

ment the count was reduced to four, five, six, and ten. So far as intestinal organisms were concerned, they were simply wiped out. I seeded waters with pure cultures of B. coli, and also others with human dejecta. Absolutely no gas-forming organisms were secured therefrom, everything of that description was entirely wiped out, even with that exceedingly small dose. It has been already stated, and I thoroughly believe it to be true, that the consumers do not get any liberated chlorine. But as I was sitting here listening to what was being said, I could not help but think what would happen if a trace did reach them. Just for the sake of argument let us suppose that that infinitesimal dose of chlorine got to them, what would happen? I was reminded of a temperance crusade in Albany some years ago when a brother got up and said, "Let a drop of alcohol get in your eye, note how it hurts and then fancy what it does in your stomach!" An irreverant individual in the corner hopped up and said, "Brother Delevan, if you get some well-seasoned soup in your eye note how it feels!" Now everybody knows that we are constantly taking into the stomach things that we are perfectly well aware are irritants, things that we call food. We know perfectly well that chlorine in sufficiency is objectionable; but the amount under consideration here is exceedingly small. Those of us who have had a capsicum plaster stuck on us, know perfectly well that it is not pleasant; yet we use pepper on our food. Any of you that should chance to sit hard on an energetic mustard plaster would know mighty well that it was food in the wrong spot, yet we take mustard as food every day. Therefore, although I think the consumers get no chlorine, yet as I sat here listening to what Brother Leal has said, it occurred to me that the amount was so small it would not make much difference anyway.

Mr. Rudolph Hering: *Mr. Chairman and Gentlemen:* The hour being very late, I shall only say a few words. I think the profession of water supply engineering owes a debt of gratitude to Dr. Leal, Mr. Fuller and Mr. Johnson for having developed this plan in such a manner that it can be efficiently and economically used in certain places, that it has come to stay with us, and that it is going to serve many a good purpose in the future.

It occurred to me a few moments ago that it is just forty years this month since I was employed as an assistant to design an intercepting sewer to protect the water supply of Philadelphia. That was the only method formerly used to protect the water supply. That sewer extended about six miles on the left bank of the Schuylkill River from the outskirts of the city to below Fairmount dam where the water was being taken. It was expected at that time that such a sewer would protect the water supply of the city. It was not built until many years afterwards. In addition to this precautionary measure the city bought property for a park for a distance of five miles on both shores of the river, to prevent houses and factories from being built near the shore and to keep out any sewage that might go into the river from this vicinity.

But even that did not completely satisfy the people, because today they have a system of water filtration to purify that very water which they first protected by purchasing land and making a park and then by building an intercepting sewer in addition. Filtering the water supply was the one way by which it was deemed possible to maintain its purity.

The method of disinfection which has been described tonight is of quite recent development, and I am quite sure that if it had been used in Phildaelphia many years ago, when the water supply, though receiving directly the sewage of over 50,000 persons, was comparatively very clear for most of the year, it would have saved thousands upon thousands of lives in the city of Philadelphia from typhoid fever death alone.

So I feel satisfied that a big step has been made in the progress of water works engineering; and while we cannot expect that this method will answer every case and take the place of filtration, or do away with a careful protection of the territory of our water supplies, this method has certainly come to stay and to fill a certain place.

In Europe they maintain that no water should be supplied to cities that is not either filtered by nature, such as ground or spring water, or is artificially purified by filters. In our country we are rapidly approaching the same ideas; but there are many cases where our new and not wealthy cities cannot afford to establish expensive filtration works, where river water is fairly good and drinkable. In all such cases I think

we can be sure of saving many lives by the use of methods such as the one that has been described tonight, until the time comes when we can afford to go further and filter the supply.

I do not wish to imply that filtration will necessarily take the pathogenic germs out of the water in all cases, although it will do so in most cases. Where there is any doubt, then, owing to the comparative inexpensiveness of the method of disinfection described tonight, it offers in addition an almost perfect solution of the problem of furnishing a high grade water supply.

Vice-President Alvord: I am sure that there are many with us here tonight who are very much interested in this subject and from whom we would like to hear a few words. Although the hour is late, the meeting is open for anyone who has a question. Mr. Hill.

Mr. Nicholas S. Hill, Jr.: I feel that in addressing the Association tonight upon the subject of the Boonton sterilization plant I am in rather a delicate position. I have been employed as one of the experts for Jersey City. To make my position clear it may be well to state that the process which has been described tonight was offered as a substitute for the prevention of the pollution of the Rockaway River; and the question of the propriety of using this method of purification, and the question as to whether the process which has been described is a proper process, are now before a Master of a Chancery Court in the State of New Jersey; it seems, therefore, that if as one of the experts for Jersey City who have had charge of the Jersey City side of the case, in conjunction with Mr. Griffin, superintendent of water, I were to open up any discussion of the question I might be putting myself in an embarrassing position.

I should like very much to discuss some features of this process, not that I would want to discuss it in a condemnatory sense, I should rather want to discuss the method of application of the process to the purification of the Jersey City water supply. I may say that we have had with us in the preparation of the municipality's side of the case the most eminent experts whom we could employ. We have had with us Professor Sedgewick, of the Massachusetts Institute of Technology; Professor Winslow, of the same institution, and Professor Phelps, who

has done probably more experimental work in the use of chloride of lime as a disinfectant than any other man in the country. We have also had with us Mr. Whipple and Mr. Goodnough, chief engineer of the Massachusetts State Board of Health. We have had Dr. D. D. Jackson, who is the chemist and expert bacteriologist in charge of the New York City water supply. The only conclusion which these gentlemen have reached has been that the application of the process as designed for Jersey City is not sufficient, is not complete; and I simply want at this time to make that statement, because I think it will be interesting to the Association to hear this question fully discussed.

In view of the fact that I do not feel that it would be proper for me to undertake such discussion tonight or to ask our experts here to enter into such discussion, I think that I can safely say that at some future meeting of this Association, probably next year, there will be prepared a statement setting forth the views of those who are engaged on the Jersey City side of the case; not, as I say, in a controversial way, not as condemnatory of the methods which have been suggested, but as throwing another light upon the process which I think would be of benefit to the Water Works profession.

Mr. A. A. Reimer, E. Orange, N. J.: I am glad that Mr. Hill has spoken as he has. I think we all will look forward with considerable interest to those papers in view of the fact that there has been presented a process that seems to be an important adjunct to the subject of purification of water. If there is any possibility of getting the papers in time for printing in the annual report even though the matter may not be complete, I think it would be valuable to all of us to have them in view of the discussion we have had tonight from what might be called the anti-Jersey City side of the case. I think we should have as many details as possible of the complete case presented to us at an earlier period than next year. The case is too one sided at present to be of large value to the profession at large.

Vice-President Alvord: Is the testimony in the case printed as yet?

Mr. Nicholas S. Hill, Jr.: The testimony will be printed. Part of it is printed at the present time. I do not know when a decision will be reached in this case; but I think I am safe

in saying that there will be no discussion until the decision is reached in the case.

Mr. R. E. Milligan: As a mechanical filtration man this subject is naturally one of the greatest possible interest. I think I can say that all mechanical filtration men have eagerly received the information which has been given concerning the effects reached at Boonton and at other places, where either wholly experimental or practical use of the hypochlorite of lime has been made. Considerable discussion among the mechanical filtration men naturally has resulted; and speaking for myself, I think we regard the use of this agent as an added safeguard to the purification of water by mechanical filtration.

Of course mechanical filtration is used more especially with waters containing color, suspended matter and algæ. In the latter case I do not understand that results of any value have been reached as to whether or not the various algæ are affected or killed by the use of this germicide. Its application in a systematic way, as you have heard described tonight, has brought out more clearly to us than anything else the exceedingly powerful effect of the minute amount employed upon the bacteria in the treated water.

One of the speakers tonight stated that with waters that are nearly good—or words to that effect—this process unaided would be very acceptable. Of course I do not attempt to quote the speaker's words exactly. In my experience there are no nearly good waters. The employment of mechanical filtration either comes because of the desire on the part of the consumer to safeguard himself and family from accidental pollution in what is otherwise a good water, as it is for example at Ithaca, where the original water was beyond question good, yet where that terrible epidemic with which you are all familiar was due to an accidental cause; or it is applied to waters that are physically repulsive. Many of these repulsive waters are excellent so far as their bacterial content is concerned, and the reduction of the bacteria or the sterilization of the waters would not render them an acceptable supply. There is, however, as all filtration men know, a class of water that borders on the impossible from the standpoint of the water chemist, laying aside its physical aspect, because the amount of bacteria is so great. While in no sense of the word sewage, it is quite beyond the range of

mechanical or any filtration efficiency. Such a water as Dr. Mason spoke of tonight in the Hudson at certain points seems to be fairly representative of that class. In these cases an additional germicidal process of this sort will undoubtedly, I am satisfied, be of the greatest possible assistance to mechanical filtration, and will be employed in my judgment on all such waters in the future as an adjunct to mechanical filtration. This will be done in the usual way known to you all, as coagulants are now fed or by the introduction of the hypochlorite of lime salt in the settling basin, or between the settling basin and the clear water well, or in the clear water well itself.

To my mind the hypochlorite process is rather one that will effect the so-called ozonization process, and will come as a practical means of accomplishing what is substantially the same thing, the sterilization of water by means of oxygen under the terms "avalable chlorine" or "potential oxygen" rather than the cumbersome and somewhat expensive process known as the ozonization of water.

Mr. Edward Bartow: *Mr. Chairman:* In view of what has been said concerning bleaching powder as an adjunct to filtration, by Dr. Leal and Mr. Hering, I would like to say a few words regarding some experiments that have been carried on by Mr. G. A. Van Brunt and myself. After the publication of the successful experiments in Bubbly Creek, by Geo. A. Johnson in one of the engineering journals, and a paper by Mr. Adolph Gehrman on the same subject before the Lake Michigan Water Commission, we started out with the intention of testing the use of bleaching powder with respect to ordinary filtration plants. First we determined the sensitiveness of the potassium iodide starch test. Finding that this test was much more sensitive than taste we thought we would be safe in trying some experiments on a larger scale at the Lake Forest filter plant. We were successful in reducing the number of bacteria, and in practically eliminating the B. coli, as shown by the presumptive test; but owing to the insufficient size of the filtration plant we gave up the experiments there.

Experiments were then made at Quincy, Ill. First I may say that we experimented on various waters, in the laboratory, namely distilled water, water from wells, and from the Mississippi river. We found that the amount of bleaching powder

that could be detected varied with the character of the water. Less bleaching powder could be detected in the distilled water than in the well water and less in the well water than in the Mississippi river water. The bleaching powder also disappeared more quickly from the Mississippi river water than from the others.

In tests at Quincy we first determined what we might call the normal. For a period of ten days tests were run on raw water and filtered water. The raw water contained from 3000 to 7000 or 8000 bacteria per cc., and the B. coli was always present, as shown by presumptive tests. The filtered water contained from 200 to 500 bacteria per cc., including B. coli at times.

At the end of ten days bleaching powder was used in quantities not exceeding two-tenths grain per gallon. By the use of the bleaching powder solution placed in the system between the sedimentation basin and the filters, it was possible to reduce the number of bacteria per cc. in most cases to below 10. The B. coli was entirely eliminated.

It seems to me that this is a good illustration of the use of bleaching powder as an adjunct to filters.

Mr. A. H. Wehr, Baltimore, Md.: Mr. Milligan referred a moment ago to the fact that possibly this hypochlorite may be found to answer as a substitute for ozone sterilization of water. You have heard this evening reference made to a paper by Mr. Walden, the Chief Engineer of the Company which I represent. For some months past, under the direction of our chief chemist, we have been making experiments with hypochlorite of lime, and we are now operating both slow sand and mechanical filters with hypochlorite as an adjunct to filtration. We have not found that hypochlorite is even likely to answer as a substitute for ozone sterilization of water, as is shown by the fact that we now have in process of construction what I believe is the first ozone sterilizer to be erected on any large scale in this country; that is to say we are erecting a 6,000,000 gallon ozone sterilizing plant to be used in connection with and addition to sedimentation. We expect to have this plant in operation in sixty days, and no doubt Mr. Walden can be prevailed upon by myself or Mr. Diven to write a paper for the next convention giving the Association some information about this ozone plant.

Vice-President Alvord: The hour being late, I will ask Mr. Fuller to close the discussion in a few words, if he has anything to add.

Mr. G. W. Fuller: *Mr. Chairman and Gentlemen:* I think that the field has been covered very thoroughly as we know it today. What Mr. Milligan has stated brings up one thought to my mind, and that is in connection with the removal of algae. While my experience is limited, I am of the opinion that this is a practical method under some conditions, and perhaps it is going to prove to be a more successful treatment than copper sulphate.

In regard to the ozonization tests of the Baltimore county Water Works plant, I think that is something that we should all look forward to with great interest. We have heard of ozone of course for many years. I remember that it was discussed at a meeting of this Association in New York City; I think it was in 1901; and as I recall it there were described several European experiences such as had been ascertained by American Engineers. I think they rather led us to feel somewhat apprehensive with regard to the uniformity and the production of ozone, and also because they referred to the fact that the efficiency of the method seems to depend upon the concentration of ozone in the ozonized air. Now that is by no means an unfair statement. We do not think the situation as to ozone has improved in the last six or eight years.

I certainly believe that in the coming years we are going to see a marked improvement as to its utilization. We have not found it particularly satisfactory in the tests that I know of in this country within the last few years.

With regard to the manageability of the hypochlorite treatment as compared with the ozone treatment, as the evidence stands today I believe that an ordinary water which might be suitable for a drinking water supply can be handled readily by the hypochlorite treatment under a great many conditions, but particularly as an adjunct to filtration. What will be the future development with regard to the range of applicability of the hypochlorite treatment I think is something we will have to look forward to.

In regard to future meetings I will be very glad if we can have further light upon this matter through discussion, which

may be written later and appear in the proceedings of the convention.

SECRETARY DIVEN: Was there algæ in the Boonton water at all?

MR. G. W. FULLER: There are at times, yes.

SECRETARY DIVEN: What effect does the hypochlorite have upon algæ?

MR. G. W. FULLER: They are killed, but not removed.

SECRETARY DIVEN: I tried some experiments just before leaving home. I did not find that it affected it at all. I used as high as one-fourth of a grain per gallon.

MR. A. H. WEHR: We found it had no effect upon the algæ in the reservoirs at all.

MR. G. A. JOHNSON: I want to make a short statement in regard to what I said a few minutes ago about testing the filter plant at Chicago. It is a fact that since the first of the year the superintendent has been making numbers of special tests with a view to economy. It is rather an expensive plant to operate, as I think you all may realize. At the time that Professor Flather was there I understand from Mr. Jennings, the superintendent, that the water did possess an odor that was perceptible. I was there the last time on Saturday, and at that time the odor had practically disappeared. At the present time Mr. Jennings informs me that it has disappeared altogether. He has located the source of the trouble.

MR. C. B. SALMON: I do not represent the State of Wisconsin, or the Railroad Commission, but I have gone so far as to have the commission read this paper, and tentatively have their consent to its being read here. As you know, Wisconsin gets in the limelight pretty often through its athletic politicians, in one way or another, especially during the last few years; but notwithstanding there seems to be quite an element of progress in the Wisconsin legislature, along some lines at least that look to an improvement of certain conditions that have existed in other states as well as Wisconsin, regarding utility companies. I should like to make the suggestion that if there are any questions that you would like to ask, that they be noted down in the order of the paper that I read, because sometimes a question later has to be explained by some question that should have been asked sooner.