This, of course, is an exceedingly important practical detail, for it is evident that the chlorine may be made to serve as an indicator of the presence or absence not only of organic matter in the water, but of non-sporing organisms. Instead of waiting for the results of a bacterioscopic examination, the simplest and shortest of which cannot be carried out under two or three days, an estimate of the amount of chlorine "absorbed" may, if necessary, be made from hour to hour, the amount of chlorine required to give the violet reaction at the end of "contact" being the amount necessary to ensure complete sterilization after the organic matter has been combined.

During dry weather the addition of very minute quantities of the oxychlorine compound is sufficient to ensure complete and continued sterilization of the Cambridge water, and the amount of chlorine once determined and the flow regulated, the process may be allowed to go on almost automatically.

During rainy weather rough tests should be made from time to time. In our experience it has never been necessary to add more than 20 per cent. of the dry-weather amount of "bleach" to the chlorine solution, the addition of this quantity invariably ensuring complete sterilization. The chlorine solution and water should be thoroughly mixed in the mains leading to the reservoir, which should be of sufficient capacity to contain at least a couple of days' supply. Equalization of the chlorine added at different times would thus be obtained, and the conversion of any slight excess of chlorine into hydrochloric acid would be ensured.

OZONIZATION.

The next method suggested, ozonization, has, of course, passed beyond the experimental stage in France and Germany, but in this country we had no plant at work.

Through the courtesy of Messrs. Siemens and the water company, I am able to show you the Siemens-Halske ozonizing apparatus at work, and to give you the results of a series of experiments carried out with this apparatus. This apparatus has been so fully described by Dr. Rideal and others that I will not worry you with details.

Whatever results can be obtained by the "bleach" method can be obtained by the use of ozone, and though the working of the process is necessarily more expensive and less simple, it has advantages, from the æsthetic point of view at any rate, over the chlorine process which will ensure its use, especially in connection with large water supplies. That it would work as efficiently as the chlorine method I was quite prepared to find, as in both cases we have the same element, "nascent" oxygen, doing the real work. In this I was not disappointed, for, working with the same water, I found that the B. coli was eliminated, and time after time I obtained 500-c.c. samples in which this took place. Moreover, water taken from the Marne, when filtered and thus converted into a water very similar to our Cambridge water after treatment with ozone, was found to give similar excellent results.

From the sentimental point of view there can, of course, be no objection to the use of "health-giving ozone," but I would warn those who take up this work that, just as in the case when chlorine is used, decomposing organic matter, or large quantities of organic matter of any kind held in solution, may, when attacked by ozone, give rise to an unpleasant flavor. These substances, which appear to be related to the amines, chloramines, etc., require further study. I mention them here in order to prevent disappointment to those who undertake to sterilize impure waters without subjecting them to some preliminary treatment.

Sterilization by the Ultra-Violet Rays.

Here, again, the process resolves itself into one of ozonization or oxidation. The intense chemical activity of the ultra-violet rays has long been recognized, and Marshall Ward and others have already utilized this activity in connection with the destruction of bacteria, both non-sporulating and spore-bearing. More recently it has been suggested and proved that water may be rendered germ-free by the action of these ultra-violet rays. Various lamps have been devised to effect this sterilization—the Cooper-Hewett lamp and others. Through the courtesy of Messrs. Siemens I am enabled to show you a simple French form of lamp which, so far as we have tested it, seems to be extremely efficient.

It consists, as you see, of a small reservoir, through which the flow of water can be so regulated that it always remains at a constant level. In the centre is an overflow pipe so arranged that all the water passing through the reservoir must come immediately beneath an electric arc spark passing between two carbons. The core of each of these carbons contains alumina, which as it burns gives off an intensely white light, containing a very large proportion of the chemically active ultra-violet rays. These rays, acting upon the oxygen in the water, convert it into ozone, or into some intensely active form of oxygen—so active, indeed, that the process of sterilization is carried out at once. How far the direct action of the ultra-violet rays on the protoplasm of the bacteria plays a further part it is impossible to state, but as to the sterilization there can be no doubt. The Cambridge water is especially suited for this method of treatment. It is very translucent, and the full effect of the rays can be exerted at once. Then the amount of organic matter present is small, and the whole of the active oxygen is concentrated on the bacteria; and, the number of bacteria being limited, the concentration factor may again receive its full value. I intend to give a further and fuller account of the experiments carried on with this lamp.

THE GREAT NORTHERN RAILWAY TUMWATER POWER PLANT.

By Frank C. Perkins

The first installation in America supplying a three-phase current for an electrified railway was placed in operation recently for handling transcontinental trains leaving Tidewater

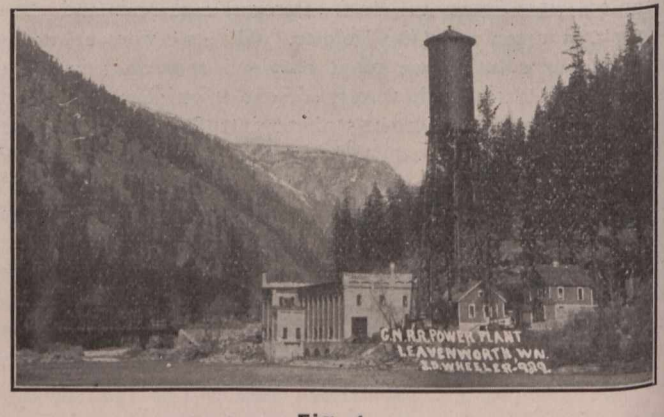

Fig. 1.

at Seattle and Everette, on the Puget Sound. The Tumwater hydro-electric plant supplies current for the Great Northern Railway trains proceeding eastward on a rising grade for eighty-five miles where they then begin the ascent of the western slope of the Cascade Mountains. The Cascade tun-