from the analytical determinations of the original acidity of the water. The author found that combined carbonate and lime treatment employed at the works had increased the hardness by the equivalent of 2.5 parts per 100,000, and that the process had been so carefully adjusted that the product contained neither free lime nor free carbonic acid. The above notes show what can be done in the way of hardening by carbonate of lime, and indicate the limits of the process.

"Excess Lime" Method of Sterilizing Water.—In the Eighth Research Report to the Metropolitan Water Board, Dr. Houston gave an account of experiments demonstrating the sterilization of raw Thames water by treating it with lime considerably in excess of that necessary to effect softening alone. The treatment of soft waters was also dealt with, and in the Ninth Report (April, 1913), this matter is followed up and notes are given showing the practical sterilization of a "very soft, peaty river water" by small quantities of lime. Experiments are quoted showing that purposely polluted water could be brought to a reasonable standard of bacteriological purity by the germicidal action of 2 parts, or even 1 part, of lime per 100,000 of water, the former proportion being effective in forty-eight hours and the latter in 144 hours. With regard to the free lime left in the water, Dr. Houston states that, if thought desirable, it could be removed by the addition of bicarbonate of soda. Dr. Houston recognizes that there would be cheaper methods of neutralizing the excess of lime "although none perhaps so apparently free from any disadvantages."

The expense of the suggested treatment will be better understood when it is explained that any free lime left in solution will require to neutralize it exactly three times its weight of bicarbonate of soda, and as this substance costs about £6 a ton, or roughly six times as much as lime, it follows that the expense of neutralizing will be 18 times the cost of the free lime left in the water after sterilization. However, neglecting the question of cost, the method may be examined from the chemical point of view. The reaction which takes place is—

$$Ca(HO)_2 + 2NaHCO_3 = CaCO_3 + Na_2CO_3 + 2H_2O.$$

Hydrate of lime + Bicarbonate of soda = Carbonate of lime + Carbonate of soda + Water

The solubility of the carbonate of lime formed has an important practical bearing on the possibilities of the process, and the matter is best illustrated by giving the results of some experiments. Samples of pure water, free from carbonic acid, were treated respectively with lime in the proportions of 1, 2 and 3 parts per 100,000, and were afterwards "neutralized" with 3, 6 and 9 parts of bicarbonate of soda. In the case of the experiment with 1 part of lime + 3 parts of bicarbonate of soda no precipitation or separation of carbonate of lime occurred, even after keeping the samples three days; but in the other two cases the precipitate formed slowly, and then settled down in about twelve hours, leaving the water perfectly clear and brilliant; but these waters were left in the condition of supersaturated solutions, from which the carbonate slowly crystallized out on the sides of the containing vessels, and were thus in states favorable for making deposits in mains. Further, it was found that the waters which were originally treated with 2 and 3 parts of lime, and neutralized with bicarbonate of soda, deposited, in the secondary separation, larger amounts of carbonate than might have been expected after allowing for the known solubility in pure water. The experiments were repeated several times, but always with the same results, and further tests established the fact that carbonate of lime is really more insoluble in water containing a little carbonate of soda than it is in pure water. (Thus, in water containing 3 parts of carbonate of soda, carbonate of lime is only soluble to the extent of 0.27 part per 100,000, as against 1.5 parts per 100,000 in pure water.)

It is fairly evident that if the free lime to be neutralized by bicarbonate of soda in the "excess lime" process exceeded 1 part per 100,000, special precautions would have to be taken, otherwise considerable deposits of carbonate of lime might readily occur in the mains.

THE CONSTRUCTION OF A REINFORCED CONCRETE RESERVOIR.

The accompanying illustrations and the following data respecting the design and construction of a reservoir and coagulation plant for the Anheuser-Busch Brewery at St. Louis, Mo., are from a paper to be read by Mr. Ed. Flad, M. Am. Soc. C.E., at the February 4th, 1914, meeting of the society. His paper includes a short explanation of the waterworks system of the company, the system having a capacity of over six million gallons per day, this water supply coming from the Mississippi River through two 20-in. cast iron intake pipes, being syphoned into intake wells, pumped into settling tanks, and clarified by chemical coagulant and rapid filtration before distribution. The chemical treatment was adopted in 1901, several years before the City of St. Louis itself began the treatment of water supply.

The low-service pumps of the system are in a brick pit, 30 ft. in diameter and 40 ft. deep. There are three centrifugal pumps having a combined capacity of 13,000,000 gal. per day, and one triplex, direct-acting pump having a capacity of 2,000,000 gal. per day.

There are two steel settling tanks, 75 ft. in diameter and 28 ft. high, one circular concrete reservoir approximately 150 ft. in diameter and 30 ft. deep, and one rectangular covered reservoir having a capacity of about 1,000,000 gal.

The filter plant comprises six Jewell filters, circular in plan, each 16 ft. in diameter, and three Reisert filters, recently completed, which are rectangular in plan, each being approximately 34 by 15 ft.

Chemical Treatment.—The water is settled by adding sulphate of aluminum (alum) and lime. A special three-story reinforced concrete building is provided for storing and preparing the chemicals.

The hopper for storing the lime is 36 by 9 by 14 ft. high, and has a capacity of 90 tons. It is placed in a pit so that it can be filled directly by shoveling from the cars. An electric elevator conveys to the third floor the hand-cars containing the lime or alum.

The alum is dissolved in a concrete tank, and is fed to the water by gravity. This alum tank has three rectangular divisions, each 10 by 7 by 5 ft. deep. Each division is charged with from 500 to 2,000 lb. of alum which is dissolved in water. It requires from 2 to 5 hours to dissolve one charge. The lime is slacked in iron tanks on the third floor. These tanks are rectangular, 12 by 12 by 7 ft. deep, with sloping bottoms. A false perforated bottom is provided at a depth of 30 in., on which the lime is placed and partly submerged in 1 ft. of water. After slaking, which requires about 1 hour, the attendant stirs the mixture, which passes readily through