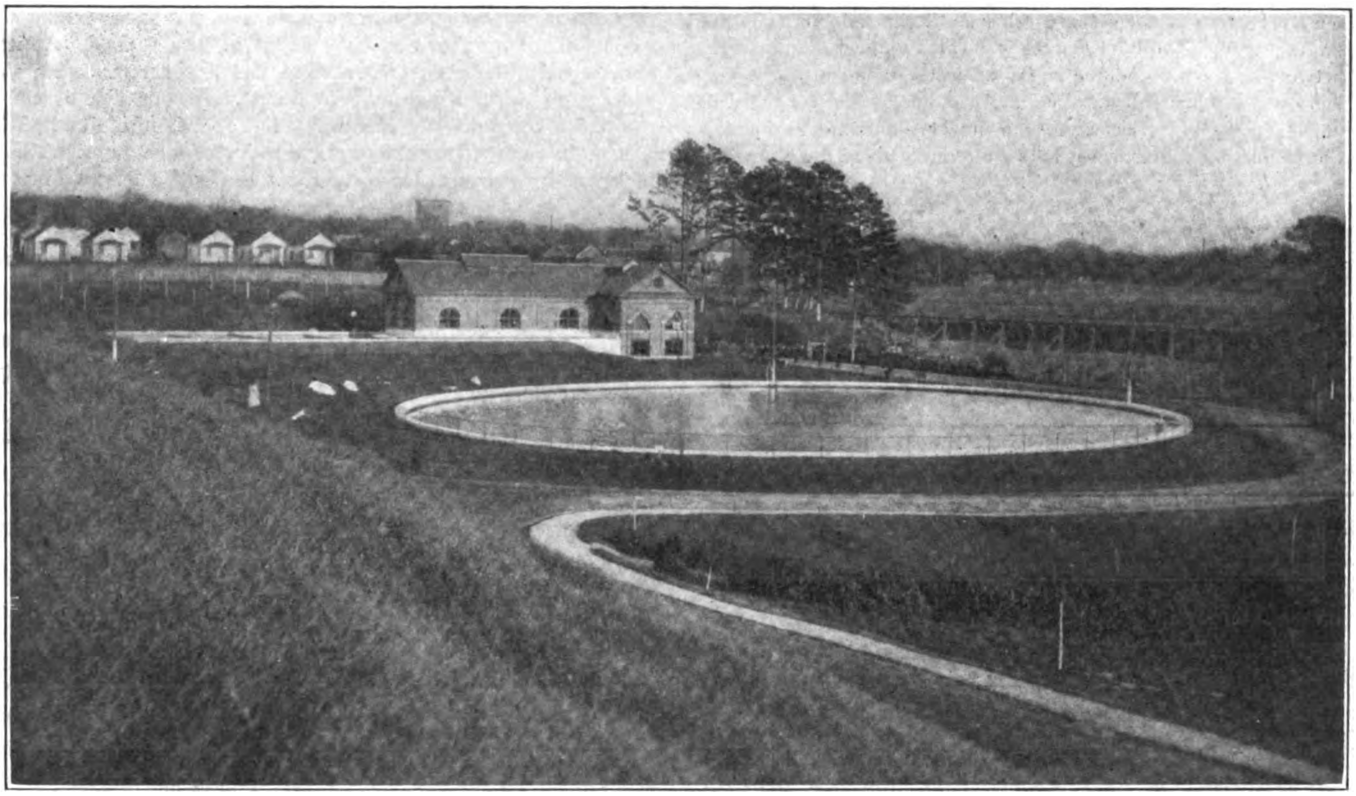
Municipal Journal
And Engineer

VOLUME XXX. NEW YORK, FEBRUARY 8, 1911 No. 6



Filtered Water Basin, Coagulation Basin and Filter House, Viewed from Reservoir

# COLUMBIA WATER WORKS

## Pumping by Hydraulic Power Plant—Turbines and Centrifugal and Plunger Pumps—Auxiliary Steam Plant—Purification by Mechanical Filters of the Gravity Type—City Under Commission Government

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COLUMBIA, the capital city of South Carolina, with a population of about 35,000, enjoys the distinction of being the only city in the State governed by a commission. The commission form of government, sanctioned by the State Legislature during the session of January, 1910, was adopted by the electors of the city in May of that year, and the commission, consisting of Mayor W. H. Gibbes and four councilmen, Messrs. R. J. Blalock, R. C. Keenan, R. W. Shand and W. F. Stieglitz, at once took charge of the affairs of the city.

Each commissioner, or member of the City Council, has been assigned to a department of the city government; one department embracing licenses, sanitation and health, and insurance and building permits; another the fire and street departments and markets and lighting; a third law and finance, schools and parks and trees, and the fourth water works and sewerage, public buildings and charities and the city jail. Each commissioner has direct control over his department, the council as a body exercising general supervision over the affairs of all departments.

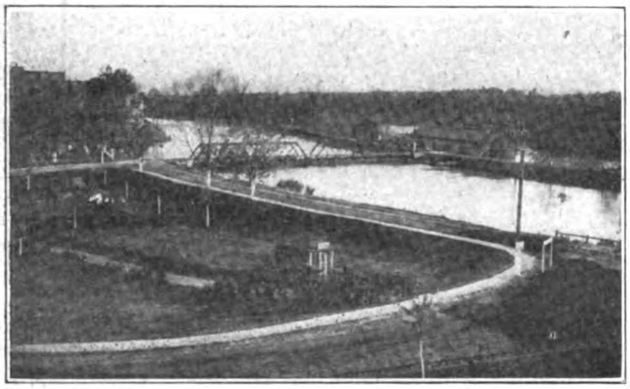
The city owns and operates its own water works. The water works department is under the direct charge of Commissioner W. F. Stieglitz as council superintendent, and Mr. F. C. Wyse as city superintendent of water works.* Water works for the city of Columbia were first authorized by the State Legislature in 1818, but a more modern plant was constructed in 1855, and the city replaced this with the present plant in 1907.

Columbia is at approximately the geographical center of the State. It occupies an area about two miles square and is quite uneven in topography, the highest point being approximately

150 feet above the Congaree river, which flows near its western boundary. At a point about opposite the northern boundary of the city the Broad river unites with the Saluda river to form the Congaree. The latter river has a fall of about 36 feet in two miles, and a portion of this fall is utilized for power purposes by several industries along its banks, a canal having been constructed for that purpose. Power from this canal is used by the city as one source of power for the water works pumping plant.

The water supply is taken from the Saluda river, the water-shed of which has an estimated area of about 2,475 square miles and contained in 1900 a population of 127,000, making the average population of the shed about 51 per square mile, most of which is consequently rural. The largest town on this water-shed has a population of about 5,000 and is distant about 50 miles from Columbia.

The power canal previously referred to parallels the Congaree river on its eastern shore. The water works plant is located on the bank of the river, the hydraulic power station lying between the canal and the river, while the balance of the plant lies on the other side of the canal. A bridge across the canal at this point gives access to the power plant and also carries the water mains between it and the remainder of the plant.



HYDRAULIC POWER STATION, CANAL AND BRIDGE ACROSS SAME, VIEWED FROM RESERVOIR

The hydraulic power plant comprises two turbine water wheels of 300 horsepower, which operate two centrifugal pumps, each having a capacity of 12,000,000 gallons per day, and two power pumps having a capacity of 3,500,000 gallons per day against the maximum pressure head contributed by the standpipe and friction in the distribution system. In addition to the hydraulic power plant there is an auxiliary steam power plant equipped with two pumping engines, each having a capacity of 5,000,000 gallons per day, the boiler plant for operating these being contained in the same building. This building also contains electrical generators which furnish power to operate the auxiliary machinery in the filter plant and for lighting the works. In addition to these pumping plants there are, immediately adjacent to them, a sedimentation reservoir, mechanical filter plant and filtered water basin; and at another portion of the city a standpipe.

As previously stated, the supply is taken from the Saluda river, the intake being near the junction of this and the Broad to form the Congaree. The intake crib is constructed of concrete and is supplied with two 30 x 30-inch sluice gates, the openings being provided with screens constructed at the outer face of the wall. From the intake crib a 36-inch suction main is laid in the bed of the Congaree river for a distance of about 1,000 feet, which ends at the pumping station in a suction chamber, which also is constructed of concrete.

The water power station, on the bank between the river and the canal, is a brick structure 29 ft. 8 in. by 97 ft. 2 in. Here are two horizontal turbines, each capable of developing 300 horsepower when operating with full gate under a head of 18 ft. and at a normal speed of 150 to 160 revolutions per minute. These turbines are duplicates and work independently of each other, having separate draft tubes discharging into separate tail-water chambers. Each of these turbines operates one centrifugal pump of the two-stage type and having a capacity of 12,000,000 gallons per 24 hours against a total head of 75 feet (including 21 feet of suction) when running at a speed of approximately 500 revolutions per minute. These pumps lift the water from the suction chamber into a raw water reservoir constructed on a knoll at one side of the plant.

The high duty pumps are two in number, of the horizontal, duplex, double-acting, plunger type, each with a capacity of 3,500,000 gallons per 24 hours against a head of 300 feet. These pumps are connected by gear wheels to the shaft of an independent turbine water wheel. They pump the filtered water into the distribution mains and standpipe, taking it from the clear water basin. The reservoir, which serves as a sedimentation basin, has an approximate capacity of 60 million gallons when filled to wthin 3 feet of the tops of the banks. It is built partly in excavation and partly in embankment, the banks having a top width of 10 feet and side slopes of two to one. At its highest part the main embankment has a concrete core wall ranging in thickness from 2 to 6 feet. At one side is constructed a concrete gate chamber 5 feet square inside and 36½ feet high, equipped with four 20 x 20-inch sluice gates. A 60-inch cast-iron drain pipe is laid for the entire length of the reservoir and to this are connected a 24-inch outlet pipe and a 24-inch waste pipe.

From the reservoir the water flows by gravity to a coagulation basin which is 52 feet wide, 100 feet long and 18 feet deep. Alum is used as a coagulant, and this and lime are applied to the raw water where it enters the coagulating basin, the amount of coagulant being accurately regulated by an automatic appliance. Close to the coagulation basin is the filter house, in which are two chemical tanks 6 feet in diameter and 6 feet high, provided with crates for holding the alum to be dissolved and an indicator gauge to show the amount of solution used per hour.

The filter house is a brick structure 128 feet long by 54 feet wide, with concrete floors. Here, in addition to the chemical tanks, are located the filters, which are six in number, of the mechanical gravity type, each having 400 square feet filtering area and designed for a capacity of 650,000 gallons per unit per 24 hours. The supply to the filters is controlled by automatic regulators which are designed to permit of variation of not more than one per cent. The filtering material consists of 30 inches of sand on a 6-inch bed of gravel. The filtered water from these is discharged into the filtered water reservoir, and from this is drawn the wash water, which is pumped to and through the filters by means of two 50-horsepower centrifugal pumps, each direct connected to a direct-current variable speed electric motor.

The filtered water reaches the filtered water reservoir through a conduit beneath the center line of the building and a 24-inch pipe. The filtered water reservoir is oval in shape, with inside diameters of 211 and 171 feet, and a total depth of 14 feet, with a capacity of approximately 2,500,000 gallons. The walls and bottom of this reservoir are constructed of concrete.

The auxiliary steam pumping station is a brick structure divided into two sections, a pump room 44 feet by 60 feet and a boiler room 41 feet by 60 feet. The stack is of brick, 5 feet in diameter and 120 feet high. There are four horizontal tubular boilers 72 inches in diameter. The pumping machinery consists of two Worthington horizontal, duplex, compound, condensing, direct acting pumping engines, each with a net capacity of 15,000,000 gallons per 24 hours against a pressure head of 288 feet, the suction lift being 12 feet. In this station is installed a direct-connected generating set having a capacity of 500 kilowatts at 250 volts, the engine being of the vertical type.

From the high-duty pumping plants the water is forced through a 24-inch rising main to the standpipe, which is located about one mile from the plant. This standpipe is of steel, 25 feet in diameter and 100 feet in height. A cut-off valve is located near the standpipe to provide for direct pumping to the distribution system around a by-pass, should this be necessary.

The distribution system consists of about 40 miles of cast-iron pipe ranging in size from 6 to 20 inches.

Frequent analyses of the filtered water are made by the city chemist, Mr. W. H. Beers, a complete laboratory for this purpose being located at the filter station. The following is a typical analysis of the filtered water:

SAMPLE OF WATER, COLUMBIA CITY WATER WORKS

| | |
|---|---|
| Color | None |
| Chlorine | 2.00 |
| Free ammonia | 0.04 |
| Albuminoid ammonia | 0.03 |
| Nitrogen in nitrates | 0.00 |
| Nitrogen in nitrites | 0.00 |
| Hardness (as parts of Ca $Co_3$) soap test | 25.00 |
| Total solids | 90.00 |
| Bacterial Analysis | |
| Coli-group organisms | None |
| Free from indications of contamination. | |

The entire plant was designed and constructed under the supervision of Mr. J. L. Ludlow, of Winston-Salem, to whom, as well as to Messrs. Stieglitz and Wyse, the writer is indebted for the information given herewith.

## DOUBLE FILTRATION OF WATER

In a paper with the above title which he read before the New England Water Works Association, Mr. H. W. Clark, chemist of the Massachusetts State Board of Health, described some experiments made and results obtained by that board in passing water to be purified through two filters in succession. At the outset he refers to the fact that the board, as long ago as 1894, suggested the double filtration of water.

Experiments conducted by the board all showed that as long as there is any impurity in a water, passing it through a fine sand filter will remove a greater or less percentage of such impurity. In one case water which had been filtered and stored for six weeks, during which a very great reduction in the bacterial content had been effected, was passed through a filter containing but ten inches of sand, which resulted in diminishing the number of bacteria remaining by from 65 to 85 per cent.

During the past five years the board has been endeavoring to answer the question: "Can an equally good result be obtained by double filtration with the two filters operating at such rates that a greater value of purified water per acre of combined filter surface can be secured?" During this time five double filter systems have been operated experimentally at the station, and Mr. Clark describes the results obtained from three of them as follows:

All of these filters were ordinary sand filters containing about 40 inches in depth of sand. In the first system the rates of operation were 10,000,000 and 20,000,000 gallons per acre daily, respectively, the rate of the primary filter being smaller than that of the secondary filter; in the second system the rates were 23,000,000 and 7,500,000 gallons per acre daily, respectively, the rate of the primary filter being greater than that of the secondary filter; and in the third system both filters were operated at equal rates, namely, 6,000,000 gallons per acre daily. The net rate of each system was 6,000,000 and 3,000,000 gallons, respectively; that is, the volume of water filtered per acre of filter surface used.

It seemed during the first few months of this work that greater efficiencies could be obtained by double filtration than by single and with the production of a greater volume of purified water per acre of filter. Taken as a whole, however, the results were as follows: Neither the first nor the second system gave results quite equal to the single filters shown on the previous table operating at a rate of 5,000,000 gallons per acre daily; neither did either system give results in coli efficiency equal to the single filter operating at the rate of 7,500,000 gallons per acre daily. With the system, however, operating at a net rate of 3,000,000 gallons per acre daily, the results were practically the same as with the single filter operating at a rate of 3,000,000 gallons per acre daily.

It is difficult to state just why this double filtration through much greater depths of sand than in use with the single filter does not always give better results than single filtration. One important reason seems to be, however, that the rate of the primary filter has generally been too great for good bacterial efficiency to occur; yet by this primary filtration the organic matter necessary to cause the secondary filter to be an efficient water purification plant has been removed. While we have some results differing from those presented here, still it does not seem reasonable to assume from all the results of Lawrence work that water of the character of that flowing in the Merrimac River can be purified more advantageously or more economically, as far as net product of filtered water is concerned, by double filtration systems than by a single filter operating at a reasonable average rate.

There is, of course, another reason that has been prominently mentioned for the operation of primary filters, and that is to lessen the area upon which the matter in suspension in the raw water is collected. This is a very prominent feature in the beginning of operation of such systems, especially when the primary filters are operated at rates approximating 100,000,000 gallons per acre daily. It always seems at first that much can be gained in this way; yet as these systems of double filtration are kept in operation at Lawrence, although the water passing to the secondary filter may remain free from matters in suspension, this secondary filter becomes an efficient biological machine, the sand grains throughout its depths become coated with the gelatinous matter necessary for this efficiency, and eventually these secondary filters at Lawrence require scraping almost as frequently and as deeply as if they were receiving raw water without primary filtration.

This, then, must be the conclusion from our Lawrence work: There is little to gain either in economy in sand removal or sand washing, or in bacterial efficiency, in double over single filtration of polluted water such as flows in the Merrimac River; that is, with an equal or nearly equal production of filtered water per acre of filter surface. We realize, of course, that each water presents a separate problem, and Lawrence results are not universally applicable.

We judge from experience elsewhere as well as from the fact that the main object at Lawrence appeared to be bacterial reduction, that these conclusions do not apply to waters high in clay and other suspended matter; although the experiments at Washington (described in our February 1 issue) apparently indicate that sedimentation is more effective than preliminary filtration in treating such waters.

## ELECTROLYTIC PURIFICATION

In a recent paper on water purification Mr. H. W. Clark, chemist of the Massachusetts State Board of Health, said: "There are so-called electrolytic methods of water purification in which the electric current is stated to act as a bactericide, but which, in the devices I have examined, simply causes the taking of aluminum from aluminum or composition electrodes and the formation of aluminum hydrate, really an expensive method of coagulation."

We have two or three times referred to a plant at Los Angeles, Cal., for treating sewage by an electrolytic process. It is unfortunate that there is not a State Board of Health or other unprejudiced scientific authority to investigate and report upon this plant. However, it has been operating for over two years and appears to be satisfactory to the officials of the city. In this plant the sewage first passes through sedimentation basins, and the cleaning of these is quite an item of expense in operating the plant. From a letter recently written by the city engineer and made public it appears that the cost of running the plant is in the neighborhood of $25 per 1,000,000 gallons purified; this including removing the sludge from the sedimentation basins, cost of current for operating the electrolytic plant and labor of attention to the latter, which occupies an hour or more every day. According to the tests made by a representative of the company which constructed the plant, the total residue was reduced from 103.3 parts in the raw sewage to 75.0 in the final effluent; the organic matter from an average of 2.24 to an average of 1.30, a reduction of 42 per cent, and the chlorine was reduced about 30 per cent. Nitrates were reduced from 7.4 parts to 4.4 and nitrites increased from zero to 3.0. Lime, magnesia and iron were reduced to from one-half to one-tenth of the contents of the raw sewage. The change in the nitrites and nitrates indicates a deoxidizing of the sewage, and it is stated that the nitrogen is finally converted by the process into ammonia salts. These results are obtained by the combined action of the sedimentation tank and the electrolytic treatment, we understand, and how much is due to each is not stated. These reports of the chemist and engineer apparently indicate a rather low degree of purification and a high cost of operation.