in operating expenses, just mentioned, make a total saving through the meters and other improvements in 1906 of over $190,000. This has all gone to the people in reduced charges for water.

The city obtained its water from an old tunnel extending only one and a third miles from shore prior to 1904. The increasing discharge of sewage into the lake from the rapidly-growing city so contaminated the water supply that the tunnel now in use was undertaken. It should have been finished in 1902, but the contractors, who were losing money on the contract, had not extended the tunnel a single foot for eleven months when the water department took direct charge of the work at the close of 1901 and completed the job by direct labor by the beginning of 1904. Immediately the deaths from typhoid per 100,000 population declined so rapidly that in 1906 there were only fourteen cities with a lower death rate from this cause among the thirty-eight cities having over 100,000 population. The death rate from typhoid in 1906 was 20.2, or less than one-third that of Cincinnati, Pittsburg or Philadelphia.

The plant has a structural value, according to careful computation, of about $11,000,000, and a bonded indebtedness of $4,441,000. The rest of the plant has been paid for out of earnings. During 1906 the earnings of the department were over $200,000 in excess of interest on the bonded indebtedness and such allowance for depreciation, to wit: 2 per cent on the structural value, as the experience of the last fifty years has shown to be necessary.

A private company would have paid taxes of about $100,000, which the public plant did not pay. On the other hand, a private plant would have charged for water for fire purposes, street cleaning and sprinkling, public parks and playgrounds, schools, and other public buildings, fountains, etc., over twice this amount.

Of the 70,000 services in use, about 57,000 are now metered, and the department has just bought 10,000 more meters, which it will set during the ensuing twelve months.

Large extensions of street mains are also well under way.

Bacteriological analyses of the water are made daily, and every effort is being put forth to make the department a model for other municipal undertakings, such as electric light, garbage works, street railways, etc., as the city is now undertaking, or may undertake in the near future.

BUFFALO

By Prof. A. C. Richardson, Buffalo, N. Y.

The first company which undertook to supply the citizens of Buffalo with water was the Buffalo and Black Rock Jubilee Water Company, which was organized in 1826 and incorporated in 1827. Before 1832 it had laid sixteen miles of wooden pipes, which were simply logs bored through from end to end, with one end sharpened to fit into the next log. Some of them are still dug up occasionally. The source of supply was the Jubilee Springs, on Delaware Avenue, near Ferry Street, and as this was higher than any

part of the district then supplied, no pumps were necessary. The Jubilee Water Works continued in existence, with commissioners of its own, in addition to the system next to be described, down to about 1898, and the land containing the springs belonged to the city as late as 1902.

This system supplied but a small part of the city, and in 1849 the Buffalo City Water Works Company was incorporated with a capital of $200,000, which might be increased to $500,000. There was trouble at first about raising the capital. The common council voted to subscribe $100,000, but this action was reconsidered, and the subscription was refused. At last, however, two Philadelphia contractors subscribed for enough of the stock to ensure the construction of the works, with the tacit understanding that the contract for the construction should be given to them. The work was begun in 1850, and completed in 1851, and the works were formally opened January 2, 1852.

The water was taken from the margin of the Niagara River, the inlet being situated on Bird Island Pier; and a tunnel about four feet in diameter and 330 feet long, running under Black Rock Harbor and the Erie Canal, connected this inlet with the wells under the pumps. Of these latter, there was but one at first, built in 1851, with a capacity of 4,000,000 gallons in twenty-four hours. Another was added in 1866, having a capacity of 6,000,000 gallons. The water was pumped into a reservoir which would hold 11,000,000 gallons, built on the block bounded by Niagara, Connecticut, Vermont Streets and Prospect Avenue, and was then distributed to the city by 33.9 miles of pipe of various sizes. This plant was the nucleus of the present water works, which have been extended and improved until they are now among the largest in the country. The pumping station is the largest under one roof in the world.

The charter of the company gave the city the right to acquire the plant at any time within twenty years from the date of incorporation, and in 1868 it was deemed necessary to do so. Accordingly, on May 7th of that year the legislature of the state authorized the city to issue bonds to the amount of $705,000 for this purpose. The purchase was consummated and the city, by three commissioners, one of whom was the then mayor, Chandler J. Wells, took formal possession of the plant August 17, 1868.

The systems above described were supplemented by a large number of wells in various parts of the city, and an old-fashioned pump with a long iron handle was a not uncommon sight on the street corners when the writer came to live in the city in 1883. All these, however, have long since been abandoned and filled up.

By the time the city took over the works in had become necessary to take measures for obtaining a more ample and a purer supply of water. Accordingly, in 1870, plans were made for extending the tunnel, duplicating it, and erecting a new inlet pier further out in the river. This work was completed and the water let in December 27, 1875. The new pier was located at a point in the river where the water is about sixteen feet deep and the current flows at the rate of seven to fifteen miles an hour. The two tunnels connecting it with the shore wells are about 985 feet long, and

together have a capacity of 350,000,000 gallons a day. There are now in the pumping station nine steam pumps of various makes and one electric pump, which together have a capacity of 212,000,000 gallons per day. Another large electric pump, for which bids have been received, will probably be added soon.

A new reservoir, on the block bounded by Best, Jefferson, Dodge and Masten Streets, was begun in June, 1889, and completed in July, 1894. It has a capacity of over 116,000,000 gallons when filled to a depth of thirty feet, and the surface of the water is then 113 feet above the level of the water at the inlet pier and 685.23 feet above mean tide at New York. As soon as the new reservoir was in use the old one was abandoned and shortly afterward pulled down. Its site is now occupied by the armory of the Seventy-fourth Regiment, N. G. N. Y., one of the finest and most imposing buildings in the city.

According to the reports of the water department the average per capita consumption of water was 319 gallons a day in 1903-04, and 336 gallons a day in 1904-05. This is an enormous consumption—greater than in any other city in the world. The calculation of it is based upon the plunger displacement of the pumps, with an allowance of 10 per cent for slip, or imperfect working of the pumps. But a special commission on water supply, appointed by the mayor in 1905, expressed in its report the opinion that the pumpage thus calculated is largely in excess of the actual pumpage, basing this opinion on the results of meter measurements on one of the larger pumps. If, however, a deduction of 20 per cent is made from the gross measurements, the average daily consumption per capita in 1903-04 would be 280 gallons, and in 1904-05, 300 gallons; and this is enormously greater than that of the largest cities in this country. New York, for instance, pumps 113 gallons per capita daily, Chicago 161.5, Philadelphia 221.9. It is quite certain that a very large part of the water pumped is wasted without doing good to anybody. For instance, in the fiscal year 1904-05, 7,795 buildings were inspected, in which 7,312 leaky fixtures were found; and the repairing of these fixtures made an actual saving by meter measurement of over 4,000,000 gallons a day. Last year a similar inspection of 3,131 buildings disclosed 2,849 leaky fixtures, the repair of which caused a saving of over 2,000,000 gallons a day. It seems likely, therefore, that if all waste could be eliminated the present supply would be not far from sufficient for the city at the present time.

Where meters are not used, the charges vary according to the size and frontage, from $2.50 to $9.00 a year, besides a special charge for each bath tub, water closet, hose-sprinkler, etc. The meter rate is six cents a month per thousand gallons for the first 22,500 gallons, and for all over that amount two cents a month for each thousand gallons; but no meter will be furnished unless the annual amount per meter is at least $5 for a ⅝-in. meter, $10 for a ¾-in. meter, and so on in proportion for larger meters.

"The change in our meter ordinance," says Buffalo's official report for 1905-06, "making a lower rate for the smaller meters, has put us in position where the smaller meters could be installed, and we have therefore placed

more meters than in any year previously; but we have still been hampered for lack of funds, or we should have placed a great many more. We have installed during the year 315 new meters, and now have 2,001 meters actively in use.

"The experience of all water departments is that a liberal use of meters causes a reduction in water used and makes a more equitable distribution of the water rates. . . . It does not reduce the legitimate use, but does stop the unnecessary waste, and almost invariably reduces the amount paid for the use of water, and thus becomes a benefit to all concerned."

The special commission above mentioned also says in its report: "While we believe that by a thorough and efficient system of inspection much of the unnecessary waste of water can be prevented, we also feel that this can be but a partial remedy, and that the only perfect remedy is the installation of a meter on every service, not only to limit waste in house services, but to exact equitable rates for water consumed, and to aid in the detection of leaks from street mains and service pipes.

"Yet we recognize that there is a strong prejudice against meters in the minds of many people, and therefore believe it to be better, instead of installing meters on all services at once, to proceed gradually, confident that before long the good sense of the people of Buffalo will indicate clearly to them that it is the proper system to adopt for the distribution of water and collection of water rates, just as it is in the case of gas and other supplies."

To quote again from the report of the special commission above named: "We believe that under ordinary circumstances the water supplied to the city through the present intake and tunnels is wholesome and good, but the evidence is conclusive to our minds that there are times when it is polluted to a degree which imperils the health of the city, and that the causes which produce this pollution are increasing in effectiveness, so that in the not distant future the water from the present source will become much more dangerous. . . . . The present intake is sometimes very seriously interfered with by ice, which checks and has almost stopped the flow of water to the pumps, causing great inconvenience to many consumers and a dangerous condition as regards fire. The objections to the present source of supply, intake and tunnel are so great that a new source of supply should be determined upon, adopted and brought into use at the earliest date possible."

The intake and tunnels have been already described. As has been said, there are nine steam pumps and one electric, the last named having been added to the plant in 1905. Most of the others are old, have seen their best days, and are expensive to run. They are housed in a building 640 feet long and 102 feet wide, located at the foot of Massachusetts Avenue, with the Erie Canal on one side and the New York Central Railroad on the other. This entire building has just been rebuilt entirely fireproof. There is a high-pressure service and a low-pressure service, both of which are connected directly with the pumps, which maintain a pressure of about fifty pounds per square inch at the pumps for the low-pressure service and seventy-five pounds for the high-pressure service. Besides this, the large reser-

voir, above mentioned, is connected directly with the former and supplies the mains when the consumption causes a lowering of the pressure from the pumps.

Besides the objections to our present water supply system which have been named above, there is the very serious one that it is the only one we have, and that there is no reserve plant to use in case of accidents. And the possibility of accidents was brought home to us forcibly in 1905 by the fact that a large lumber barge broke away from its tow, floated down the river and was wrecked on the Inlet Pier. It took many weeks to get her off, and many more to repair the damage to the pier. "The damage was worse than we had anticipated," says the last official report of the water bureau, "and very few people realize how close a call they had to having their source of supply cut off completely, so that it would take months to resume its use."

The special commission before mentioned was appointed in 1905 to devise remedies for the defects of the existing system; and in accordance with their recommendations plans have been made and contracts let for the construction of a new pumping station at the foot of Porter Avenue, a new tunnel and inlet large enough to supply 400,000,000 gallons daily to the pumps (this with an eye to the future growth of the city), the inlet to be located in the Emerald Channel, where pollution has been shown by a long series of observations and experiments to be impossible, and a branch tunnel connecting the new station with the old so that the new inlet can supply both. Then, when the new plant is completed and in use, the old intake and tunnels are to be closed so that no water can reach the pumps from them, while the old plant is to be kept as an auxiliary and reserve. The new system, it is estimated, will cost $2,800,000, and its construction is already under way.

The charter requires the water department to be self-supporting. It must pay all running expenses, including extension of mains and principal and interest of bonds issued for its benefit, out of its own revenues. The extension of the pipes is somewhat hampered by this necessity, as there is always a lack of funds for this purpose. All other obligations must be met first. For instance, there are about eight miles of pipe to be laid, the money for which has not yet been earned. If any surplus were left after meeting these obligations it would be turned into the general fund. But this state of things, according to an official in the comptroller's office, has never occurred since the city has taken possession of the water works.

SAN FRANCISCO, CAL.

By MURRAY GROSS, University of Pennsylvania, Philadelphia.

The City of San Francisco does not own a municipal water plant but is being supplied by a private corporation, viz., The Spring Valley Water Company.

Up to the sixth decade of the past century, San Francisco received its domestic supply of water from watering carts, wells and springs. Supplies for the hand fire-engines were drawn either from the bay or from large