kept at the level of that in the basins by means of a 2-inch connection from the valve well to the reservoir.

The new pumping station was built by Messrs. Floto Brothers, and the reservoir built and pipe lines laid by Mr. A. W. MacDonald, both of Steubenville, and are now under the charge of Messrs. D. J. Sinclair, Thomas Barclay and C. J. Foreman, trustees of the water department, and Mr. S. B. Curfman, who fills the offices of city engineer and superintendent of waterworks. The cost of the new works may be summarized as follows: Land, $3,796; road to reservoir, $4,108; engineering, $8,135; pumping station, wells, tunnel and intake, $44,272; pumping plant, including boilers, $37,934; reservoir, $24,328; pipe lines, $78,837; total, $201,410. The new works cost $7,900 less than was estimated by the designers. The total value of the old and new plants is $250,000. The operating expenses are about $9,650 a year, all told, and the interest charges are $6,850. It should be said in closing that the annual typhoid fever death rate is only 2.8 per 10,000 population, and the city has two complete systems of piping, one for domestic purposes at 45 pounds pressure, and the other carrying water at 110 pounds pressure for fire protection and hydraulic motors.

TUBE WELL EXPERIMENTS AT LOWELL, MASS.

At the Portsmouth meeting of the New England Waterworks Association, one interesting paper was presented by Mr. George Bowers, City Engineer, of Lowell, Mass., describing the results obtained with the third set of tube wells sunk for the waterworks of that city.

This plant is located on a strip of land owned by the city. A line of wells was laid out and driven about 34 feet south of the south line of the Boulevard and parallel to it, being about 500 feet from the river. Sixty wells were driven on this line, those on either end yielding so small an amount of water that the line was not extended. Twenty-six of these wells were connected temporarily and pumped four days, yielding 570 gallons per minute; during this test the ground water was lowered 12 feet, and later 29 of the whole number were pulled up, their yield being insufficient to warrant their being retained in the plant.

Another line of 66 wells was then driven parallel to the first and 280 feet nearer to the river; these were connected and tested in groups of 20 each, the average yield per well, when pumped in this manner, being 25 gallons per minute. Samples of water collected from these wells and analyzed showed the presence of free ammonia and iron, in consquence of which they were abandoned and the pipes pulled up. A line of 22 wells was next driven at right angles to those connecting with the line first driven; when these wells were tested all but five proved good.

The next wells were laid out and driven in a line parallel with the first two lines described and 170 feet south of the one first driven. In this line are 122 wells which have been tested for quantity, in groups of from 15 to 20 wells each. When the water here was analyzed each supply was found to be of excellent quality. The plant contains 169 2½-inch wells which vary in depth from 27 to 40 feet. They are driven wells and a very large point was used to protect the screens in driving. The screens used here varied in length to correspond with the depth of the water-bearing stratum at each well; this lies about 25 feet below the surface and varies in depth from 5 to 15 feet. The earth above this stratum is composed of very fine sand and river silt, which is almost impervious to water. Between this bed of water-bearing sand and bed rock is a quicksand, varying in depth from 30 to 40 feet, in which no water is found even at the surface of the rock where it is generally found. The wells are connected by flanged suction pipe of the following sizes: 20-inch, 13 feet; 14-inch, 1,152 feet; 12-inch, 326 feet; 10-inch, 170 feet; 8-inch, 130 feet; 6-inch, 265 feet—total, 2,056 feet. On every length of the suction pipe is cast a 2½-inch branch connection, at an angle of 45 degrees to the main pipe; this causes all the pipe to be classed under the head of specials. This is far better than the custom of connecting one or two lengths of pipe with a short branch special, as it greatly reduces the number of joints, a very important item in work of this kind.

The connection of the suction pipe with the well is made as follows: Into the branch is screwed a piece of 2½-inch pipe, to which a gate of the same size is attached; next is placed a piece of lead pipe about 3 feet long with a flanged joint nearest the well, and last, a piece of 2½-inch pipe of the right length to make the connection with the curved tee joint at the well. This is a very easy way to connect the wells, as the lead pipe may be used to correct any small error in line or grade, a difficult undertaking with iron pipe. A lead pipe should never be used for a water supply until it is known that it will have no effect upon it, and, as the service pipes in Lowell are lead, this was the first problem to solve.

The suction mains are connected with a large horizontal air receiver 11 feet long and 6 feet in diameter, and each pump is connected independently with the receiver. The suction mains are laid about 3 feet below the surface of the ground on a pile foundation, on a true grade declining from the pumps. Great care was taken by the contractor in making the suction mains, branches and all connections air-tight. Every pipe and special was tested for air before it was laid, and many of them which had passed the water test were found defective under this test. Of the first shipment of pipe more than half were found by the air test to be defective and were returned to the foundry. Most of the small specials found in stock were defective also, and the contractor was obliged to order extra heavy ones made to meet the test. All the testing for air was done in the field; this was done by connecting the piece to be tested with a pump and forcing air into it while submerged in a tank of water. That this was a wise precaution has been well proved, as this plant has been very free from air.

The air receiver is placed in the pump pit, which is 26x28 feet, and with it are connected two 10x18x10-inch Blake pumps, each having a capacity of 3,000,000 gallons per day. As the pumps deliver the water into a conduit only 4 feet above the plungers, their work is very light. Over this pit is erected a temporary building, and when this is replaced by a permanent one and permanent pumps put in, Mr. Bowers sees no reason why this plant should not be run by electricity, generated at the central pumping station, as economically as by a separate steam plant.

The contract for this plant was similar to that of the others, the contractor agreeing to furnish a plant capable of providing a stated amount of water per day during a year's test for a given price per million gallons, and, in addition to this, was paid for all the water delivered which was pumped during the year. On April 30, Mr. Bowers' certificate was sent to the Water Board, stating that the contract between the City of Lowell and B. F. Smith & Brother was completed, and that the contractors were entitled to the full payment for 3,000,000 gallons, also a supplementary contract for 1,500,000 gallons, making 4,500,000 gallons in all. This plant has never been pumped to its limit, the amount of water the contractors were allowed to pump each day being fixed by the superintendent of waterworks.

The City of Lowell has now an abundant supply of water of excellent quality. The first plant, built by the Cook Well Company, of St. Louis, was accepted and paid for as a 2,500,000-gallon plant in September, 1893, and it has continued to supply that quantity when wanted ever since. The second plant, built by the Hydraulic Construction Company of New York, was accepted in April, 1896, as a 3,000,000-gallon plant. During its year's trial the company pumped 1 [illegible] 961,983 gallons, being at the rate of 3,109,186 gallons per day. The third, just described, is called a 4,500,000-gallon plant, although it has yielded 5,000,000 gallons and is capable of doing so when necessary. This makes a total of 10,000,000 gallons per day when running in a normal condition. This amount could, of course, be increased very much in case of emergency. The average amount of water used by the city for the year 1897 was 6,594,364 gallons per day, and the average amount for the month of January, that being the month of greatest consumption, was 7,422,483 gallons per day, showing that for the present, at least, there is an ample surplus.

It will be readily seen from these figures that it is unnecessary to use the three plants all the time. In fact, one is held in reserve most of the time. By this arrangement any repairs can be very easily made, as either well plant can be shut off and the city's supply of water taken from the other two. The quality of the water has from the first been excellent, and now that the quantity is assured, Mr. Bowers is entirely satisfied with the result of tube-well experiments in Lowell.

It should be added that the full paper and discussion will appear in the "Journal" of the New England Water-Works Association, which has already printed papers on the two earlier plants.

HISTORY OF THE BUFFALO WATER WORKS.

Some time ago Mr. Edward B. Guthrie, M. Am. Soc. C. E., prepared a historical sketch of the Buffalo, N. Y., water supply, which was an interesting account of the growth of one of the largest plants in this country. Parts of the paper were of local interest chiefly, although a large portion was of general engineering value, as will be seen from the following abstract:

The earliest mention of the water supply which Mr. Guthrie could find was in a paper by S. Ball, printed in 1825, in which the city was stated to be wholly dependent on wells 10 to 30 feet deep. Four fire cisterns holding 10,000 gallons each were ordered built in 1831 at as many street corners. These were of brick, with arched tops, and often served a useful purpose of late years after the steam apparatus had replaced the old hand pumps. They were filled with water hauled from the canal in a large cask.

The first water system put in operation in the city was that controlled by the Jubilee Springs Water Company, which began operations in 1826, and developed a number of springs. Log pipes were used, and some have been found in good condition in recent years. Sixteen miles of pipes were laid up to and including the year 1832. The old stone house covering the springs is an odd sight on Delaware avenue, the principal residence street of the city. Another singular fact is that water from these springs is still permitted to be used by a portion of the community. For some years and at present, the business of the system has been conducted by a board of commissioners, and is sustained practically by the city.

In January, 1843, the trustees of the first ward were authorized to make a contract for laying pipes to bring water from the Jubilee Springs through the principal streets of the ward. A contract was made in 1845 for an aqueduct of logs 10 and 12 feet in length, not less than 11 inches in diameter at the small end, and bored out to 4 inches inside diameter, which were joined together with cast-iron thimbles having a flange in the middle tapering off a little to the end. The pipes were banded at each end with a strap of good American iron, 1¼ inches wide, ⅛ inch thick and 7½ inches in diameter. The contract price was 11¾ cents per foot length. Excavation was paid for at 22 cents per cubic yard in the woods, and 10 cents per cubic yard clear digging. By these log pipes, without intervention of pumps, and supplemented by wells, the city was supplied for nearly half a century, or until it had a population of about 50,000.

The company which developed the nucleus of the present plant was started March 15, 1849, with some of the leading citizens as incorporators. The capital stock was $200,000, with power to increase to $500,000, the city reserving the right to purchase the same in 20 years.

The plan was to draw the supply from Niagara River, as the charter of the company forbade taking water from the harbor or Buffalo River. A cistern and two high-pressure engines were to be constructed on the shore, and water forced to a 7,000,000 gallon reservoir. This was to be 600x260 feet in plan, 18 feet deep, and formed by an embankment 18 feet wide on top and 54 feet at the bottom, with a stone and brick lining. Thirteen pipes from 4 to 16 inches diameter were to distribute the supply from the reservoir throughout the city. The company had some doubt as to the plans, so it retained the late William J. McAlpine to pass on them. He did so, suggesting certain modifications, and the works were built by Battin & Dugan. Water was first distributed to the city on January 5, 1852, A. P. Ketchum being superintendent at the time. On May 1, 1854, there were 1,036 consumers, and on January 1, 1864, 32½ miles of pipe had been laid and there were 2,498 consumers.

The tunnel, as constructed, started west of the face of the Bird Island pier, and forms what is now known as the Bird Island inlet, which was used in March, 1894, when the supply of water through the main tunnel was diminished by the pressure of large accumulations of ice. The two pumps put in were of 2,000,000 gallon capacity each, of the Cornish type with vertical plungers, supplemented in 1867 by a Shepard engine with a capacity of 6,000,000 gallons, which was built in Buffalo.

As the years went by, friction arose between the city and the company as to the kind and character of the water furnished, the number of hydrants for fire service, and other subjects, as is often the case in communities with a water supply under private management. In 1858, steps were taken to issue city bonds for a new supply, and in 1866 and 1867 reports were obtained from John Ditto on the cost and advisability of several different supplies. The company's plant was finally bought by the city in August, 1868.

The works was placed in the hands of three commissioners, whose successors continued in charge of the department until 1893, when it was turned over to the Board of Public Works, and became the Bureau of Water.

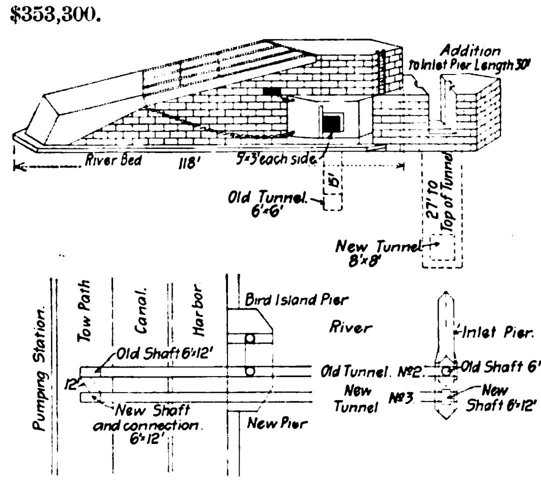
There were two old engines and one new one, 35 miles of pipe, a reservoir of 13,000,000 gallons capacity and a short tunnel in the plant at the time of purchase. In 1869, specifications were asked for a plan for increasing and improving the system, and 13 plans were submitted.

One of the provisions to be considered was the feasibility of using the flow of the Niagara River to operate the pumps, and prizes of $2,000, $1,000 and $500 had been offered for the best three plans. The first prize was awarded to Thomas Dark, Sr., who submitted a plan practically that of tunnel No. 2 of the present plant, though different in detail. In addition to an intake tunnel it included a 21,900,000-gallon reservoir and filtering basin for filtering 28,000,000 gallons per 24 hours on 51,684 square feet, or 3 pints per square foot per minute.

Early in 1870 steps were taken to construct a tunnel and pier in accordance with these plans. Bids were received, but only after a severe struggle in the Council, mainly over the question as to location. Clark & Douglass were awarded the contract at $170,000 for the construction of the tunnel to a point about 700 feet west of the Bird Island Pier, together with the intake in the river, shaft, and other work. This intake was to have been a pier 45x25 feet on the bottom with ½ inch batter per foot. In April, 1871, City Engineer John Ditto submitted plans for a change in the character of the intake, for he believed that the pier contemplated was inadequate to withstand the force of the large fields of ice moving in the eight-mile current.

Finally the contract price was increased to $240,000. In March, 1872, the contract was further changed by extending the tunnel to 1,000 instead of 700 feet in length, the increase in cost being $109,000.

Another change was made afterward by shortening the tunnel to 878 feet on account of the difficulties, and deducting $18,300 from the contract; at the same time the Council allowed the contractors an additional $22,600 on the ground that this was the increased expense of the change in the location of the intake pier. At this time the tunnel and pier had cost $353,300.



INLET PIER AND TUNNELS, BUFFALO.

Affairs seemed to go from bad to worse notwithstanding the concessions in the original price, so that it was decided to release the contractors and re-advertise for the work. The new contract was awarded to John Hickler for $117,324, in July, 1873, and another for $65,000 in November of the same year.

Under the first contract the pier was completed in 1874 and it was supposed the tunnel would soon be completed, but this was not the case. Finally a report was made to the Council that the contractor has been paid $31,383.75, and as he would not complete the work, that the same should be abandoned and proposals be re-advertised for completing it. This was consumated. The tunnel was finally completed by day labor on December 27, 1875, on which date water was passed through it. The total cost, including the new inlet from Bird Island, was $519,403.

This tunnel was to have been an oval, brick-lined conduit; as finally constructed it was without lining and from 4½ to 10 feet by 9 feet, with an iron shield about 6 feet in diameter, located about 130 feet east of the intake. This was put in to shut off the water, which came in through large seams near the bottom of the tunnel at that point.

The length of the tunnel from the shore shaft to the shaft at Bird Island Pier is 320 feet, and about 1,020 feet to the center of the inlet pier. Its capacity at mean water level is over 125,000,000 gallons in 24 hours. It is driven through limestone, having seams through which came quantities of troublesome sulphur water. The work was carried on without the use of compressed air. It was thought there was a direct connection between the tunnel and the river by way of the seams, but this proved not to be the case. Pumps of large capacity were put in, and finally the work was completed. The seams struck in the last tunnel, through which large quantities of water pour, are at about the same location as those encountered in No. 2 tunnel, and are probably connected with it.

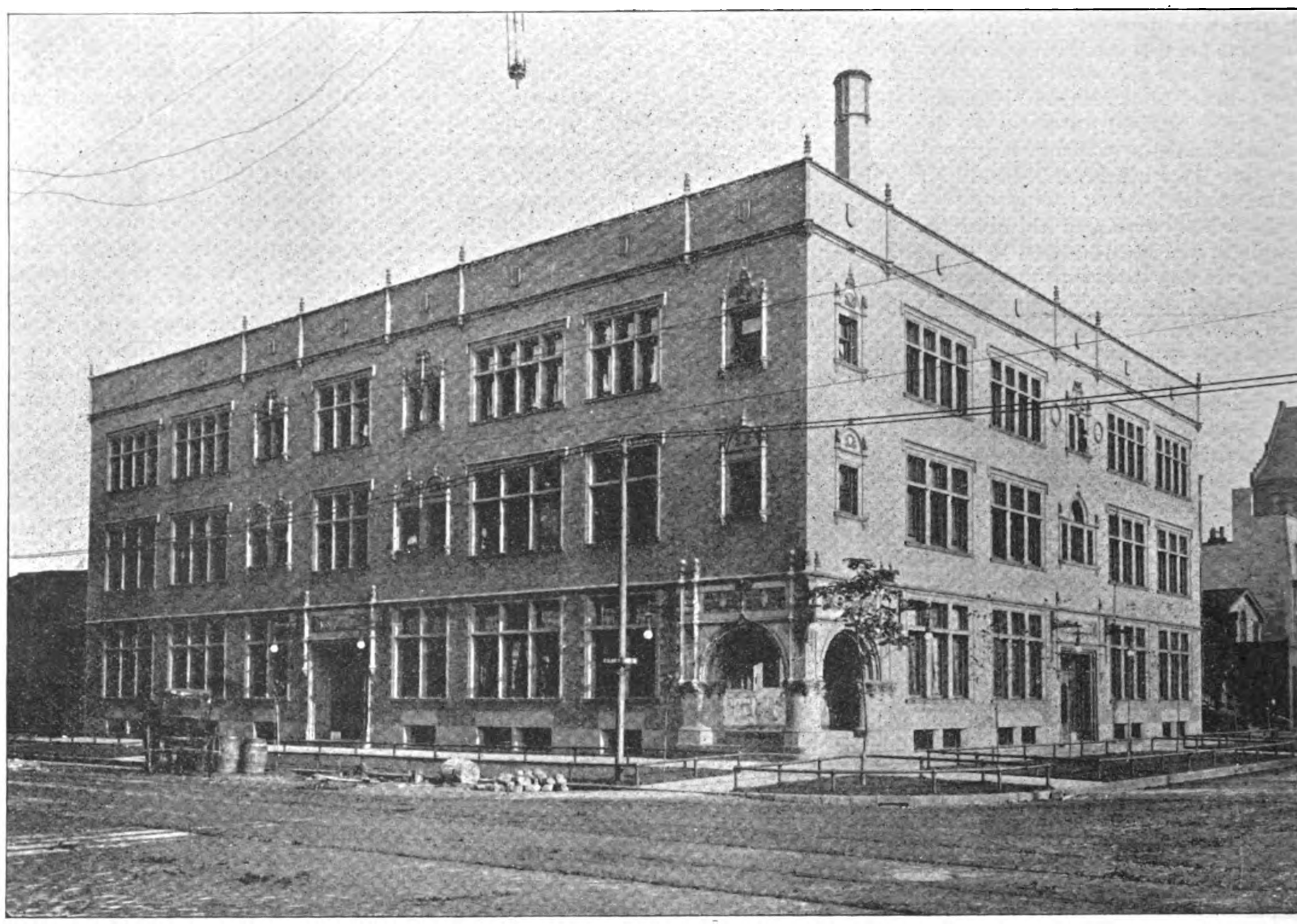
The intake pier as first planned was about half the size of that finally completed, which is of limestone, 118x22 feet on the base and 32½ feet high, having an irregular hexagonal top of 36x16 feet. It has a long sloping nose facing upstream, on which floating ice and débris can rise without injury to the structure. The first contractors, Clark & Douglass, are said to have lost several cribs in attempting to locate this pier, and had made no progress upon cancellation of the contract. The second contractor, J. Hickler, succeeded in constructing it with an open caisson or timber crib in about 15 months, though with great difficulty on account of the rapid current at this point. The pier is connected with a tunnel through a circular shaft 6 feet in diameter, the water being brought to the shaft through two rectangular inlets 5 feet high and 3 feet wide, one on each side of the downstream end of the pier. The sills of these inlets are about 8 feet 9 inches below the mean water-level. The capacity of the inlet at a stage of water 3 feet below mean water level is 115,000,000 gallons a day, which was the capacity of the pumps prior to the installation of the last 30,000,000-gallon pump. When the water level fell still lower, the flow into the shaft was reduced, and when this level was about 1 foot below the lintel of the inlets, only 72,000,000 gallons could enter. The incapacity of the inlets, together with the trouble from ice, gave rise to the shortage of supply late in the winter and early in the spring. The trouble from ice was further aggravated by the fact that the ratio of inlet area to shaft area was only 1.06 to 1, so that the velocity through the inlets, when the pumps were run to their full capacity, was about 6 feet per second. This velocity, of course, would carry into the shaft whatever came on the surface and increase the trouble from anchor ice.

Since the completion of the pier, shields of plate iron have been placed outside and about 2 feet in front of the masonry surrounding the ports to protect them from surface ice. There are gates in these shields in front of the ports, which can be closed in winter, thus requiring the water to pass down and up again between the shields and pier before entering the ports. This has given rise to some difficulty, as the water at low temperature comes in contact with the cold surface of the iron and masonry and causes the formation of more ice, requiring continual watchfulness to maintain the flow. During recent winters a steam boiler has been placed on the pier to keep the surface warm and thaw the ice to prevent this trouble. During the short time it has been in use it has met expectations.

When the city first purchased the works there were two old Cornish pumps and the new Shepard pump, with a total capacity of 10,000,000 gallons. In 28 years there has been an increase of 135,000,000 gallons or 1,350 per cent. in the plant, whereas the increase in population has been from 117,000 to 362,000, a total of 245,000, or at rate of 210 per cent., so that by a very rough comparison there has been an average increase of 5,000,000 gallons per day in the pumping capacity of 9,200 in the population.

In 1895 it was evident that more water was needed, so Mr. Guthrie recommended that temporary relief be provided by a tunnel driven parallel to the original one to an extension of the existing pier, so that the trouble from ice would be lessened, and the demand for water met until such time as a new plant could be built. This tunnel, No. 3, has been constructed and is 8 feet in diameter and about 1,000 feet long.

The tunnel contract was given in July, 1895, to A. C. Douglass, at $65,000, and the extension of the shaft was sublet by Mr. Douglass to Hingston & Woods, for $35,600. Mr. Douglass had great difficulty in pushing this work, which was



THE GOODRICH HOUSE, CLEVELAND, O.
COBURN, BARNUM, BENES & HUBBELL, ARCHITECTS.

done on the open system, without the use of compressed air, relying upon pumps. Comparatively little difficulty was experienced until the work reached about the same point where the seam was located which caused such trouble in tunnel No. 2. Here great difficulty was encountered from water, and the tunnel was finally completed by the use of compressed air, as described in "The Engineerng Record" of December 18, 1897.

The financial record of the plant to January, 1897, is as follows: Purchase and extension, $8,587,824.62; interest, $4,644,409.62; operation, $3,181,512.27; total, $16,413,746.51.

The receipts in this department in this time have been: Water rates, $10,228,258.84; bonds, $4,029,382; appropriations, $1,693,612.52; total, $15,951,253.36, or $46,493.15 less than disbursements. The bonds outstanding at this date were $3,565,882.

It will be seen that practically, though the water rates are low at the present time, about 60 per cent. of the old plant and its extensions, operations, and interests have been paid for by the water receipts.

"We have a plant of 145,000,000 gallons daily capacity, and a population of approximately 375,000." Mr. Guthrie writes, "and such a plant ought to be able to take care of a city having a population of a million and upwards. In my mind such methods cannot be carried on indefinitely on the old theory that water should be as free as air. It means not only this continual increase of pumping plant, cost of maintenance and repairs, but also laying mains of greater size to maintain the pressure than is necessary. There is no solution to this but to require the people to pay for what they use. There is no hardship in this. There is nothing else we have except it is paid for in this way, though I am aware the prevailing opinion is that everyone should, at a minimum cost, be allowed to run all the water they desire, whether it is put to a useful purpose or not, which simply means pumping additional water, so that more can be carried off through the sewers to the river. This does not seem sound policy. There is no desire to require the people to be curtailed in the rightful use of water, but this abnormal waste does none any good, which can be readily seen, for if the average was cut down one-half there would still remain a quantity which is very much above the average of that used in the large cities of the country."

The records of consumption are somewhat indefinite, for some years an allowance has been made for slip of pumps, while most of the time no such allowance has been made, or is not mentioned if it was. The average pumpage increased from 5,500,000 gallons, or 50 gallons per capita daily in 1870 to 95,000,000, or 254 gallons per capita in 1896.

THE GOODRICH HOUSE, CLEVELAND, O.

Much study was involved in the planning of the building known as the Goodrich House, at the corner of Bond and St. Clair Streets, Cleveland, O., which was recently completed for social settlement work. In view of the number of buildings of this character that are being erected it has been thought worthy of description. Messrs. Coburn, Barnum, Benes & Hubbell, of Cleveland, were the architects of the building and Mr. George S. Rider was the consulting and mechanical engineer.

The house, as shown by the accompanying elevation, is designed in the Gothic style, ornamented with Spanish Renaissance detail. The building consists of basement, first, second and third stories. In the basement are located the engine, boiler and pump rooms, private laundry, store room, bakery, refrigerating plant room, locker room, shower bath, boys' lavatory and bowling alley. On the first floor are the restaurant, kitchen, kindergarten and kitchen garden rooms adjoining, gymnasium and audience room combined, reading room, office of the head resident, and lavatories. On the second floor are located the general reception room or parlor, sitting room, women's bathrooms, resident physician's office, men's and boys' club rooms, game room, class rooms and linen room. On the third floor are located the private parlor, the various chambers in which the residents of the house live, women's bathrooms, private bathrooms, store room and a large, unfinished part which will eventually be completed as the needs of the house require. The building is built of brick and terra cotta. The basement and foundation walls are built of hard burned common brick, laid with grouted joints in Sandusky Portland cement mortar, upon footings of, first, a concrete course of 1 foot thick by 4 feet wide, then a 10 inch x 3 foot bluestone course, for all outside walls, and proportionate footings for inside walls. The face brick are impervious and of the common shape. The terra cotta is quite ornate in portions. The face brick and terra cotta are laid with La Farge Portland cement, to prevent staining and efflorescence. This work is backed up with, and the interior of the walls built of, hard burned common brick laid with shoved joints in native cement mortar.

The house is built on the slow-burning construction plan. Floors are made of 2x4 inch and 2x5 inch joists, spiked solidly together, resting on steel beams and on brick walls. The steel columns which carry the steel beams are encased with Portland cement fireproofing. The partitions are made of 2x6 inch studding, covered with wire cloth lath, with ceilings treated in the same manner, and all steel beams are so encased. The beams in all cases are exposed on the ceilings. Quartered oak is used throughout for window and door casings, and all other finish. All wood is finished with a dull rubbed varnish finish. The floors are quarter-sawed oak filled with beeswax filler, and finished with shellac. The walls are of common lime, sand and hair plaster, tempered with Portland cement and left in a rough sand finish. All walls are finished with three coats of paint, the last coat being stippled. The floors of all bathrooms and lavatories are made of "granito," laid upon concrete and steel bar fireproofing, and are finished with a marble base upon which rests the paneled wainscoting.

The steam for furnishing power and heat to the entire building is generated by two boilers equipped with automatic stokers. All the water