conveys the water, 3,891 ft. to Lake Clifton, which is elliptical, 1,700 by 1,000 ft., of 80.25 acres area, and 31 ft. deep, with its surface 168 ft. above tide. Provision is made for six 40-in. mains for distribution from this reservoir. Two of these mains will be put in use.

The tunnel from Loch Raven to Lake Montebello was begun in December, 1875, and completed in November, 1880. It is straight for seven miles, and is 65 to 900 ft. below the surface, and for six miles is through hard blue granite. A tunnel for one mile through limestone, in which large quantities of water, many fissures, and several pockets of semifluid material, were encountered. Fifteen shafts were sunk, and the headings were left at 32-ft. points; 11,691 ft. of the tunnel were arched. All drilling was done by hand, and by blasting with giant powder or dynamite.

The tunnel cost for excavation $1,862,598.62, and for arching, cleaning, and filling the shafts, $297,651.32.

The cost of the new permanent supply works to Dec. 31, 1880, had been $4,704,260.83.

All distributing pipe are of cast-iron. Changes in the distribution system have been made within the last five years, by which the head and circulation have been much improved. The amount of small mains removed and replaced was 1,467,091 ft. of pipe, 2-in. and 4-in. pipe is kept up. Of 1,467,091 ft. of pipe now in use, 981,954 ft. are of less than 6-in. diameter.

There are about 49,000 water takers; 954 meters are in use.

The population and pipsage every tenth year have been as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Population</th>
<th>Mile of pipe</th>
</tr>
</thead>
<tbody>
<tr>
<td>1828</td>
<td>80,020</td>
<td></td>
</tr>
<tr>
<td>1840</td>
<td>190,614</td>
<td></td>
</tr>
<tr>
<td>1850</td>
<td>397,364</td>
<td></td>
</tr>
<tr>
<td>1860</td>
<td>724,148</td>
<td></td>
</tr>
<tr>
<td>1870</td>
<td>897,584</td>
<td></td>
</tr>
<tr>
<td>1880</td>
<td>1,157,160</td>
<td></td>
</tr>
</tbody>
</table>

The consumption is not given in the reports, and does not seem to be known.

The Water Department is in charge of the Mayor and Fire Commissioners. James H. Siler was "Water Engineer" from 1837 to 1887, and James Curran has held the position since that time.

The works of additional supply have been in charge of R. K. Martin, C.E.

The expenses and revenue of the works for the eleven years ending Dec. 31, 1880, were as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>5,528,507.00</td>
</tr>
<tr>
<td>Interest on bonds</td>
<td>3,609,439.23</td>
</tr>
<tr>
<td>Maintenance and extension of old works</td>
<td>2,409,029.94</td>
</tr>
<tr>
<td>Total revenue</td>
<td>10,723,630.00</td>
</tr>
<tr>
<td>Outstanding bonds, December, 1880</td>
<td>9,000,000.00</td>
</tr>
<tr>
<td>Total expenses</td>
<td>10,723,630.00</td>
</tr>
<tr>
<td>Total expenses</td>
<td>10,723,630.00</td>
</tr>
</tbody>
</table>

In 1881 the waterworks put in charge of a Board of Directors from the Common Council.

In 1875 a condensing engine, designed by Geo. Shields, was built, with upright cylinder of 45-in. diameter and 96-in. stroke. The double-acting plunger pump is below the cylinder, and of 18-in. bore. A stormy day, the driving being done by a cracking rod from the piston rod.

In 1854 a duplicate of this engine was built. The pump cylinder of this was bored to 18 1/2 in. in 1879. These two engines are now used exclusively for the low service, pumping against 185-ft. head.

In 1865 a condensing engine, designed by Geo. Shields was built. The steam cylinder is of 100-in. diameter and 144-in. stroke, vertical, and beneath a double-acting plunger pump of 45-in. bore. Before 1874 this engine could not run faster than 5 double strokes per minute, and the force-main was supple-tied by high water in the river, which rose over the steam cylinders. In 1881 the engine-house floor was raised to about 2 ft. above the high water of 1874.

In 1865 a condensing engine, designed by T. R. Scowden, was built, with upright cylinder of 45-in. diameter and 96-in. stroke. The double-acting plunger pump is below the cylinder, and of 18-in. bore. A stormy day, the driving being done by a cracking rod from the piston rod.

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to the Continent, he inspected the celebrated sewers of Paris and the fields of Genevilliers, where the sewage is utilized. Especially interesting were the cities of Hamburg, where the first systematic sewage works were built; Frankfort-on-Main, the best-modelled city in the world; Berlin, which on account of its size, the absence of a large river, and being nearly on a dead level, offers a most difficult problem in drainage; and Munich, where elaborate studies have been made, in investigating its preparation for the entire re-sewering of the city. Next in interest were Vienna, where this matter has been very thoroughly treated; Zurich, whose engineer is the pioneer; Continental sewage improvements; and Amsterdam, where the best example of the much-talked-of Lierum system can be seen. He had the pleasure of meeting nearly all of the prominent engineers and sanitarians interested in sewage in England, France and Germany, and returned on the 18th with perhaps the most complete collection of books, reports, drawings, specifications, etc., on this subject to be found in the United States. Mr. Hertag has for several years past given special attention to sanitary engineering, his position as engineer in charge of the sewage system of his native city, giving him particular advantages, to which he has added the benefits of unceasing study and observation. Already regarded as an authority on sewage matters, the experience of the past year of travel and study must place him in the front rank of that branch of the profession which is now rising to special prominence in Europe and America. In order to recuperate from the effects of hard work and climate, Mr. E. L. Cortissell, Assistant Engineer on the Survey of Capt. Eads' Tehuantepec Ship Railway route, has returned, and is at present with his family at North Egremont, Mass. Many miles of travel in England, required to complete the work left unfinished by the auxiliary Mexican Commission who assisted Capt. Eads in his exploration. A line through from city to city, not only accomplished by the commissioners, is the work to be done, and this work Capt. Eads is doing without the assistance of the government. Capt. Eads is now in the city of Mexico, securing the ratification of his concession by the Mexican Congress. THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.*

BY J. JAMES B. CROUSE, M. AM. SOC. C. E.

(Continued from page 158.)

CINCINNATI, CONTINUED.

Eden Park Reservoir was begun in 1866. The upper basin was brought into service in 1875, and the lower in 1878.

It lies in a deep, rapidly-descending ravine, and, to utilize it for reservoir purposes, a retaining wall was constructed, 119 ft. high, 485 ft. wide at the base, 23 ft. wide at bottom of reservoir, and 35 ft. wide on top. Its extreme length is 1,851 ft. It contains about 78,000 barrels of building stone. The support of the part of road-way there are 8 elliptical arches constructed on the outer face of the wall, each 55 ft., by 18 ft. rise. These arches, as the copings and plinthea, are faced with dressed Dayton stone.

The southwestern portion of the lower basin is of filled ground 85 ft. in depth. The division wall is 80 ft. wide at base, 30 ft. at 40 ft. in height, and is divided into efficient and influent chambers. At the west end of this wall the effluent chamber is located, and the influent pipe at the other end. The outlet for effluent pipes was made by tunneling through the rock. The structure is made of four courses of brick on cement, 15 ft. diameter and 1,100 ft. long, and cost $75,000.

The total cost of this improvement was $1,660,000. The upper division contains 57 million and the lower 43 million gallons.

An iron tank for Westernß Hill service, erected in 1880, is 100 ft. in diameter by 45 ft. in height, and is made of Siemens-Martin steel. The plates are from $4 to $5 in. thick.

The main works in which are located the pumping engines for the supply of the low and middle services are situated on the bank of the Ohio River, 3 miles west of the city, and about 5 miles above its upper line. The water is taken from the river near its channel, and about 100 ft. from the river front of the pump house, conveyed through iron pipes and stone aqueducts to the pump wells.

In low water 40-in. iron pipes furnish the principal portion of the supply to the pumps. In high water the bed of the river and extend 40 ft. from the stone well which forms the outer limit of the aqueducts. There are two aqueducts, one 5 ft. and the other 20 ft. in width.

In the lower portion these in 1867 were wrought iron pipe, intended for an independent supply for the large engine, but owing to the irregular operations in the past of this engine, the pipe now is packed with rock fill.

Owing to the extreme fluctuations in the river, ranging nearly 60 ft., the suction pipes of pumps are placed below low water mark, and the pumps, within the proper vacuum limit during extreme-low water conditions. The engines on the other hand, are placed above high water mark. The No. 4 engine-house is water-tight for extreme stages, while from the main building the water can be kept out for heights under 4 ft. of mean low water.

The water of the Ohio River at Cincinnati is gathered from a drainage area of about 77,700 square miles, 8,000 square miles of which near the city forms the principal portion, and the remainder is of the water strongly impregnated with salts of lime. The hardness of the river water varies throughout the year in proportion to the contribution from the limestone basin.

The water is subject to contamination, owing to the situation of the works within the city limits. The eddy of the Deer Creek Canal caused much pollution, which was brought to the attention of consumers.

The sinking of loaded barges temporarily destroyed this eddy, and afterward the aqueducts were extended and new shorelines formed, which remedied this evil.

The water of the Ohio River differs from most streams in that it is water-tight for extreme stages, while from the main building the water can be kept out for heights under 4 ft. of mean low water.

The use of meters was begun in 1860, and there are now 454 in use. Hydraulic elevators began to be used in 1931, and at present 318 take water from the city mains. The ram created by them has caused an excessive number of leaks in the old pipes.

Under a general law of the State of Ohio, passed in 1858, the water-works were under the control of a board of three trustees, elected by the people, until 1876, when a Board of Public Works was constituted, composed of five members elected by the people. In 1879 the Board of City Commissioners was formed.

The executive officers of the works have been as follows:

The cost of the revenue and the works have been as follows:

Construction.

Total cost.

Interest on bonds.

Outstanding bonds.

$8,500,000 at 6.

$1,984,064.

$11,140,008.78

$1,823,000.