conveys the water 5,391 ft. to Lake Clifton, which is elliptical, 1,700 by 1,200 ft., of 30.25 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 first be put in use.

The great tunnel from Loch Raven to Lake Montebello was begun in December, 1875, and completed in November, 1880. It is straight for seven miles, is from 65 to 300 ft. below the surface, and for six miles is through hard blue gneiss rock, and 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 worked at 32 points; 11,691 ft. of the tunnel were arched. All drilling was done by hand, and blasting by giant powder or dynamite.

The tunnel cost for excavation $1,382,598.92, and for arching, cleaning and filling the shafts, $397,011.32.

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 pipe is very great, and the use of 2-in., 3-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; 524 meters are in use.

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

Year.	Population.	Miles of pipe.
1830	80,620	....
1840	102,313	....
1850	169,054	45
1860	212,418	127
1870	267,354	206.2
1880	332,190	277

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 five Commissioners. James S. Suter was "Water Engineer" from 1857 to 1867, 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:

Expenses—Maintenance and extension of old works	$2,409,929.94
New works from Gunpowder River	4,704,260.83
Interest on water bonds	3,609,439.23
Total expenses	$10,723,630.00
Revenue	5,528,507.00
Outstanding bonds, December, 1880	9,000,000.00

VIII.—CINCINNATI.

Cincinnati, on the north bank of the Ohio River, in lat. 39° 6′ 30″ N. and long. 84° 24′ W., embraces about 24 sq. miles. A plain 60 to 100 ft. above the low-water river level extends along the river and back for some distance, when the ground rises rapidly to an elevation of 400 ft., and a second plateau affords fine building sites.

Founded in 1789 and incorporated as a city in 1819, its population in 1820 was 9,642, when Samuel W. Davis constructed works for the supply of water, consisting of a pump on the river bank, driven by horse power and lifting the water into a tank, whence another horse-power pump lifted it into a wooden reservoir, whence it was distributed through wooden pipes.

A steam engine with cylinder 12-in. diameter and 60-in. stroke, with a wooden beam, driving from one end two pumps, lifting water from the river to a tank on the engine-house floor, and thence forcing it to the reservoir by two pumps at the other end of the beam, all the pumps having 6-in. bore and 48-in. stroke, was substituted for horse power for pumping in 1824. This engine was remodeled in 1828 and abandoned in 1844.

On Jan. 27, 1826, Mr. Davis obtained a charter for the Cincinnati Water Company, with a capital of $75,000. In 1828 an 8-in. iron main was laid from the reservoir. In December, 1831, a fire destroyed the pumps, and the city was without water for three weeks.

A second steam-pumping engine was erected in 1832. It was an upright direct-acting engine, with fly wheel. The cylinder had 25-in. diameter and 96-in. stroke. The double-acting plunger pump beneath it, had 17-in. bore. The force main was of 20-in. diameter. This engine was used until 1864.

After several unsuccessful efforts to sell the works to the city, the sale was accomplished on June 15, 1839, and the water-works put in charge of a Board of Directors from the Common Council.

In 1846 another high-pressure engine, designed by Geo. Shield, was built, with horizontal steam cylinders 28-in. diameter and 120-in. stroke, working a fly wheel, to the crank-shaft of which was connected a vertical double-acting plunger pump of 14-in. bore and 120-in. stroke.

This engine has been in constant use ever since, pumping into reservoirs, with 165-ft., and since 1875 with 224-ft. lift, and is stated to be the most economical engine now in use in the water-works of Cincinnati. Steam is cut off at ⅜ stroke. In 1847 the pump was temporarily stopped by high water in the river, which rose over the steam cylinders. In 1851 the engine-house floor was raised to about 2 ft. above the high water of 1847.

In 1851 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 fly wheel is driven by a connecting rod from the piston rod.

In 1854 a duplicate of this engine was built. The pump cylinder of this was bored to 18¼ in. in 1879. These two engines are now used exclusively for the low service, pumping against 165-ft. head.

In 1865 a condensing engine designed by Geo. Shield was built. The steam cylinder is of 100-in. diameter and 144-in. stroke, vertical, and beneath it is a double-acting plunger pump of 46⅛ in. bore. Before 1874 this engine could not be run faster than 5 double strokes per minute, and the ram was so great that the force-main burst five times. Since 1874, owing to a change in the pump valves, it has been possible to run at 9 strokes per minute, and in 1879 the addition of 75 ft. to the working head improved its performance.

The force-main from this engine is 50-in. diameter, of wrought-iron, half-inch thick.

Two duplex, non-condensing engines, designed by T. R. Scowden, were erected in 1872–74. The steam cylinders are 28-in. diameter and 96-in. stroke, working pumps with buckets of 23½-in., and plungers of 16½-in. diameter.

High-service engines were constructed in 1869, from designs of A. G. Moore, taking the water from the main at the level of the low-service reservoir, and lifting it 290 ft. The first engine is a duplex non-condensing engine, with steam cylinder of 18-in. diameter, and 60-in. stroke, and pumps of 9-in. bore, enlarged in 1874 to 11-in., and in 1879 to 13½-in.

A compound engine, designed by A. Warden, was added to these works in 1879. It has a high-pressure cylinder of 14-in., a low-pressure cylinder of 22½-in., pumps of 10-in. diameter, all of 30-in. stroke.

The first reservoir built by the city was constructed in 1851, on Third st., 750 ft. from the engine house, and 165 ft. above it. It is rectangular, with dressed stone walls, entirely above the surface of the ground. It is in two divisions and its capacity is five million gallons.

In 1869 an iron tank 38 ft. high and 60 ft. in diameter was erected for the Mt. Auburn high service, and a similar one in 1870. The plates are 50 by 144 in. and from 11/32 to 7/16 in. thick. The vertical joints are double riveted. The bottom plates are ¼ in. thick.

[TO BE CONTINUED.]

We are pleased to acknowledge the receipt of the Eleventh Annual Report of the Water-works of Dayton, Ohio, from Jos. E. Waltz, Civil Engineer.

CORRESPONDENCE.

GRAPHIC METHOD OF PUTTING IN R. R. CROSSINGS, ETC.

BALTIMORE, MD., April 9, 1881.

EDITOR ENGINEERING NEWS:

Can you inform me through the columns of your valuable paper, of which I am a constant reader, where I can find graphic methods, diagrams, for putting in crossings from parallel tracks, both straight and curved, so it can be done with lines and a tape measure? Very truly yours,

H. W. B.

COMPRESSIVE STRENGTH OF CYPRESS.

VICKSBURG, Miss., April 7, 1881.

EDITOR ENGINEERING NEWS:

Will you allow me through your valuable columns to solicit a little information, which I have so far been unable to obtain through the medium of text-book or tables. What is the tensile and compressive strength of cypress? Also, what amount of straining force can cypress timber stand? Where can I purchase a chain similar to the one described by S. S. Haight, in ENGINEERING NEWS, Feb. 12, 1881?

I, as one of the "profession of peg setters" sincerely thank you for your able endeavors to disseminate truth and advance and elevate our profession.

Respectfully, YOUNG ENGINEER.

AMERICAN ENGINEERS IN MEXICO.

The following letter from a subscriber in Mexico we publish for information. The books mentioned we cannot find in New York, and we will be obliged if any reader of ENGINEERING NEWS can supply the needed information. [ED. ENGINEERING NEWS.]

GOATZACOALCOS, MEXICO, March 11, 1881.

EDITOR ENGINEERING NEWS:

I wish a copy of Bailey's instructions to the geodetic surveyors of Australia, which are mentioned in Frome's Geodesy, or a complete work on the use of the portable transit instrument in obtaining latitude and longitude. I see that the plain transit may be used for latitude, if adjusted to the prime vertical; but find no method given for such adjustment. Do you know whether the instructions to the British Columbia Boundary Surveyors are published, or the methods used by them for astronomical location? I wish to establish here an observatory for time, etc., and need the above information. Will you send me some book or papers covering this ground? I have a very good chronometer, which I shall regulate for standard time of road, and perhaps for the shipping. I am at present so busy on construction that I can spare no time for the purpose, but shall put up my instruments as soon as my section of R. R. is completed, say in 3 or 4 months. I would like to purchase a good second hand portable astronomical transit, if you could recommend one; but as you probably cannot, I shall send to Fauth & Co., of Washington.

Very Respectfully, ARTHUR HAVILAND,
Assistant Engineer, T. & O. R. R.,
Jaltipau P. O., Mexico.

HOWE TRUSS SPLICE.

PORTLAND, Me., April 12, 1881.

EDITOR ENGINEERING NEWS:

Mr. F. C. Doran's splice turns out exactly as I expected. He admits now that he "never designed or built a bridge with the splices in the lower chords of the exact proportions" shown in his plan, in your paper of Jan. 1. He takes back the statement that his splice had borne the est of experiment and practical work, and says

to the Continent, he inspected the celebrated sewers of Paris and the fields of Gennevilliers, where the sewage is utilized. Especially interesting were the cities of Hamburg, where the first systematic sewerage works were ever built; Frankfort-on-Main, the best drained 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 just been completed in 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 of Continental sewerage improvements, and Amsterdam, where the best example of the much-talked-of Liernur system can be seen. He had the pleasure of meeting nearly all of the prominent engineers and sanitarians interested in sewerage 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. Hering has for several years past given especial attention to sanitary engineering, his position as engineer in charge of the sewers of Philadelphia giving him particular advantages, to which he has added the benefits of unremitting study and observation. Already regarded as an authority on sewerage 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 especial prominence in Europe and America.

In order to recuperate from the effects of hard work and climate, Mr. E. L. Corthell, 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. Mr. Williams, Assistant Engineer, remains to complete the work left unfinished by the auxiliary Mexican Commission who assisted Capt. Eads in his exploration. A line *through* from gulf to ocean, not fully accomplished by the commission, 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 R. CROES, 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, 48½ ft. wide at the base, 22 ft. wide at bottom of reservoir, and 25.8 ft. wide on top. Its extreme length is 1,251 ft. It contains about 76,000 perches of building stone.

For 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 well as the copings and pilasters, are finished 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 and 10 ft. at top, and 400 ft. in length, including effluent and influent chambers.

At the west end of this wall the effluent chamber is located, and the influent pipes at the other end.

The outlet for effluent pipes was made by tunneling through the hill. The structure is made of four courses of brick on cement, is 12 ft. diameter and 1,100 ft. long, and cost $78,000.

*Copyright 1881.

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 Western Hill high service, erected in 1880, is 100 ft. in diameter by 48 ft. in height, and is made of Siemens-Martin steel. The plates are from ¼ to ⅝ 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, about three-quarters of a mile from the centre of the city, and about 5 miles within 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, and conducted through iron pipes and stone aqueducts to the pump wells.

In low water two 40-in. iron pipes furnish the principal portion of the supply to the pumps.

These lie on the bed of the river and extend 40 ft. from the stone wall which forms the outer limit of the aqueducts. There are two aqueducts, one 5 ft. and the other 20 ft. in width.

In the large aqueduct there is a 60-in. wrought-iron pipe, intended for an independent supply for the large engine, but owing to the irregular operation in the past of this engine, the pipe is now packed with river deposit.

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 lift during extreme low stages. The engines, on the other hand, are placed above high water mark. The No. 6 engine-house is water-tight for extreme stages, while from the main building the water can be kept out for heights under 33 ft.

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 furnish 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 in a marked manner in 1867 by the burning of a large distillery on the canal. The whiskey found its way into the canal, thence into the river, where it was carried by this eddy into the pumps, and then delivered to the water consumers.

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

At the time of the purchase of the water-works by the city in 1838, the water company had laid 117,848 ft. of wooden pipe, bored logs of 2½ in. diameter, and 20,243 ft. of iron pipe, mostly of 3 and 4 in. diameter. All pipe laid since that time have been of cast-iron.

The proportion of small pipe is great, 108 miles out of 189 being less than 6 in. diameter. There are now, however, no pipe laid of less than 6 in. diameter.

The small pipes, particularly at dead ends, have been much obstructed by sediment from the water, and within a few years great improvement has been effected by connections for circulation and by frequent blowing out.

Owing to the peculiar topography of the city, there was a good deal of difficulty for many years in arranging the distribution. In Nov., 1877, the city was divided into three district services, but the mains not having been originally laid in contemplation of this division, the circulation of water in some parts is very bad, and a number of dead ends were unavoidable. These are being corrected as fast as possible.

The city is now supplied by two 35-in. mains from Eden Park (middle service) Reservoir and two 20-in. mains from the low-service reservoir.

The low service is supplied from the old Third Street Reservoir and embraces the low elevations South of Third street, Eastern avenue to its terminus and west of Baymiller street to State avenue. It also furnishes water for two-thirds of the hydraulic elevators.

The flow line of the reservoir is 170 ft. above low water mark in the Ohio River. The lowest point on the street it supplies is about 60 ft., and the highest point 100 ft. above low water. The average pressure at fire plugs is about twenty-five pounds. It furnishes 33 per cent. of the total water supply.

The middle service is supplied from the new or Eden Park Reservoir, from which the high service also takes its supply. The flow line of the reservoir is 232 ft. above low water mark. The lowest point on the street it supplies is above 60 ft., and the highest 180 ft., above low water mark. The average pressure at fire plugs is 45 pounds.

The high service takes its supply from the main feeder from Eden Reservoir, under a head of 60 ft., and forces it into two tanks, situated on the summit of Mt. Auburn, against a head of 340 ft (friction included). From this point the water is distributed (or rather partly so, for these tanks are merely stand-pipes to keep up the head, as part of the distributing pipes are directly connected with the pump main) to the higher levels. It requires nearly one per cent. of the water supply to satisfy this demand, which is rapidly increasing.

Another high-service works is in course of erection for the supply of the western hills. The flow line of its tank will be 520 ft. above low water mark. The pumps will have an average load of 140 pound to the sq. in.

The population, pipeage and consumption every tenth year have been:

Year.	Population.	Miles of Pipe.	Daily consumption in millions of gallons.
1840	46,338	24 27	1.06
1850	115,436	45.76	2.40
1860	161,044	83.66	4.82
1870	216,239	133.08	10.44
1880	255,708	188.86	19.48

The use of meters was begun in 1860, and there are now 545 in use. Hydraulic elevators began to be used in 1872, 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:

Superintendents.	Engineers of Pump Works.	Civil Engineers.
1849..E. Hinman.	T. R. Scowden.	....
1851..Lewis Warden.	"	.....
1854..James Cooper.	Lewis Warden.	....
1857..S. W. Irwin.	Americus Warden.	....
1859..R. C. Philips.	George Shield.	....
1861..J. B. Earnshaw.	"	.....
1863..T. J. Weaver.	"	.....
1865..Joseph P. Mayer.	"	H. Earnshaw.
1867.. "	John G. Richardson.	"
1871..Henry Earnshaw.	"	"
1873..Gasaway Brasheers.	R. T. Scowden.	.....
1874..Gassaway Brashears.	Americus Warden.	.....
1876..William Kirton.	"	.....
1878..James E. Bell.	"	.....
1879..A. Warden.	"	C. H. Boeckh.
1880..Arthur G. Moore.	"	"

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

Construction	$6,509,583.10
Operation and maintenance	3,399,640.89
Interest on bonds	1,241,804.79
Total cost	$11,140,028.78
Revenue	9,014,523.78
Outstanding bonds	1,625,000.00