

gining of each pipe to prevent the water from following it. Under each is a drain pipe of 10-in. diameter.

The force main is connected with the supply mains, and at their junction is a 30-in. wrought-iron stand-pipe 55 ft. high, extending 25 ft. above the water surface of the reservoir.

The supply main is a 20-in. cast-iron pipe, and is carried across Bass River, the arm of the sea between Beverly and Salem, in a wooden box on piles, passing under the channel by an inverted siphon of 30-in. pipe, boxed with heavy timbers and filled around with concrete.

Water is supplied to the town of Beverly by special contract.

The distribution is by wrought-iron and cement pipe, of which 85 miles were in use in 1879. In that year there were in use 343 hydrants and 117 meters. The number of taps is not given. The consumption in 1879 was 1,940,000 gallons per day.

The population of Salem in 1880 was 27,598.

The total cost of construction to November, 1879 was \$1,338,155.48.

In 1879 the revenue was \$50,629.74.

The works were built by a board of Water Commissioners, and have been managed by the Wenham Water Board.

James Slade was chief engineer until 1868. James P. Kirkwood was consulting engineer during construction, after February, 1868, and Charles H. Swan the chief engineer. James W. Lyon is the Superintendent.

XLV.—NEWPORT.

Newport, Kentucky, is on the south side of the Ohio River, opposite Cincinnati, and separated from Covington by the Licking River on the west.

The site of the town was first occupied in 1791. The population in 1871 was 16,000, when water-works were built by the city, after the plans and under the superintendence of Theodore R. Scowden, C. E., taking water from the Ohio River, 4 miles above the city.

The engine-house is on limestone rock at the river's edge. Through an arched opening in the wall the water is admitted to the pump-well, the floor of which is 3 ft. below extreme low-water mark.

The water is lifted 350 ft. through a 20-in. cast-iron main, 1,445 ft. long, by a direct-acting non-condensing pumping engine, with vertical steam cylinder of 26 in. diameter and 48 in. stroke, 57 ft. above a double acting plunger pump of 13½ in. bore. The connection between the pump and the main is by an 8-in. pipe.

At the crest of the bluff, the force main discharges into a cast-iron main of 24 in. diameter for 275 ft., and of 20 in. diameter for 4,318 ft., in which distance it falls 56 ft., discharging into the reservoir formed by an embankment across the junction of the two ravines, and divided into two basins by a transverse embankment. The main dam is 85 ft. high, built of earth, with stone paving on the slope. The water surface is 8 acres and the capacity 41 million gallons. The surface drainage from the surrounding country is carried under the reservoir in 24-in. iron pipes, meeting in a 36-in. pipe, which passes under the dam, with stone collars 8 ft. square and 2 ft. thick every 12 ft.

Two 30-in. effluent pipes, laid through the dam, conduct the water to the 20-in. supply main in the city.

On June 17, 1875, one of the 24-in. drain pipes broke, the north basin was rapidly emptied and the slopes slid in. On examination, it was found that half the drain pipes were broken. They were stopped up, surface drains made, and the banks reconstructed. The slopes of the south basin showed a tendency to slip in 1878, and not more than 12 ft. of water could be safely put in it, and in 1879 one foot less was stored. In 1880 there were indica-

tions of saturation of the earth past the centre of the main bank.

The distribution is by cast-iron pipe. In Dec., 1880, there were 20.45 miles in use, nearly half of which is of 4-in. diameter. There were 110 fire hydrants, 1,577 taps and 16 meters in use at that date. The consumption is not given, but the engine is reported as working to its full capacity nearly all the time. The population in 1880 was 20,438.

The cost of construction, including repairs to 1881, had been \$780,781.11, and the revenue from water rents \$91,356.61. The bonded indebtedness is \$700,000. The total receipts for the year 1880 were \$21,861.99, and the expenditures \$13,288.39.

The works are controlled by a board of three trustees, who report to the Common Council. George Hornung was the Engineer and Superintendent from 1873 to 1877. From 1878 to 1881 B. R. Morton has been City Engineer and Superintendent of the Water-works.

XLVI.—NORWICH.

Norwich, Connecticut, in lat. 41° 32' N., long. 72° 5' 28" W., is 15 miles from Long Island Sound, at the confluence of three small streams which form the Thames River, and which, having a rapid descent, afford a valuable water power.

The population, which in 1810 was 3,528, had increased to about 15,000 in 1868, when water-works were constructed by the city, after the plans and under the superintendence of John T. Fanning, C. E.

The supply is by gravity from two small streams N. E. of the city, 252 ft. above tide level and 225 ft. above the main street of the city. The impounding reservoir is formed by an earth dam 25 ft. high and 468 ft. long, 25 ft. wide on top, with rubble masonry heart wall through its centre, and its inner slope paved with stone.

The overflow waste-way is in a depression a mile from the dam, leading to another valley. The shores of the reservoir are cut down vertically to 4.5 ft. below the flow line, and protected by a vertical dry stone wall, 2.5 miles long. The area of the reservoir is 66 acres, and its tributary watershed 0.75 sq. mile. Two filtering dams have been made at the inlets of tributary streams.

From a masonry gate-house on the inner slope of the dam a 16-in. copper pipe, designed by Mr. Alba F. Smith, with a flexible joint which permits the end of the pipe to be adjusted to take the water from the pond at any depth, conducts the supply to the gate chamber.

The first pipe collapsed in 1873, and was replaced by one of heavier copper.

The distribution pipes are of wrought iron and cement. They are mostly of 6-in. and 4-in. diameter. More than 9 miles are less than 6-in.

On Oct. 13, 1869, and July 27, 1873, the distribution pipes were struck by lightning. In the first case 2,000 ft. of pipe were injured and in the second 94 ft. The joints appeared to have been "struck with a ball 2 in. in diameter, leaving a dent in the form of a spoon and with the appearance of burnished silver." In March, 1880, there were in use 30 miles of pipe and 245 hydrants.

The number of taps on March 31, 1873, was 1,503. Service pipes are of wrought iron and cement.

The population in 1880 was 21,141. The consumption is not stated in the reports.

The cost of the works to March 1880 had been \$411,870.94, the receipts for the previous year \$24,169.24, and the cost of maintenance, \$6,262.62.

The works are managed by a Board of Water Commissioners.

The superintendent is H. B. Winship.

XLVII.—WILLIAMSPORT.

Williamsport, Pennsylvania, is in lat. 41° 14' N., long. 76° 2' W., on a plain between the north bank of the West Branch of the Susquehanna River and a range of hills. The town was founded

about 1795, and incorporated as a city in 1861.

Lycoming Creek flows through the city from the north, and parallel to it is Loyalsock Creek, two miles east of the city limits. Two private companies supply the city with water. The Williamsport Water Company, incorporated in 1853, when the population was 2,500, procures its water from Hagerman's Run, and the Citizen's Water & Gas Company, incorporated in 1865 as the Lycoming Gas & Water Company, procures water from Mosquito Creek. Both of these are mountain streams, south of the river, each draining about 25 sq. miles, and dammed about a mile and a half from the city at 140 ft. above the river. Neither company has more than a small basin, less than a hundred feet square, for settling purposes.

The water is conveyed to the city in two 16-in. cast-iron pipes, which pass under the river for 1,000 ft. The distribution pipes are of cast iron. The two companies supply 2,500 consumers and 150 fire hydrants, for which the city pays \$10 each per annum. The population in 1880 was 18,934. Meters are not used. The amount of water used, and the details of cost and revenue are not furnished. J. H. McMinn is superintendent of the Citizen's Water & Gas Company.

XLVIII.—DAYTON.

Dayton, Ohio, is on a level plain at the confluence of the Mad and Great Miami rivers. Settled in 1796, it made little progress until 1829 on the opening of the Miami Canal. It was incorporated as a city in 1841.

Water-works were built by the city in 1869-70, taking the supply from wells and from the Mad River.

The first well was sunk 300 ft. south of the Mad River and ¼ of a mile above its junction with the Miami. The well is about 20 ft. in diameter, and is sunk below the bed of Mad River. A conduit connects it with a trench 100 ft. distant, which is 108 ft. long, 18 ft. deep and 15 ft. wide. The well and trench are both roofed. The capacity of this source was about 500,000 gallons per day. In 1873, the supply falling short, connection was made directly with the Mad River by three lines of 20-in. cast-iron pipe, laid out into the river, the end supported in a revetment wall of masonry 15 ft. high and 50 ft. long. Against the wall boulders were piled to act as a strainer. Inside the levee the pipes are also supported by a masonry wall. The water from this had a brownish color and a strong odor and taste.

A second well was dug in 1875-6 30 ft. deep and 18 ft. diameter. This supplied about 500,000 gallons per day.

The supply being inadequate, and resort being constantly had to the Mad River, which is very impure and takes the drainage of a thickly populated valley, the construction of a second filter gallery was begun. In 1880, 106 ft. of it had been finished. It is a rectangular chamber, 4 ft. wide and 8 ft. high, with dry stone side walls, flat stone cover and plank flooring, 26 ft. below the surface of the ground.

The first pumping engines consisted of two Holly elliptical rotary pumps of 2,000,000 gallons capacity and a set of gang pumps of 3,000,000 gallons capacity in 24 hours. In 1880 these pumps were removed and four piston pumps on an inclined frame, geared to the old engine, 3 to 1, were substituted.

The second pumping engine erected in 1873-4 is a Holly Compound Engine, with four steam cylinders, of 18-in. diameter and 30-in. stroke. The pump cylinders are 12 in. in diameter and 30-in. stroke. The capacity of this engine is 4,000,000 gallons in 24 hours. The engines pump directly into the mains under 50 lbs. ordinary pressure and 100 lbs. fire pressure.

The distribution is by cast-iron pipe, of which in 1880 32.5 miles were laid, most of which is of 4