sumers and the annual expenditures and revenue are not furnished.

LIII.—TAUNTON.

Taunton, Massachusetts, is on the Taunton River, 23 miles south of Boston. It was incorporated as a town in 1639 and as a city in 1864.

Water-works were built by the city in 1876–7, after the plans and under the superintendence of George H. Bishop, C. E.

Water is taken from a filter gallery or basin, 100 ft. from the shore of the Taunton River, at Shallow Water, and pumped directly into the mains. The filter basin is 400 ft. long with slopes of 2 to 1. Its bottom is 17 ft. wide at 8 ft. below mean low water mark. The slopes are paved with stone for 18 ft. from the bottom and sodded above. The ground rises back of the basin, and the ground water rises 14 ft. in 1,000 ft., after which the slope is flatter.

In 1877 a daily draft of 250,000 gallons, lowered the ground water near by about 2 ft., and a draft of 600,000 gallons per day for 5 days affected the surface of the ground water 80 ft. from the basin.

A 36-in. wrought-iron pipe laid 4 ft. below the bottom of the filter bed conducts the water to the pump well 28 ft. deep. The well is also connected with the river by a 30-in. wrought-iron pipe ending in a plank crib 20 by 18 ft., inside of which is a second crib 12 by 10 ft. The space between these two cribs is filled with broken stone, with a 2-in. opening between each plank of the crib.

The water is pumped directly into the mains by a Holly compound engine with four steam cylinders of 14-in. diameter, operating four pumps of 9¾-in. diameter, all of 24-in. stroke.

For fire pressure a horizontal high-pressure engine drives two rotary Holly pumps.

The distribution is by cast-iron pipe, 27.5 miles of which, with 239 fire hydrants and 182 meters, were in use January, 1880. In January, 1878, there were 651 taps. Most of the service pipe is of wrought iron lined with cement. The consumption in 1879 was 394,061 gallons per day. The population in 1880 was 21,213.

The cost to Jan. 1, 1880, was $276,876.18.

The works are managed by a board of three commissioners. George H. Bishop was chief engineer to 1878.

LIV.—NEWTON.

Newton, Massachusetts.—In 1875 works were built by the city, after the plans and under the superintendence of Edward Sawyer, C. E.

Water is taken by a natural open filter basin on the bank of the Charles River, on the other side of the river from Newton in Needham, no suitable filtering material being found on the Newton side.

The basin follows the river in the shape of a bow. As first built, it was 975 ft. long, and in 1877 its length was increased 600 ft. The bank at this point is composed of large free gravel, which passes the water freely. The basin is from 70 to 88 ft. in width. Embankments were built along its sides for protection. The outer embankment is 10 ft. wide on top, about 10 ft. high above the natural surface, with inside slope of 2½ to 1 and outside slope of 2 to 1, paved on the outside with a stone paving about 2 ft. thick.

In 1880, under advice from William E. Worthen, C. E., a test pipe 2 in. in diameter was driven through the strata of fine sand on the bottom of the basin, 35 ft., to coarse gravel. The water rose in the pipe above the level of the water in the basin. Four 2.in., six 1½-in., three 1¼-in. and one 4 in. wrought-iron pipes were then driven, which are estimated to yield from 4 to 5 hundred thousand gallons in 24 hours.

A 24-in. outlet pipe crosses the river and conducts the water to the pumping station. As first built it extended to within 56 ft. of the engine house, and for the remaining distance a stone masonry culvert, 3 × 3.5 ft. was laid.

In 1880, under the direction of William E. Worthen, C. E., a 24-in. cast-iron pipe was laid in this conduit from the pipe chamber to the pump well, and the conduit filled with concrete to stop the flow of all ground water and quicksand into the well. As the use of a pump at the lower end caused a large inflow of quicksand, 8 1½-in. pipes were driven 35 ft. deep, spaced 15 ft. apart each way. Pumping from these driven wells removed the water from the trench, and the work was completed without difficulty. The interior of the conduit is accessible through two chambers, one in the bank at the basin and one 56 ft. from the engine house.

The pump well is 9.83 × 29.75 ft. and 15 ft. deep. The bottom of the well is a platform of Georgia pine, and the walls are of brick masonry.

The pumping machinery consists of one duplex high-pressure Worthington engine of 1,000.000 gallons capacity, with water plungers of 12-in. diameter and 15-in. stroke, and one Worthington compound duplex engine, with water plungers of 22-in. diameter and 50-in. stroke, of 5,000,000 gallons capacity.

The water is pumped into a pentagonal reservoir, in two divisions, built in excavation and embankment on Waban Hill, containing 15,000,000 gallons, with its water surface 265 ft. above low tide. A puddle wall is built in the bank, and a puddle lining 2 ft. thick extends under the bank, down the slopes and over the bottom. The slopes are covered with 6 in. of small stone, on which is a 15-in. pavement of stone.

Distribution is by cast-iron pipe, of which there were laid on Dec. 31, 1880, 60.3 miles, 6 miles of which is less than 6 in. in diameter. There were at that date 324 fire hydrants, 1,937 taps and 467 meters in use.

The population in 1880 was 16,995 and the daily consumption 468,476 gallons.

The total cost of construction to Dec. 31. 1880, exclusive of interest, was $854,937.73. The cost of maintenance since 1876 has has been $38,577.59 and the receipts $117,250.64.

In 1880 the expenditures were $9,758.70 and the revenue $33,734.58.

The works are managed by a committee of the Common Council, H. Nelson Hyde, Jr., being the superintendent, and since 1878 Albert F. Noyes, the city engineer, acting as engineer of the water-works.

LV.—ALEXANDRIA.

Alexandria, Virginia, is on the south bank of the Potomac River, 6 miles below Washington City. The ground rises from the river to an elevation of about 50 ft.

Founded about 1780 its population in 1851 was 9,000, when water-works were built by a private company after the plans of Frederick Erdman, C.E. Water is taken from Cameron's Run. A mill site was purchased, and a new iron 20-ft. wheel put in, driving a double acting 10-in. pump with 120-in. stroke, which forced the water through a cast-iron pipe into a reservoir 200 ft. square and 16 ft. deep, 96 ft. above tide, in two divisions. A 10-in. main led to the city; seven miles of pipe were laid. In December, 1852, these works had cost $88,000, and there were 180 takers, and in the following year 400 takers.

In 1855 a steam pump was erected. The dam was considered unsafe in 1857, and an old raceway leading from a point further up the stream was cleared out and put in use just before a freshet swept away the dam. A small dam above then enabled the company to obtain all necessary water. In this year the steam engine was used only thirty-eight hours. The military occupation of the city from 1861 to 1865 created so great a demand for water that much muddy water was pumped and the reservoir had to be cleared in 1866. The dam was washed away during the war, and a slide occurred in the reservoir bank. The dam and reservoir were again seriously damaged by storms in 1867. A new reservoir was built in 1874, after the plans of Washington Blythe, C. E. It is in excavation and embankment, is 300 by 500 ft. and 17.5 ft. deep. In 1879 slight leaks in it were reported.

The pipeage, consumption, hydrants and taps are not given in the reports.

From 1851 to Jan. 1, 1859, the expenditures were $125,399.45, and the receipts $46,162.19. During the war the accounts were kept irregularly, and since then comprehensive statements do not appear. In 1879 the receipts were $14,680.63, and expenses $4,241.07.

Daniel W. Lewis was superintendent from 1851 to 1866, and Francis J. Power from 1867 to 1881.

LVI.—KALAMAZOO.

Kalamazoo, Michigan, in lat. ——, N., long. —— W., is situated in a valley 150 miles long and 100 miles wide, filled from 500 to 700 ft. in depth with glacial drift, saturated with water and underlaid with rock.

The first water supply was furnished by the Michigan Central Railroad Company, being the overflow from their tank at the depot. It was brought from Arcadia Creek in wooden logs. The overflow was conducted to a cistern in the court-house yard. It was used for fire purposes.

In 1860 George Bolles contracted to pump water for fire supply from his dam on the Arcadia; subsequently the dam was removed and the pumping done from Lawrence & Gale's factory.

In 1869 water-works were built by the city, taking their supply from a well sunk to 7 ft. below Astell's brook. This water proving impure, a brick well 24 ft. in diameter, the wall resting on a cast-iron shoe, with a cutting edge, was sunk by dredging from the interior through 14 ft. of fine sand into a porous gravel. The water then stood 24 ft. deep in the well. It is pumped directly into the mains by a Holly engine with two piston pumps, of nominal capacity of one million gallons, and two rotary pumps of like capacity. In 1873 two piston pumps were added. In 1877 the rotary pumps were replaced by a Worthington high-pressure duplex engine, of two million gallons capacity. Wood is used as fuel in the furnaces.

The distribution is by cast-iron pipe. In April, 1881, there were 15.9 miles of pipe in use, 12 miles of which are of less that 6-in. diameter; 147 fire hydrants are in use and 573 taps.

The population in 1880 was 11,937, and the daily average consumption 803,468 gallons.

The cost to 1881 has been $168,678.58, the total expenses of maintenance $87,229.12, and the total water rents $40,034.65.

The receipts for the year ending March 31, 1881, were $5,194.32, and the cost of maintenance $6,857.71.

The works are managed by a committee or fire and water. Until 1874 they were under control of the chief of the fire department. Since that time George H. Chandler has been the chief engineer.

LVII.—NEW LONDON.

New London, Connecticut, is situated at the mouth of the Thames River, on one of the best harbors in the United States. Founded in 1646, it was incorporated a city in 1784. In 1802 the city was partially supplied by the Aqueduct Co., the water being conveyed through logs from a spring near the northern part of the city. About 1840 the lower streets and wharfs were supplied through cast-iron pipe from a mill pond in the northern part of the city, and also from a well near the Wilson Manufacturing Co.'s works, in the centre of the city, the last named supply being pumped with power furnished by the Wilson Manufacturing Co.

In 1860, the 4-in. pipe from the mill pond having become obstructed with rust, it was replaced

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with a 6-in. wrought-iron and cement pipe, which is yet in good order. The 3-in. cast-iron pipe from the Wilson Works is now used by the city works, and sustains a head of 140 ft.

In May, 1871, the legislature passed "an act to supply the city with pure and wholesome water," which was ratified by the citizens in September, 1871, and a board of water commissioners appointed.

The works were constructed in 1872, at which time the population was about 9,600; in 1880 it was 10,529.

Lake Konomoc, from which the supply is drawn, is about 6 miles from the city. It lies between high wooded hills, has a drainage area of 976 acres, and is 180 ft. above tide water. The original lake, which had an area of 110 acres, was raised 10 ft. by a dam built about 700 ft. below the outlet, increasing the area to 225 acres and capacity to 600,000,000 gallons. The city is supplied by gravity directly from this lake without intervening reservoir.

The site for the dam (which was very unfavorable, though the best that could be selected) was between two sand hills, the muck in the intervening valley being underlaid with a thin stratum of hard pan, which was in turn underlaid with quicksand from 4 to 15 ft. deep. The hard pan was left undisturbed and covered with a layer of concrete, on which a cement masonry wall was built through the entire length of the dam, and running into the banks on each side and to a height of one foot above high-water mark. As an additional precaution, a row of sheet piling was driven near the upper edge of the dam, and the whole filling in front of the masonry wall puddled and paved. The overfall (25 ft. wide) is in the centre, and built of granite laid in cement. The front is protected with a timber apron. No leak has ever been discovered through or under the dam. Water is drawn from a granite gate-house built on the dam through a 24-in. cast-iron pipe, a 16-in. running outside the gate-house for use when making repairs. The gate-house is arranged with screens and gates for drawing water from different heights.

The first 6,800 ft. of supply main is of Scotch clay pipe, with cement sleeve joints, and is under a head of from 18 to 20 ft.; the remainder of the supply and distribution mains are of wrought-iron and cement pipes, in sizes from 16 in. to 4 in. The length of mains in September, 1880, was over 21 miles, of which 6.5 miles is 4 in. and 6 miles 6 in. In the year ending September, 1880, there was 50 leaks, caused principally by a slight leakage in the lap, which oxidized the iron until it gave away. The present practice of coating the shells with asphalt before lining with cement has overcome this difficulty in pipe laid during the last three years.

The service pipe, which was originally of rubber-coated wrought iron, is being replaced with cement-lined.

The number of service pipes in use is 1,285. The annual receipts are $16,647.32, no charge being made for fire hydrants or other public uses. The cost of maintenance is about $8,000 per year, and the total cost of the works is $291,840.

Meters have been used since 1873; there are now 25 in use.

The works are under the direction of a Board of Water Commissioners, of which William H. Barns has been president since the beginning of the work.

The works were designed by J. T. Fanning, C.E., who was retained as consulting engineer, W. H. Richards being the engineer in charge during the construction of the work, and the superintendent since that time.

### LVIII.—POUGHKEEPSIE.

Poughkeepsie, New York, is on the east bank of the Hudson River, 75 miles above New York City. The ground rises rapidly from the river to a plateau 150 to 200 ft. high, and at College Hill rising to an elevation of 500 ft.

Settled in 1690, and incorporated as a city in 1854, its population in 1870 was 20,080, when water-works were built by the city after the plans and under the superintendence of J. B. G. Rand, C. E., James P. Kirkwood being the consulting engineer.

Water is taken from the Hudson River just above the city. A wharf, built on piles at the outer end in 24-ft. water, and of crib-work filled with stones near the shore, extended 80 ft. into the river. A box conduit 1 ft. high and 4 ft. wide conducted the water from 4 ft. below low-tide level to the lower pump well.

In 1877 a new inlet was made of 107 ft. of 24-in. cast-iron pipe in a box filled around with concrete and lowered into place at one operation. Its weight was 35 tons.

In 1880 the wharf was rebuilt.

From the lower pump well the water is lifted 20 ft. by a Worthington pump into a settling basin 25 × 60 ft. and 12 ft. deep, in three compartments arranged to deposit the heavier particles held in suspension in the water. From this basin it passes on two filter beds, each 200 × 73½ ft. and 12 ft. deep, with 6 ft. of filtering material arranged as follows: 24 in. sand, 6 in. of ¼-in. gravel, 6 in. of ½-in. gravel, 6 in. of 1-in. gravel, 6 in. of 2-in. broken stone and 24 in. of 4 to 8-in. broken stone, resting on a concrete floor, on which are open stone culverts which convey the water to an intermediate basin 6×85 ft. and 16 ft. deep, from which it passes to a reservoir 28×88 ft. and 17 ft. deep. From this reservoir it passes by 408 ft. of 18-in. pipe to the pump well. The filter beds cost $54,000. The cost of cleaning, washing and renewing the sand was, for each million gallons filtered, $3.50 in 1876, $1.51 in 1877, $2.40 in 1878, $2.75 in 1879 and $2.59 in 1880. The washing of the sand costs from 65 to 122 cents per ton.

In 1878 leakage from the filter beds caused anxiety, but it is not alluded to in later reports.

The rate of filtration per hour was, in 1876, 10.8 in.; in 1887, 10.2 in.; in 1878, 10.4 in., and in 1879, 6.9 in. The average quantity filtered per day has been 1,500,000 gallons.

From the pump well, the filtered water is lifted, by a Worthington pump, 264 ft. through 7,700 ft. of 18-in. cast-iron pipe to the distributing reservoir on the north slope of College Hill, 540 × 210 ft., and 11.5 ft. deep, holding 12,000,000 gallons. It is in excavation and embankment, with puddle wall in the centre of the banks, and puddled bottom, covered with 3 in. of coarse gravel. It has not leaked.

Distribution is by cast-iron iron pipes, of which 16.2 miles were laid in 1874 and only 1,000 ft. have since been added. There are 286 fire hydrants, 1,326 taps and 122 meters. The population in 1880 was 20,207, and the daily consumption 1,408,392 gallons. This is 216,000 gallons per day less than in 1876, notwithstanding an increase of 286 in the number of taps. The reduction is ascribed to the increased use of meters.

The works cost to Dec. 31, 1874, $602,545.09. The receipts for the six years since 1874 have exceeded the expenses for maintenance by $8,624.25. In 1880 the receipts were $19,379.34 and the expenditures $18,626.85.

The works are managed by a board of six water commissioners. Theodore W. Davis, C. E., was resident engineer of their construction, and superintendent to November, 1880. Charles E. Fowler, C. E., is the present superintendent.

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CORRECTIONS.—Readers will please make the following corrections:

July 9. *Worcester*, p. 273, 8th paragraph, for *Coe's* read *Coes'*.

Ninth paragraph, for 16 *miles* read 76 *miles*. Full reports to date having been received since the article was written, insert after 9th paragraph:

On Nov. 30, 1880, there were in use 79.94 miles of pipe, 633 fire hydrants, 5,200 taps and 3,791 meters.

The expenditures and revenue for the 9 years from 1872 to 1880 have been as follows:

| | Cost of construction. | Cost of maintenance. | Interest. | Revenue from water. |
|---|---|---|---|---|
| 1872 | 242,085.78 | 14,528.27 | 35,593.02 | 58,416.03 |
| 1873 | 111,526.93 | 23,327.96 | 44,583.25 | 93,291.13 |
| 1874 | 106,562.85 | 16,367.71 | 40,619.00 | 95,582.52 |
| 1875 | 51,233.09 | 26,320.96 | 33,541.00 | 101,713.93 |
| 1876 | 150,217.89 | 15,815.91 | 25,513.00 | 98,585.14 |
| 1877 | 41,381.25 | 24,104.17 | 23,249.00 | 88,965.17 |
| 1878 | 35,275.02 | 13,765.26 | 24,689.00 | 73,673.17 |
| 1879 | 23,354.09 | 11,066.91 | 22,950.00 | 73,149.40 |
| 1880 | 39,625.35 | 15,124.37 | 22,124.00 | 84,325.80 |

A report on sources for additional supply was made by the City Engineer on June 25, 1881.

At end of tenth paragraph, read:

The city engineers have been Phineas Ball, 1864 to 1873; C. H. M. Blake, 1874 to 1878; Percy Daniels 1878, and C. A. Allen, 1879–81.

Frank E. Hall has been Water Commissioner since 1872.

July 16. *Troy*, p. 285, 2d column, 48th line, for 429 *miles*, read 42.9 *miles*.

July 23. *Hartford*, p. 293, 2d column, 1st line, for *J. W. McAlpine*, read *William J. McAlpine, C. E.*

30th line, for *dyke pond*, read *a pond*.

46th line, for *Coldwell*, read *Caldwell*.

42d line, for *east*, read *earth*.

*Lynn*, p. 293, 3d column in 5th paragraph of Lynn, read 16 *ft. high*.

P. 294, 1st column, 34th line, for *walls* read *wells*.

*Hudson*, p. 295, 10th line, for *screw* read *screen*

July 30. *Toledo*, p. 305, 7th line, for *Carl Schonn* read *Carl Schon*.

P. 305, 3d column, in the acknowledgments, for *Pere Haute* read *Terre Haute*.

[TO BE CONTINUED.]

Received from Col. Zimmerman Davis, Secretary and Treasurer Charleston W. W. Co., history of Charleston, S. C., Water-Works; from W. H. Richards, Superintendent New London Water-Works, reports of New London Water Commissioners, 1874 to 1880. Also history and description of New London Water-Works.

## NEW YORK AND BROOKLYN BRIDGE.

(*Continued from page* 302).

From a paper read by Mr. Francis Collingwood before the American Society of Civil Engineers, June 17, 1879, we make the following extracts in regard to the

### APPROACHES.

"The work on the designs for the approaches to the East River Bridge was begun about Jan. 1, 1877. The Brooklyn approach has a length of 900 ft. on the centre line, and starts from the street grade at Sands street, rising 2.85 ft. per 100 to the rear of the Brooklyn anchorage, where it has a height of about 60 ft. above ground. It is crossed by several streets at high angles, and has one curve at about 200 ft. from Sands street. The width throughout is to be 100 feet.

"The New York approach is 1,546 ft. long, rising from grade at Chatham street, 8.25 ft. per 100 ft. to the rear of the New York anchorage, where it is 68 ft. above ground. It will be 100 ft. wide for about 500 ft. from the entrance, and 85 ft. for the remaining distance. In Brooklyn all the streets will be crossed by box or plate girders. In New York, Pearl and Cherry streets, together giving an opening 210 ft. on one side and 170 ft. on the other, will be crossed by trussed girders; Cliff and Vandewater streets by semi-circular stone arches 51 ft. 8 in. span; Rose street by a three-centered

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