ture of the tunnel somewhat over that of the mountain, but with any considerable increase of this, the absorbing power of the mountain begins to act rapidly, so that its influence in combination with that of ventilation will effectually neutralize that coming from the men and lamps. Measuring these factors by calorics we find :

1. Mountain Warmth: As this is lower than the temperature in the cutting, the mountain takes up heat from it. In this case it was 8.9 calorics per minute.

2. Lamp Heat: The flame of a tunnel lamp consumes 15.5 gr. of oil per hour. Three lamps will give 8.5 calorics per minute.

3. Bodily Heat from Men: Eight persons give 3.5 calorics per minute.

4. The heat production from breathing is so inconsiderable that it may be left out of the question.

We thus see that the influence of human heat is to that of lamps in the proportion of 1:6, or that six men give out as much heat as a lamp. This influence rises or decreases with higher or lower temperature. At 32° it ceases altogether.

THE HISTORY AND STATISTICS OF AMERICAN WATER-WORKS.*

BY J. JAMES R. CROES, M. AM. SOC. C. E.

(*Continued from page* 365.)

LXXXVI.—NEW HAVEN.

New Haven, Connecticut, is in lat. 41° 18′ 28″ N., long. 72° 56′ 30″ W., on a sandy plain at the head of a shallow harbor, between West and Mill rivers and the Quinnipiack River, about three miles from Long Island Sound. Founded in 1638 as an independent colony, it was about 1680 brought under the jurisdiction of Connecticut by the charter granted that State by Charles II. It was incorporated as a city in 1784.

In 1860 the construction of water-works was begun by the New Haven Water Company, a private corporation, after the plans of Julius W. Adams, C. E., and water was first supplied on Jan. 1, 1862, Thomas N. Doughty, C. E., being the chief engineer after June, 1861, Col. Adams having resigned to enter the army.

Water is taken from Mill River, about 2 miles from the city, where the stream, with a water shed of 56 square miles, is dammed at a narrow gorge. The dam is 500 ft. long and 38.5 ft. high, built of heavy stone, from 3 to 6 ft. wide on top, and 25.7 ft. wide at the base, backed with 8 in. of concrete from the rock foundation to the water level. A gravel embankment is placed against this, 20 ft. wide at top and 100 ft. wide at its base in the deepest part of the river. The reservoir thus formed is called Lake Whitney, is 25 miles long and averages 20 ft. deep, holding 500 million gallons. An overfall 150 ft. long is constructed at the east end. From a chamber near the west wing, a wrought-iron 48-in. pipe, 13 ft. below water surface, conducts the water for supply and power to the pump house, where two 30-ft. back pitch overshot wheels, each with 80 buckets 6 ft. long, operate two pumps of 16-in. diameter and 60-in. stroke, forcing the water through 3,100 ft. of 16-in. cast-iron main to the reservoir on Sachem's Hill, 129 ft. above tide water, built in excavation and embankment. In plan the reservoir is an ellipse, with diameters of 488 and 244 ft. at water line, and 19 ft. deep. The bottom and slopes are covered with 18 in. of puddle overlaid with 4 in. of concrete, which on the slopes is overlaid with a 12-in. stone wall laid in cement. It is in two divisions. The force main is arranged to deliver into either the reservoir or the distribution pipe. A 16-in. cast-iron main 11,341 ft. long leads to the city. Two 12-in. mains have since been added.

In 1868 the waste way of the dam at Lake Whitney was raised 4 ft., increasing the storage capacity by 59 million gallons.

In 1871 a steam pump built by the Yale Iron-Works was erected for use when water was low, and a 24-in. wrought-iron and cement force main was added.

In 1876 the company purchased the property of the Fair Haven Water Company, consisting of reservoirs, pipes, etc., furnishing an auxiliary supply by gravity.

Distribution is principally by wrought-iron and cement pipe, which are manufactured by the company after a method designed by D. Goffe Phipps, the secretary of the company.

There are in use 80 miles of this pipe and 22 miles of cast-iron pipe, with 362 fire hydrants, 4,904 taps and 54 meters.

The population in 1880 was 62,882. The consumption is not given.

The cost of the original works was $357.045.62.

The extensions and maintenance have cost $485,-475.93, and there has been paid for interest and dividends $958,421.15. The total receipts from water rents have been $1,625,626.91. The capital stock is $900,000, and the bonded indebtedness $325,000.

Daniel Goffe Phipps has been the secretary since 1865.

The question of the purchase of the works by the city is now under discussion.

LXXXVII.—HAMILTON.

Hamilton, Canada, is on Burlington Bay, at the western extremity of Lake Ontario, in lat. 43° 16′ N., long. 79° 50′ W. The city is on sloping ground, extending from the bay for about 1¼ miles to the foot of a hill. It was settled in 1779, but as late as 1830 had only 653 inhabitants. In 1859–61 water-works were built by the city, after the plans of Thomas C. Keefer, C. E., taking the supply from a filter basin on Burlington Beach, a sand and gravel bar which separates the bay from Lake Ontario. The water of the bay is unfit for use, in consequence of its being the receptacle of the city sewage and the wash of the streets and the surrounding territory, which is a red clay; also of the drainage of enormous vegetable deposits in the great Desjardin Marsh. The lake water is reddened by the wash of the clay banks, and at times is filled for miles with fine sand held in suspension.

A basin of 1½ acre area was dredged in the beach to about 6 ft. below the level of the lake. This basin has furnished pure water. It was enlarged and deepened about 1872. In October, 1879, continuous pumping at the rate of 2.5 million gallons per day for a week lowered its surface 2.6 ft. below the lake level.

Two compound condensing beam and fly-wheel engines, with bucket and plunger pumps, with vacuum vessel on the suction and large cast-iron air chamber on the force mains, lift the water into a reservoir.

The high-pressure cylinders are 24-in. diameter and 72-in. stroke. The low-pressure cylinders are 42-in. diameter and 96-in. stroke.

The Barton reservoir, of 15,000,000 gallons capacity, is nearly midway between the pumps and the city, on the mountain side, 185 ft. above the lake. The pumping main, of 18-in. diameter and 6 miles long, leads directly to the distribution, with a side branch leading to the reservoir which is thus made a side pocket to receive surplus or supply deficiencies. The commercial part of the town is 70 ft. above the lake. A small engine pumping into a tank supplies a few houses on the hill above the reservoir level.

The loss of head in the city from increase of consumption and inadequate mains became so great that in 1870 a plan proposed by J. C. Keefer and John Kennedy was adopted, by which the pumps are to be enlarged, another 20-in. force main laid, and a central reservoir built in the city.

The distribution is by cast-iron pipe, of which 65 miles are in use, with 438 fire hydrants and 8,200 taps. Two meters are in use.

The population in 1880 was 35,009, and the daily consumption about 1,800,000 United States gallons.

The works cost $650,000 up to 1860.

The total expenditures to Dec. 31, 1880, were $945,353.38, and the receipts $397,793.17. In 1880 the receipts were $99,729.07, and the expenses for maintenance $27,628.56, and for new construction, $75,193.24. The bonded debt is $991,878.36. The works are controlled by a Committee of the Council. William Haskins, C. E., is the manager.

LXXXVIII.—WILMINGTON.

Wilmington, Delaware, is in lat. 39° 43′ N., long. 75° 32′ W., at the confluence of the Brandywine and Christiana creeks at the head of navigation, about 2 miles from the Delaware River and 28 miles from Philadelphia. The city is built on elevated ground between the two creeks. The vicinity is hilly and the bed of the Brandywine rises 120 ft. in 4 miles.

The city rises from the creek level on three sides, reaching an elevation of 243 ft. at its northwest boundary.

The first Swedish colony in America landed here in 1638. In 1698 a Swedish church was built which is still standing. The town was founded in 1732, incorporated as a borough in 1740 and as a city in 1832.

In 1803–4 "The Wilmington Spring-Water Company" was organized for the purpose of supplying the borough with spring water. A "fountain" was opened in High, now Fourth street, and supplied that part of the town below Fourth street. In 1810 the borough purchased these works for $10,000. The water was conveyed from the springs in wooden pipes, along the principal streets, to cisterns, from which it was drawn by pumps. The supply gradually failed, from 35 gallons per minute in 1810, to 14 per minute in 1820.

In 1825 a 3-in. iron pipe had been laid to a reservoir between Chestnut and Elizabeth streets, now Tenth and Eleventh streets, and Market and Orange streets. A contract was made for iron pipe and fire-plugs to conduct the water from this reservoir down Market street to High (Fourth) street.

In 1827 a water power was purchased on the Brandywine, which was used to drive an overshot wheel 14.5 ft. in diameter, and 45.25 ft. wide, which worked a double acting force pump of 8-in. bore and 72-in. stroke, which lifted the water 99 ft. through 2,120 ft. of 8-in. pipe into two reservoirs. In 1832 another similar pump was added. On July 1, 1879, the wheel went to pieces. A Jonval turbine, working two pumps of 1.6 million gallons capacity in 24 hours was ordered, and was, after much delay, put in operation on Jan. 5, 1881.

In 1855 a Cornish bull engine was erected, with pump of 18-in. diameter and 90-in. stroke, and a capacity of 3,000,000 gallons in 24 hours. It was always held in reserve, and run only when the water power or other steam pumps failed. It has not been used since 1877.

In 1864 a Worthington duplex high-pressure pump with pump cylinders 10 in. in diameter and 9-in. stroke, with capacity of 550,000 gallons in 24 hours, was erected, taking water from the pipes at Tenth and Market streets, and raising it to a reservoir at Eighth and Rodney streets through an 8-in. main.

This pumping station was abandoned in 1878, and the engine repaired and removed to the Cool Spring pumping station, where a Knowles pump of 1.5 million gallons capacity was also placed in 1880.

In 1872 a Worthington compound duplex engine