In 1874 the wooden conduit from the spring to the pump-house was replaced by an 18 inch iron pipe.

Until the year 1800, there were in the United States, including Bethlehem, only eight waterworks, as follows, in the order of the year of their construction: Providence, R.I., 1772; Salem, Mass., 1796; Geneva, N.Y., and Portsmouth, N.H., 1797; Worcester, Mass., 1798; Morristown, N.J., and Peabody, Mass., 1799.

From 1800 to 1810 there were eleven waterworks built; from 1810 to 1820, seven; from 1820 to 1830, thirteen; from 1830 to 1840, eighteen; from 1840 to 1850, twenty-five; from 1850 to 1860, fifty-six; from 1860 to 1870, one hundred and three; from 1870 to 1880, three hundred and eighty-one; from 1880 to January 1st, at the beginning of 1894, there were over 2,100 waterworks in the United States, and over 120 in Canada. The proportion of waterworks in which water is pumped by steam is rapidly increasing, and the subject of pumping engines to do this work is becoming more important every day, but the conditions under which they operate are so varied that it is impossible to go into details in this letter, and I shall, therefore, treat the subject in a general way.

The first requirement of a pumping engine is that it must be able to pump water under the peculiar conditions which it has to work, and to do this continually, successfully and economically. Its ability to operate day after day, year after year, under the varied requirements of the service, with the least possible expense of repairs and delays, is the most essential fact to be taken into consideration, but, at the same time, it must be capable of easy management, and take care of itself to a great extent after being properly adjusted and started at its work.

The second requirement is economy of steam. Economic use of steam is, of course, important and desirable, but it must not be accomplished at too great expense of repairs and the necessity of continual attention and adjustment on the part of the attendant. The cost of a pumping engine is another important consideration, and is the "stumbling block" of waterworks companies and committees generally, when a few thousand dollars more of first cost has many times outweighed the above-mentioned qualities, and it has been demonstrated to their sorrow and cost that to own some pumping engines is sufficient to bring great loss and almost ruin, even if the engine had been taken as a gift, on account of the bills for repairs which are contracted, that things may be kept moving.

Pumping engines may be divided into two general classes—crank and fly-wheel or rotation, direct-acting or non-rotation, and are made of almost endless variety as to details, the particulars of which I do not care to enter into in this letter. Just where to draw the line that a crank and fly-wheel engine should be used and not a direct-acting engine, appears to be debatable ground, and where engineers, like doctors, disagree. It therefore behooves me to handle this part of my letter with great care, and endeavor not to tread on the toes of any pumping engine manufacturer.

The history of the pumping engine construction commences in this country, as in England, with the Cornish engine. This engine gave fine results in the department which it originated—mine pumping. The engine was inordinately large for the work, and made only a casual stroke now and then, as demanded by the flow of water into the mine, the water being delivered at the surface with no force main, and there being no demand for uniform flow.

A glance at the conditions under which it works will explain the otherwise unaccountable fact that a pumping engine without a rival in one place has a failing reputation in another. Its honors were never qualified until it was transplanted from the home of its usefulness to do duty in a service where water was to be discharged through a long main to a great height above the pump, and under the requisition of continuous and uniform delivery. This was the very requirement which, from its nature, the Cornish engine was unfitted to meet. The Cornish engine is in its nature precarious, requiring constant watchfulness on the part of the engineer, and cannot safely be trusted for a minute without this care and supervision. This uncertainty of its action, great first cost, and expensive repairs, has finally led to its abandonment for waterworks. The crank and fly-wheel engine was the first and most obvious alternative. While emulating the economy of the Cornish engine, it was positive in its motion and safer in its character. In the crank and fly-wheel engine, steam is cut off at a certain fraction of the stroke, while the remainder is finished by expansion, aided by the momentum of the fly-wheel, thus producing great economy in the use of steam at the expense of intricate machinery. These engines operate either vertically or horizontally. They require expensive and massive foundations to absorb the shocks and jars incident to their working, this being especially true of vertical engines, the momentum of the fly-wheel in its revolutions increasing to a large extent the accidents that would otherwise be trifling.

The use of duplex direct-acting steam-pumping engines in waterworks dates from about 1854, and it was brought in direct competition with the Cornish, and crank, and fly-wheel engines. The duplex engine is horizontal in action and usually allows the steam to follow the piston throughout its stroke, thus preserving great simplicity and compactness in working parts.

The foundations required are much lighter and less expensive than that for a crank or fly-wheel engine.

The duplex engine is essentially two direct-acting pumps placed side by side, their valve motions being so arranged that the motion of one pump acts to give steam to the other, after which it finishes its own stroke and waits for its valve to be acted upon before it can renew its motion. This pause allows all the water valves to seat quietly, and removes everything like harshness of motion, keeping up a uniform delivery, without pulsation or noise. The smoothness of motion and simplicity in steam valve mechanism reduces the liability of accident to a minimum. While it is not claimed that the compounding condensing duplex engine is capable of developing the highest duty, their yearly records are excellent, ranging from 50,000,000 to 65,000,000 duty, and trials have been reported as high as 120,000,000.

It is claimed for these engines that their moderate first cost—engine proper, foundation and building, as well as inexpensive repairs, and small expense of replacing any important part—makes them in a majority of cases the most economical to use.

In conclusion, I trust that I have brought out a few points which may be of interest to your readers on the subject of pumps and pumping machinery. I find in conversation with numbers I come in contact with that pumps and pumping machinery are very poorly