The Leavitt Pumping Engine

at

Chestnut Hill Station

of the

Metropolitan District Commission

Boston, Mass.

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Photos 3 and 4, by C. J. MacFarlane, Belmont, Mass.

I CHESTNUT HILL PUMPING STATION

The first public water supply for the City of Boston introduced water by gravity from Lake Cochituate in 1848. Thirty years later, in 1878, an additional source of water supply was achieved by diversions from the Sudbury River.

Annexation of towns adjacent to old Boston added to the city a considerable number of elevated areas to which water had to be raised by pumping above Cochituate and Sudbury elevations.

High service pumping of water was established at Chestnut Hill with the construction and equipping of the High Service Pumping Station in 1887, which was developed into one of the principal pumping facilities of the Metropolitan District Commission.

This station is located on the south side of the Chestnut Hill Reservoir in Brighton. Architecturally, the buildings of the high service station are an imposing group, built of Milford granite with heavy trimmings of Longmeadow freestone (sandstone).

The pumps are entirely driven by steam engines, with the boiler room in the east wing of the building and the pumps in the main portion. For many years the boilers were fired by coal, delivered by rail on the adjacent former Boston & Maine Railroad. Coal-firing was replaced by oil-firing in 1954.

Our special interest on this occasion is the Leavitt Pumping Engine, installed in 1894 as Engine No. 3 of the Chestnut Hill Station, to provide added capacity to the existing pumping units in order to meet the increased demand in the high service areas of Boston. This engine was of unusual design and its performance attracted much attention in the field of steam engineering and municipal water systems.

The engine is still in its original location, retired in 1928 though kept in operating condition for some years thereafter. The Smithsonian Institution, of Washington, D. C. considers this an outstanding example of steam engineering. Beside drawings and pictures of this engine the Smithsonian has in its possession scale models of this and the Louisville, Kentucky, Leavitt-Riedler pumping engine.

II THE LEAVITT - PUMPING-ENGINE

The name plate of the engine bears these words, “Boston Water works, Riedler Pumping Engine, Designed by E.D. Leavitt, Built by N.F. Palmer Jr. & Co., Quintard Iron Works, New York.”

It is a triple expansion, three-crank rocker engine, with pistons 13.7, 24,375, and 39 inches in diameter and 6 foot stroke. The cylinders are vertical and inverted, and are carried, together with the valve gear, on an entablature supported by six vertical and six diagonal columns rising from the bed plate.

The engine connecting rods act upon rockers somewhat like bell-cranks, carried in pedestals on the bed plate. From each rocker, two additional connecting rods run, one to the shaft of the fly wheel, this rod being nearly horizontal when the crank is at its highest point. The other connecting rod runs in the other direction at an angle of about 30 degrees, from the horizontal to the plunger rod of the pump proper. The leverage of the various pins in the beams is such that the stroke, of six feet in the case of the steam pistons is reduced to four feet for the pump plungers, which is also the amount of the double throw of the cranks. The crankshaft has three cranks set at angles of 120 degrees, the low pressure crank leading, followed by the intermediate and high pressure cranks. The shaft is carried on four adjustable four-box pedestals with overhung end cranks. Between two of these pedestals is the flywheel, and between the other two, the gear for driving the camshaft.

The steam and exhaust valves of the engine are gridiron slides worked by cams on a horizontal shaft, which is driven by gearing from the crankshaft. The cut-off of the high pressure cylinder is regulated by the governor through the agency of a hydraulic cylinder, which advances or retards the cut-off cam by means of a spiral sleeve; the cut-offs of the other cylinders are fixed.

Steam enters the high pressure cylinder through a separator forming a part of the inlet pipe. After expanding in this cylinder it passes through a tubular reheater to the intermediate cylinder, and thence through another similar reheater to the low pressure cylinder. The reheaters have steam of boiler pressure, or about 185 psi, on the inside of the tubes and the working steam on the outside. All the cylinders are steam-jacketed on head and barrels, the low pressure cylinder at 100 psi and the other two at 185 psi. Drains from high pressure jackets and reheaters are returned to the boiler and low pressure jacket drains and water removed from the steam by the separators are discharged to the hotwell.

There are three double-acting inclined pump plungers, each of four-foot stroke and 17.5 inches in diameter. The pump foundation is below the floor of the engine room, the pump chambers being tied to the engine bedplates by horizontal


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CHESTNUT HILL H. S. PUMPING STATION
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girders, as well as by the pump crosshead guides, which are inclined 30 degrees to the horizontal. This peculiar arrangement of inclined pumps was found necessary to suit existing conditions of the engine house, pumpwell, etc. By reduction of stroke from that of the engine, as well as by the relation of diameters, an increased capacity for pressure is obtained.

The pump bases or suction chambers, six in number, one for each end of each pump, are connected together and the bases of each pump are connected by a separate suction pipe. The lower or working pump chambers are surrounded by annular spaces throughout their height, forming vacuum chambers. The Upper pump chambers contain the delivery nozzles, and above these are the air chambers, all six of the latter being connected by pipes.

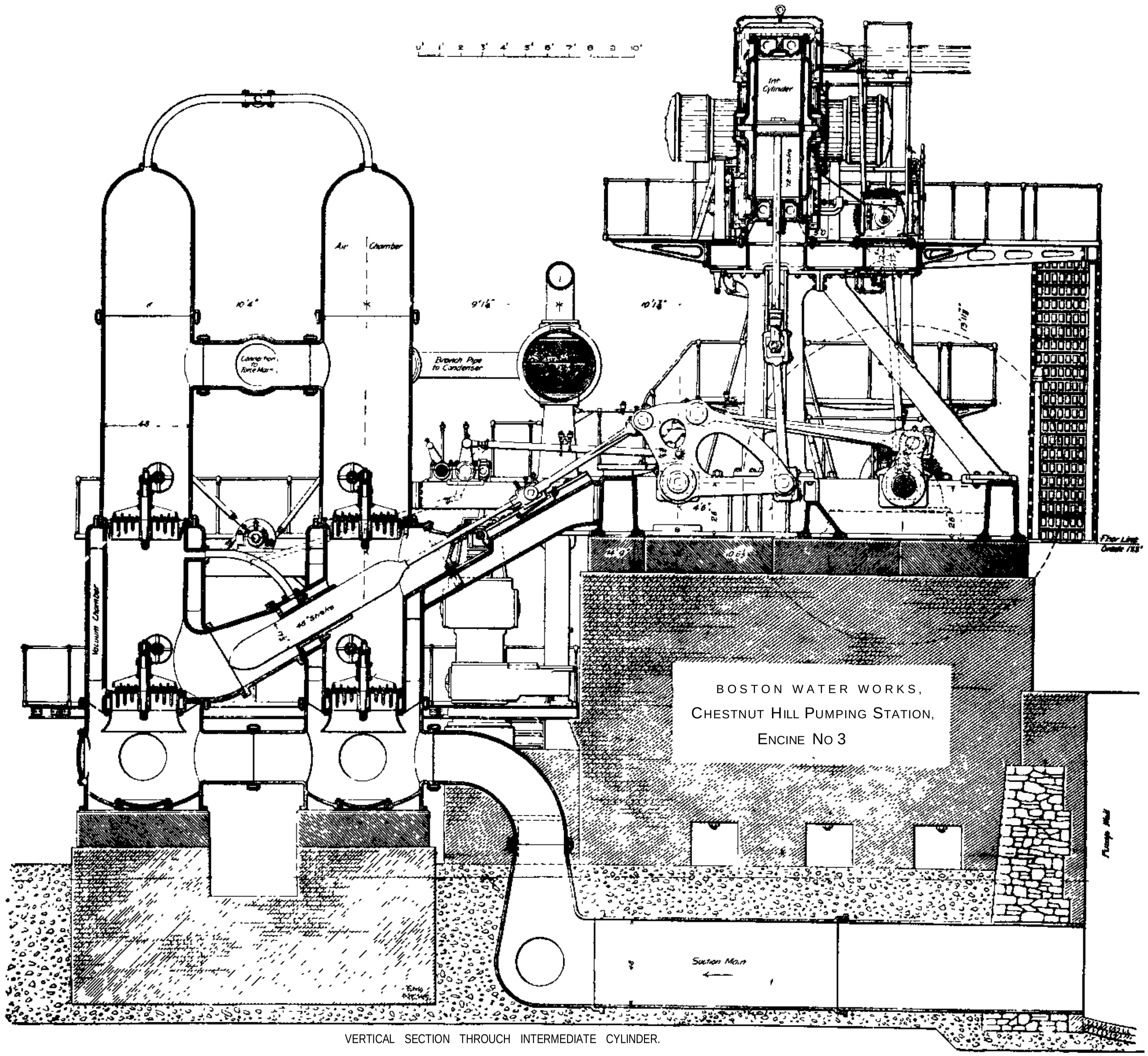
The pump valve mechanism, somewhat similar to the valve rod system of a Corliss engine, is one of the characteristic features of the engine, based on the invention of Prof. Riedler of the Royal Polytechnic school, Berlin, Germany. This engine was designed to run easily at 60 revolutions per minute, pumping against a head of 128 feet, a speed made possible only by the use of the Riedler valve gear, introduced to the U.S.A. in the design of this machine (actually, another Leavitt-Riedler engine began operation a year earlier). At the normal speed of 50 revolutions per minute, the pumping capacity is 20,000,000 gallons in 24 hours.

The pump valves consist of a number of rigidly connected rings, each ring closing an annular opening in the valve seat as shown in the sectional view. The Upper valves are delivery valves and the lower are suction valves. The diagonal rods running from the center cam, Corliss engine fashion, and moved by the connecting rods leading from the main rockers, operate to close each valve positively at the exact moment of the reversal of the stroke. As soon as the valves are closed the mechanism moves out of the way, leaving the valves free to open automatically. This feature makes possible the high velocity.

Water is taken from the air chambers to the force main by a horizontal pipe branching into them, also to the 1410 square foot surface condenser, where the pumped water passes through the tubes and condenses the engine exhaust steam. After passing through the condenser the water is delivered to the force main.

Directly below the condenser is the air pump with a 24 inch cylinder diamater and 12 inch stroke, worked by an arm from one of the rocker shafts operating the pump valve gear.

Steam for the engine was furnished by a Belpaire fire-box boiler having two separate furnaces and a common combustion chamber. This bciler, no longer in existence, was 34 feet 4 inches long, with a least internal shell diameter of 90 inches. The boiler tubes were 201 in number, 3 inches in diameter and 16 feet long. A Green economizer heated the feed water by flue gases before the water entered the boiler.



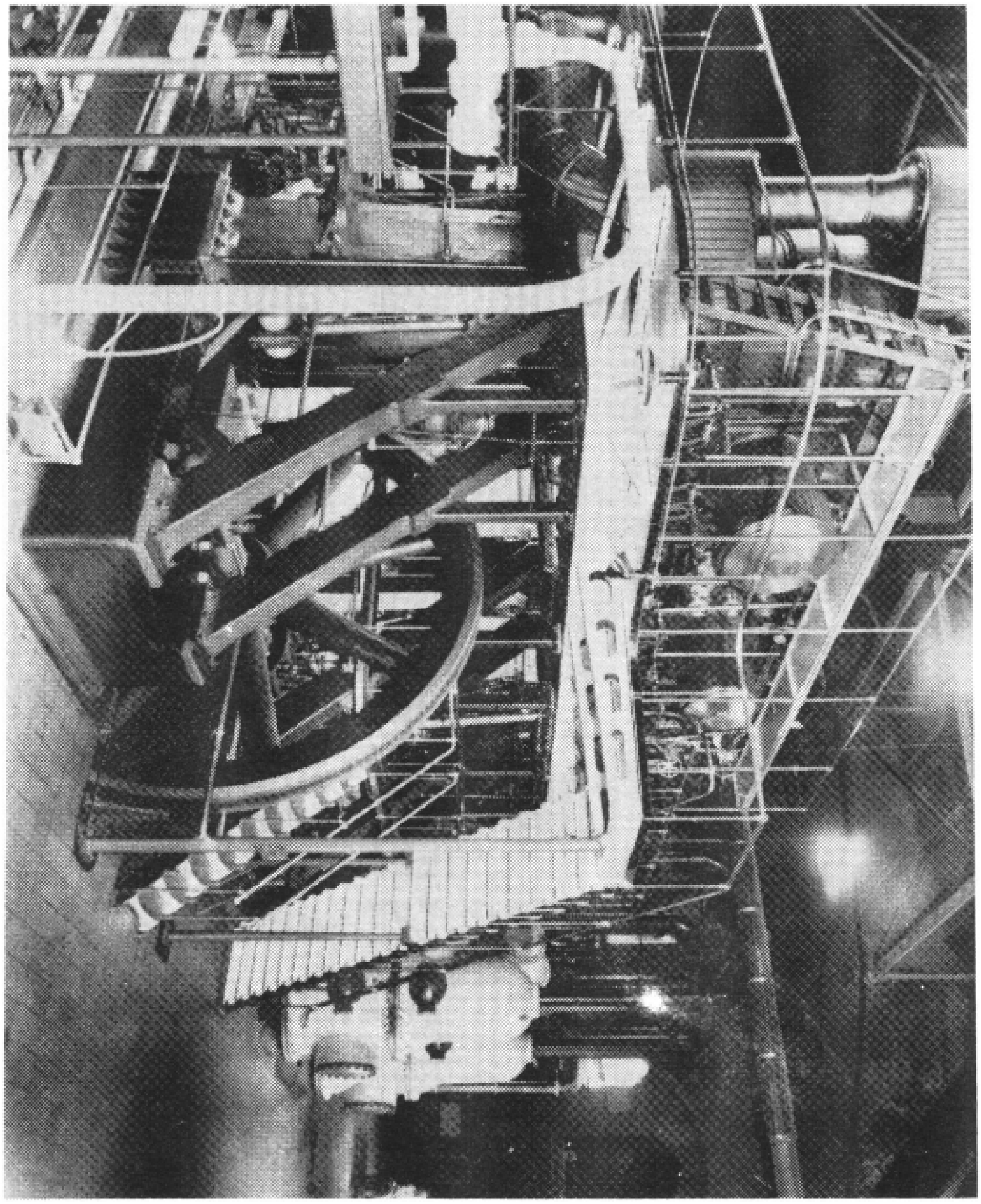
VERTICAL SECTION THROUCH INTERMEDIATE CYLINDER.

In 1895 a large group of engineering students, under the direction of Professor Edward F. Miller of the Massachusetts Institute of Technology, conducted a very detailed performance test on the engine, principal results of which are tabulated below:

TRIPLE-EXPANSION LEAVITT PUMPING-ENGINE AT THE CHESTNUT HILL STATION, BOSTON, MASSACHUSETTS

Duration, hours	24
Total expansion	21
Revolutions per minute	50.6
Steam-pressure above atmosphere, pounds per square inch	175.7
Barometer, pounds per square inch	14.9
Vacuum in condenser, inches of mercury	27.25
Pressure in high and intermediate jacket and reheaters, pounds per square inch	175.7
Pressure in low-pressure jacket, pounds per square inch	99.6
Horse-power	575.7
Steam per horse-power per hour, pounds	11.2
Thermal units per horse-power per minute	204.3
Thermal efficiency of engine, per cent	20.8
Efficiency for non-conducting engine, per cent	28.0
Ratio of efficiencies, per cent	74
Coal per horse-power per hour, pounds	1.146
Duty (foot-pounds per 1,000,000 B.T.U)	141,855,000
Efficiency of mechanism, per cent	89.5

Although most of the engine, including the principal castings, was produced in the U.S.A., Mr. Leavitt believed that forgings produced by the Krupp works in Germany were the best obtainable. In keeping with his high standards, he specified Krupp forgings in the Chestnut Hill pumping engine, and that name appears on several critical parts. The workmanship shown in these components was a point of interest to visiting engineers and students.



III BIOGRAPHICAL SKETCH OF THE DESIGNER

Erasmus Darwin Leavitt, Jr.

1836 - 1916

Erasmus Darwin Leavitt, Jr., was born in Lowell Mass., on October 27, 1836. After early education in the Lowell public schools, he served a three-year apprenticeship in the machine shop of the Lowell Manufacturing Company. Following a year's employment with the firm of Corliss and Nightingale, Providence, Rhode Island., he became assistant foreman at the City Point Works (south Boston) of Harrison Loring, where he had charge of construction of the engine of the U.S.S. Hartford.

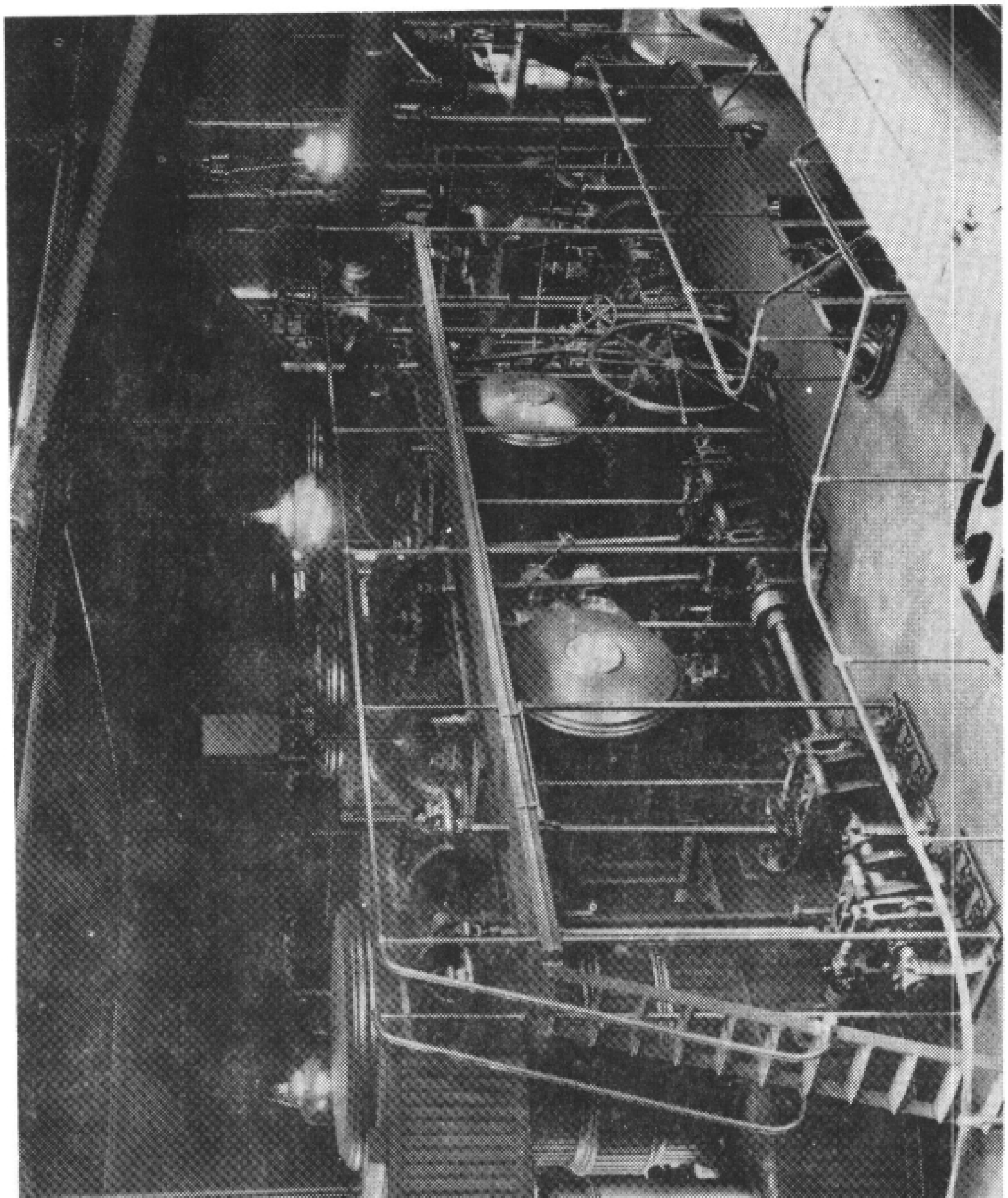
From 1859 to 1861 Mr. Leavitt was Chief Draftsman for Thurston, Gardner & Co., steam engine builders of Providence, Rhode Island, leaving to enter the U.S Navy at the start of the Civil War. In 1865 he was made instructor in Steam Engineering at the U.S. Naval Academy, Annapolis, Maryland.

In 1867 Mr. Leavitt resigned to resume private practice as a Mechanical Engineer, specializing in pumping and mining machinery. Sixteen patents were issued to him between 1855 and 1889 in this field. A pumping engine of his design, installed at Lynn, Massachusetts, and tested in 1874, brought him into prominence in the engineering world. He became Well acquainted with leading engineers of several European countries, among these, Professor Riedler of the Royal Polytechnic School, Berlin, Germany, from whom he acquired the right to use the Riedler pump and valve gear in the U.S.A.

One of his best known and most successful designs including the Riedler features was that of the twenty million gallon per day pumping engine, installed at Chestnut Hill in 1894 and operated for over thirty years by the Boston Water Works and the Metropolitan District Commission.

In addition to serving as a consultant for cities and pump and engine builders, Mr. Leavitt was mechanical engineering consultant for Calumet and Hecla Mining Company from 1874 to 1904, during which time his reputation and fame in the field of mechanical engineering were further recognized as having done more than any other American engineer to establish sound principles and propriety of design.

Mr. Leavitt was granted an honorary degree of Doctor of Engineering from Stevens Institute of Technology in 1884, the first recipient of this degree from the Institute. Prominent in many engineering societies in this country and England, Mr. Leavitt was an original member of the American Society of Mechanical Engineers and its President in 1883. He was also a Fellow in the American Academy of Arts and Sciences.



He served on the Boston and Cambridge Bridge Commission, the Visiting Committee of the Engineering Department of Harvard University and of the Observatory, and was greatly interested in the Cambridge Young Men's Christion Association.

Mr. Leavitt was a striking example, — perhaps among the last, — of engineers, who, without what is called technical training, have achieved the highest distinction in the ranks of Mechanical Engineering and have left a memory which marks almost an epoch in the practice of steam engineering.

Mr. Leavitt died on March 11, 1916 at Cambridge, Massachusetts, where he had lived for many years. At the time of his death he was survived by his three daughters, his wife having died in 1889.

IV REFERENCES

Fitzgerald, Desmond, -- A Short Description of the Boston Water Works, 1895, Boston.

Peabody, Cecil H., Thermodynamics of the Steam Engine. 6th Edition, 1909, M.I.T.

The Technology Quarterty, Vol. IX, 1896, Massachusetts Institute of Technology Archives.

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