

Dimensions.

	Feet.
Height above ground line.....	282
Outside diameter foundation	30
Outside diameter 2 feet 6 inches above ground	28
Inside diameter 2 feet 6 inches above ground.....	12
Inside diameter at top.....	12

Foundation.—The chimney is founded on a ledge of sandstone. The foundation, 30 feet in diameter, is built of granite blocks, laid on their natural beds. At the surface of the ground there is a dressed granite base 2 feet 6 inches in height, laid in clear Portland cement, the remainder of the foundation being in Rosendale cement and sand.

Upon this base is placed the brickwork, consisting of three cylinders, as follows:

Outer Shaft.—Batter, 0.42 inches per foot, for a height of 100 feet.

First section... 75½ feet high, 28 feet diameter 24 inches thick.
 First section... at junction of inner shaft.... 36½ inches thick.
 Second section 60 feet high..... 20 inches thick.
 Third section.. 70 feet high..... 16 inches thick.
 Fourth section 74 feet high, including cap.. 12 inches thick.

279½ high above granite base.

Inner Shaft.—Vertical, 18 feet diameter; 75½ feet high; 8 inches thick.

At this height the inner shaft connects with the exterior brickwork, making the masonry at that point 36½ inches thick, as above.

Lining or Core.—Uniform inside diameter, 12 feet.

It is entirely separate from the outside masonry, except the doorways and flue-openings, and is built up as follows:

First section.... 100 feet high, 16 inches thick.
 Second section.. 60 feet high, 12 inches thick.
 Third section.... 90 feet high, 8 inches thick.
 Fourth section.. 29½ feet high, 4 inches thick.

279½ feet high above granite base.

Construction.—The core was laid in mortar of lime and sand; the outside shell in lime, cement, and sand.

Ladder and Lightning Conductor.—On one side of the chimney is a ladder of iron extending from the ground to the top, and on the opposite side is a ¾-inch galvanized iron-wire rope, both ladder and rope being connected with a copper ring, having four spurs, the central point of which extends 8 feet above the top of the shaft. The bottoms of both ladder and rope are connected to a 16-inch water-pipe.

Duty.—Two wrought-iron flues enter the chimney, one 5 feet by 6 feet, and the other 5 feet by 11 feet. The chimney is constructed to provide for 15 sets of boilers; only 12 are now in use. Each set has 103½ square feet of grate surface, and is rated at 300 horse-power.

Weight.—Chimney, 3,392 tons; cap, 18,600 lbs.

Materials.—Brick used, 1,101,000; 6,875 cubic feet stone masonry.

Cost.—\$18,500.

Holyoke Machine Company (1883). Flue, 42 inches square by 120 feet high.

Double Wall.—Inner wall to within 24½ feet of top, above this wall the flue is enlarged to 48 inches square.

There are three arches in each side with stone water-tables above each, and a double arch at the top of chimney.

The top is covered with a casting bolted together in sections; 144,044 bricks were used in its construction, and its cost was, aside from cast cap, \$2,160.60.

Weight of cast cap was 869½ lbs., which, with labor, adds \$31.41 to cost, or a total of \$2,192.01.

An internal ladder of round iron provides means of access to the top.

Each wall is built in three steps or thicknesses, not given above the base, where the outer wall is 16 inches, 54 feet high, those above it probably 12 inches, 23 feet high, and 8 inches for the balance, 12-inch inner, 39 feet core; those above probably 8 inches, 45 feet, and 4 inches, 55½ feet high.

A very clear engraving of this chimney can be found in the *American Machinist*, March 24, 1883.

Pacific Mills, Lawrence, Mass. Architect and builder, H. F. Mills, C. E.; built 1873.

Description.—Brick, octagonal outer shaft, circular inner shaft, vertical inner lining. Shaft situate 210 feet from boilers.

Dimensions.

	Feet.	Inches.
Total height.....	242	0
Height of outer shaft, including footings.....	233	0
Height of inner lining.....	234	0
Outside measurement, outer shaft at base.....	20	0
Outside measurement, outer shaft at top, under projecting cornice	11	6
Inside diameter, vertical flue.....	8	6

Foundation.—Foundation bed, 19 feet below ground; coarse gravel; concrete, 35 feet square, enclosed by pine-sheet piling 1 foot thick; rubble masonry of granite, in Rosendale cement, 7 feet high.

Outer Shaft.—This is constructed in six sections, viz.:

First section	12 feet high, 28 inches thick.
Second section ..	18 feet high, 24 inches thick.
Third section ...	20 feet high, 20 inches thick.
Fourth section ..	40 feet high, 16 inches thick.
Fifth section	60 feet high, 12 inches thick.
Sixth section....	83 feet high, 8 inches thick.
	233 feet high above granite masonry.

Inner Shaft:

First section	27 feet high, 24 inches thick.
Second section...	154 feet high, 12 inches thick.
	181 feet.

Lining:

First section	20 feet high, 20 inches thick.
Second section...	17 feet high, 16 inches thick.
Third section	52 feet high, 12 inches thick.
Fourth section....	145 feet high, 8 inches thick.
	234 feet above granite masonry.

Construction.—The foundations were laid in mortar of Rosendale cement and sand; the outer shell in mortar of Rosendale cement, lime, and sand; and the flue-walls in mortar of lime and sand.

Duty.—In the winter of 1873, the vertical flue having reached 90 feet in height above ground, boilers having 542 square feet of grate surface were connected with the chimney, with satisfactory results. The chimney was designed to serve boilers having 700 square feet of grate surface.

Weight.—The approximate weight of the chimney is 2,250 long tons.

Bricks.—There were 550,000 bricks used in the construction of the shaft.

Lightning Conductor.—The shaft was struck by lightning in June in 1880, after which date a lightning-rod was put up. It consists of a seamless copper tube, $\frac{5}{16}$ inch thick, 1 inch inside diameter, at the top of which are seven points radiating from a ball 4 inches in diameter, the top of the central point being $8\frac{1}{2}$ inches above the iron cap. The rod is attached to the chimney by brass castings, and is connected at the base to a 4-inch iron pipe extending 60 feet to a canal.

This is a very weak chimney, the diameter at the base is 15 feet; one-tenth of the height (a common rule) would give 21.1 feet.

J. B. Francis, in a report on the above chimney, says 44 lbs. wind-pressure per square foot would blow the chimney down.

Brick chimney of the Narragansett Electric Lighting Company, at Providence, R. I. Designed by Messrs. Remington and Henthorn, Providence, R. I.

The foundation of the chimney consists of piling and concrete, and to arrange for it 44 square feet was excavated 5 feet 6 inches below the zero line of high water, and the sides protected by 3-inch spruce sheet-piling 16 feet long.

Over this excavation the pile-driver, having a ram weighing 2,200 pounds, was rolled.

Spruce piles, 50 feet long, were driven as far as possible without breaking, and were spaced 30 inches centre to centre, as shown in Fig. 1.

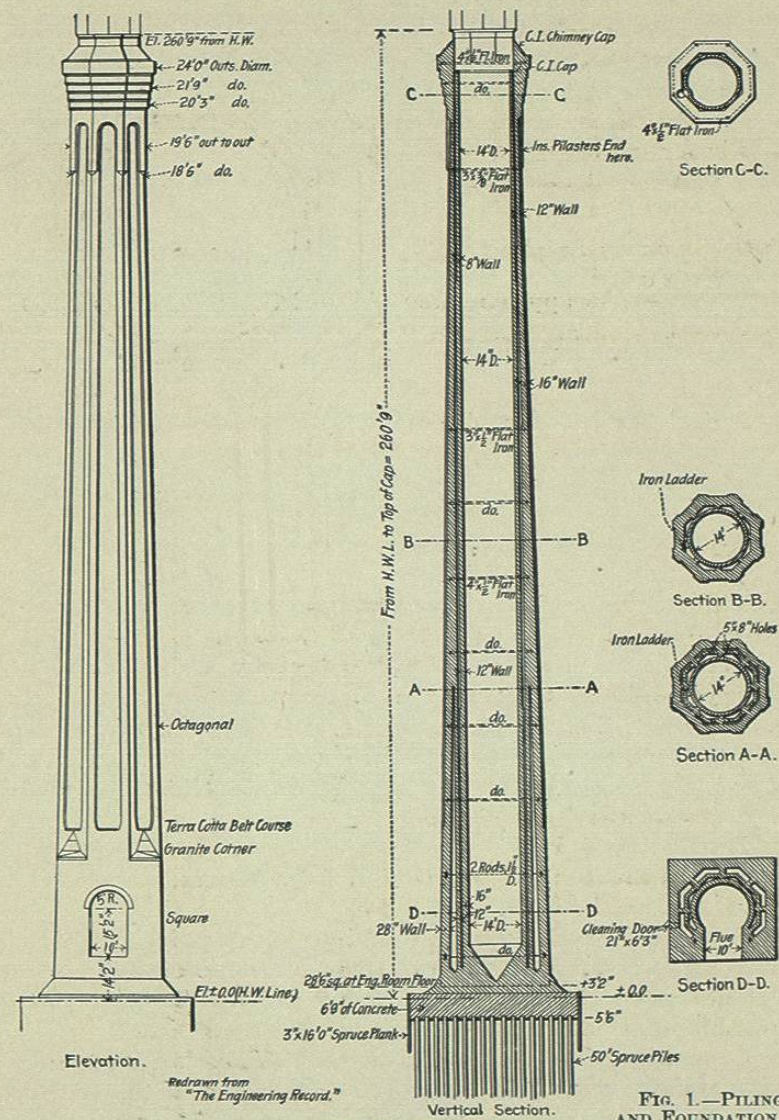


FIG. 1.—PILING AND FOUNDATION.

ILLUS. No. 26.

BRICK CHIMNEY, NARRAGANSETT ELECTRIC LIGHTING COMPANY, PROVIDENCE, R. I.
260 feet 9 inches high. Flue, 14 feet diameter.

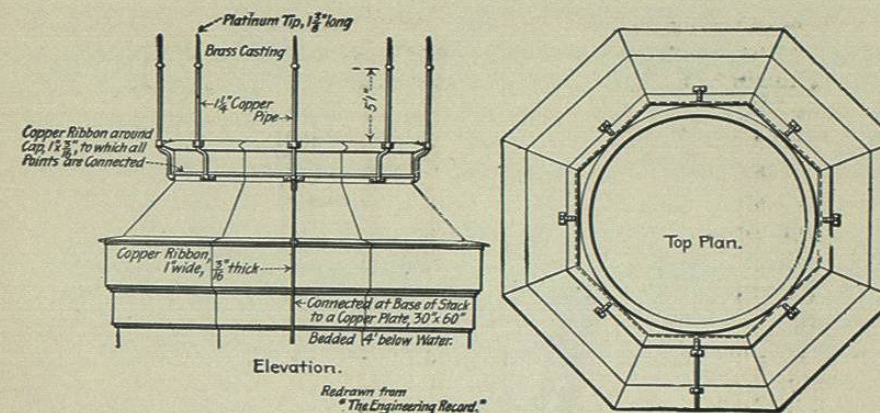


FIG. 2.—CHIMNEY CAP—LIGHTNING PROTECTION.

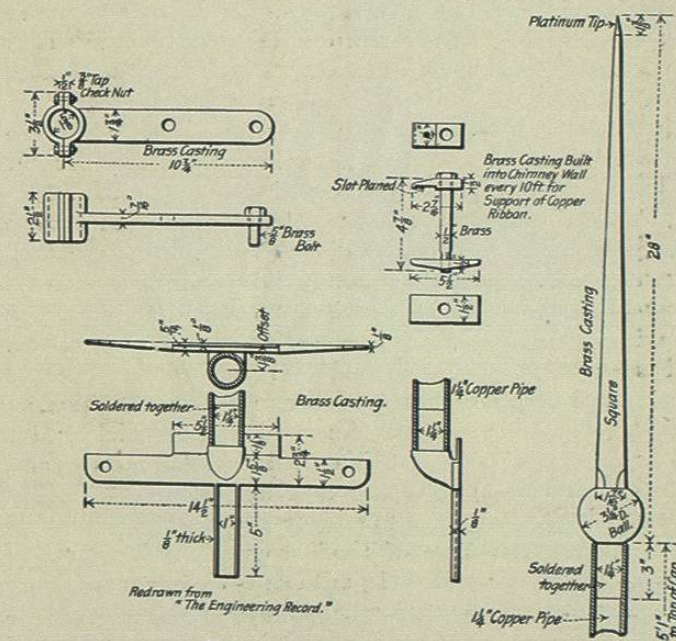


FIG. 3.—LIGHTNING FIXTURES.

ILLUS. No. 27.

NARRAGANSETT ELECTRIC LIGHTING COMPANY, PROVIDENCE, R. I.

There are, however, many more piles shown in this cut, but those were driven to sustain other structures alongside. In the drawing of chimney, of which there are 231 piles, they are shaded lightly that they may be more readily recognized.

These piles are cut off uniformly at 5 feet below the high-water line, the earth around their heads thus being 6 inches below their tops. The intervening space between the sheet-piling was filled in with concrete composed of one part of Norton's hydraulic cement, two parts sand, and three parts coarse gravel and broken stone.

This mass was carried up to the 1 foot 3-inch level, and consequently, formed a foundation 6 feet 9 inches thick, with the head of each pile projecting 6 inches therein. This was then covered with earth and allowed to season during the winter. On May 31, 1889, work was resumed by laying the first brick of the chimney. This was carried up in the form of a square of 36 feet, to a height of 3 feet 2 inches, and from that level the base of the chimney proper, which was 28 feet 6 inches square, was started.

The centre of the chimney was fixed by building into the chimney a cast-iron plate, upon which was a well-defined centre mark.

From this centre mark all measurements and plumbing were established while the chimney was being built.

As each 20 feet in height was built, the centre of its axis was re-established, and if any deviation from the plumb was found it was corrected before the next 20-feet level was reached.

The base of the chimney, as before stated, is 23 feet 6 inches square; consists of three walls, an outer wall 28 inches thick, an intermediate wall, octagonal in form, 12 inches thick, and a core wall, circular in section, 16 inches thick. The outer and intermediate walls are joined together by pilasters 12 inches thick.

In commencing the base of the core wall each course of brick was set back $2\frac{1}{2}$ inches from the previous course, until the inside diameter, 14 feet, was reached, when the wall was carried plumb 16 inches in thickness up to the 78 feet 2-inch level, where it was reduced to 12 inches, and run up to 193 feet 2 inches, where it was again reduced in thickness to 8 inches,

and thus carried to 249 feet 9 inches. This wall, complete, was laid up in lime mortar which had been slaked from three to six months before using.

The outer wall, of rectangular cross-section, was carried up to the 38 feet 2-inch level, where, at each of the four corners, cut granite blocks were laid to change from a square to an octagonal cross section.

The chimney was built entirely from the inside platforms, the masons working overhanded, and thus no staging was necessary on the outside. Up to the level of the granite work all the stock used was carried up a ladder placed on the outside. But at this point there was constructed inside the 14-foot chimney-flue an elevator, fitted with safety clutches, and capable of carrying a thousand pounds, although not more than four hundred and fifty was allowed to be placed upon it at any one time; and thereafter everything used in the process of construction was sent up the elevator, to hoist which a 19-strand steel cable was used. The temporary framework inside the flue consisted of four 6 by 8-inch timbers, laid across each other at right angles in pairs, and built into the walls at intervals of every 5 feet.

Through the opening at the centre the elevator passed.

Over these timbers was laid a platform of 2-inch plank, upon which the masons performed their work. To these 6 by 8-inch horizontal timbers, at opposite corners, were bolted the vertical guides for the elevator and its upright framing, by which it was hoisted; these were spliced out at the top each alternate staging.

The opening for smoke-flues is 10 feet wide and 18 feet high, with a 28-inch arch of 5 feet radius. The lower part of the opening is on the 14 feet 2-inch level.

Directly below and above the opening on the 13 feet 2-inch and 33 feet 2-inch levels, were placed on each of the four sides of the chimney, and 8 inches from the outside surface of the wall, two $1\frac{1}{4}$ -inch diameter rods, with $1\frac{1}{2}$ -inch ends, connected together by cast-iron plates 12 by 14 inches square.

Openings were left at each corner so that the nuts could be examined occasionally as the work dried out.

From and including the 53 feet 2-inch level, there were laid

edgewise at each 20 feet in height and 8 inches from the outside surface of the chimney wrought-iron bars of 4 inches by $\frac{1}{2}$ inch with their ends bolted together, forming an octagon corresponding to that of the chimney. At the 153 feet 2-inch levels these braces were reduced in size to 3 inches by $\frac{1}{2}$ inch, and were not again used until the 223 feet 2-inch level, or where the commencement of the head was reached, at which point bars 3 inches by $\frac{3}{8}$ inch were bolted together in the wall. Their next application was in the head, where two braces made of 4-inch by $\frac{1}{2}$ -inch iron were used to help in binding the heavy brickwork together during construction, which had considerable overhang (2 feet 9 inches on each side).

With reference to the outside walls, the outer and intermediate walls, with their connected pilasters, were built as one structure and terminated on the 83 feet 2-inch level (see p. 106), where by the batter the outer wall is thus joined to the intermediate, and become one wall from that point.

At this level two holes 5 by 8 inches were left in each of the eight sides of the intermediate walls, so that the intervening space between the outer and inner walls might be ventilated, if by any possible chance gases should find access to this space.

These ventilating spaces or holes are in communication with the space between the outer wall and the core, which is carried nearly to the top.

An attempt has been made to protect the structure from lightning, by encircling the cast-iron cap with a copper ribbon 1 inch by $\frac{3}{16}$ inch thick, to which are connected, by riveted and soldered joints, eight brass upright sockets, one in the centre of each panel of the cap.

To these brass sockets castings are secured by soldered joints $1\frac{1}{2}$ -inch seamless drawn copper tubing, which extends upward above the top of the cap and conforms to the shape thereof, and after projecting 5 feet above the top of cap the tubes are each surmounted by a brass casting 28 inches long, tapering in cross section, and having at its extremity a platinum point $1\frac{3}{8}$ inches long.

The encircling ribbon around the cap is connected to the ground ribbon by a brass casting thoroughly riveted and sol-

dered thereto, which, as it runs down the chimney is secured in position by brass clamps with bolts built into the brickwork as it progressed.

This arrangement, as a whole, is shown in detail in Figs. 2 and 3.

The lower end of the ribbon, which is 1 by $\frac{3}{16}$ -inch copper, rolled in one piece 285 feet long, terminates in a copper plate 30 inches wide by 60 inches long, and $\frac{1}{8}$ -inch thick, and is buried 4 feet below the natural level of the water in the soil of the premises.

This plate is buried in a load of powdered coke, 18 inches being placed above and 18 inches in thickness below the plate, and the whole filled up with gravel.

CHIMNEY AT CLARK'S THREAD WORKS, KEARNY, N. J.

"One of the tallest chimneys in America has been erected at the works of the Clark Thread Company, at Kearny, near Newark, N. J. The shaft is circular and 335 feet in height; it is 28 feet 6 inches in diameter at the base and 14 feet at the neck. Its internal diameter is 11 feet in one circular flue. The top is surmounted by a cast-iron coping weighing 6 tons and made in 32 sections bolted together by inside flanges.

"The foundation is concrete, made with 6 parts crushed limestone, 3 parts sand, and 1 part German Portland cement. This foundation is 40 feet square and 5 feet deep, resting on a bed of firm gravel. On this is founded the base of the chimney of brick and extending 4 feet above the surface of the ground. The material used was brick laid in mortar made $1\frac{1}{2}$ sand to 1 of Portland cement. The shaft up to 160 feet in height was laid with mortar made of 6 parts sand, 2 parts lime, and 1 part cement; the sand and lime have stood for three months previously made up as mortar, and the cement was added just before use. The top of the chimney was laid in mortar made of 3 parts sand to 1 of lime and 1 of cement.

"The outer bricks were first quality North River, and the backing bricks were of a good quality New Jersey brick. At intervals of 20 feet an iron ring 4 inches wide, $\frac{3}{4}$ to $\frac{1}{2}$ inch

thick placed edgewise, was built into the walls about 8 inches from the external surface.

"At the base the chimney is double, with an outer wall 5 feet 2 inches thick, and inside of this is a second 20-inch wall placed about 20 inches inside the first. From the interior of the main wall eight buttresses are built up, nearly touching the main flue wall and intended to keep the flue proper from sagging. The interior wall starting with 20 inches in thickness is gradually reduced until at 90 feet high it is 8 inches thick, and at 165 feet it ceases entirely. No fire-brick was used in the lining.

"Two horizontal flues enter the base of the chimney directly opposite to each other, and a 12-inch deflecting wall is built across the shaft between these flues for a height of 16 feet. The two flues are arched and are 7 feet wide and 8 feet high, and in these flues will be placed feed-water heaters for the boilers; 21 boilers of 200 horse-power each will depend on this one chimney.

"The lifting was done by an inside elevator, with a 3½ by 3 foot platform, running between 4 by 6 inch guides braced against the inside walls. The interior platforms, erected at every few feet, rested upon two 3 by 8 inch beams built in the wall. The greater part of the brick laying was done by 8 bricklayers and 5 helpers, with 7 laborers on the ground supplying material.

"The foundation and base were put in and the shaft run up 18 feet in December, 1887. The work was again commenced in April, 1888, and finished in September, or in 150 days of 9 hours each. The total weight is about 5,000 tons, divided as follows: Brickwork, 9,051,900 pounds; concrete, 1,000,000 pounds; iron-work, 40,000 pounds. The base contains 1,600 square feet, which would give a load of about 2.8 tons per square foot. No permanent means of access to the top were provided; as if such access becomes necessary a small balloon can be sent up the shaft with a line and allowed to descend on the outside, and a line sufficiently heavy for use is thus carried up."—*Engineering News*, November 10, 1888.

With a flue temperature of 210° Fahr., a draft of 1½ inches has been observed.