

ILLUS. No. 8.

STEEL CHIMNEY AS USED IN AND ABOUT PHILADELPHIA, PA.

DESIGN AND CONSTRUCTION OF TALL STEEL STACKS.

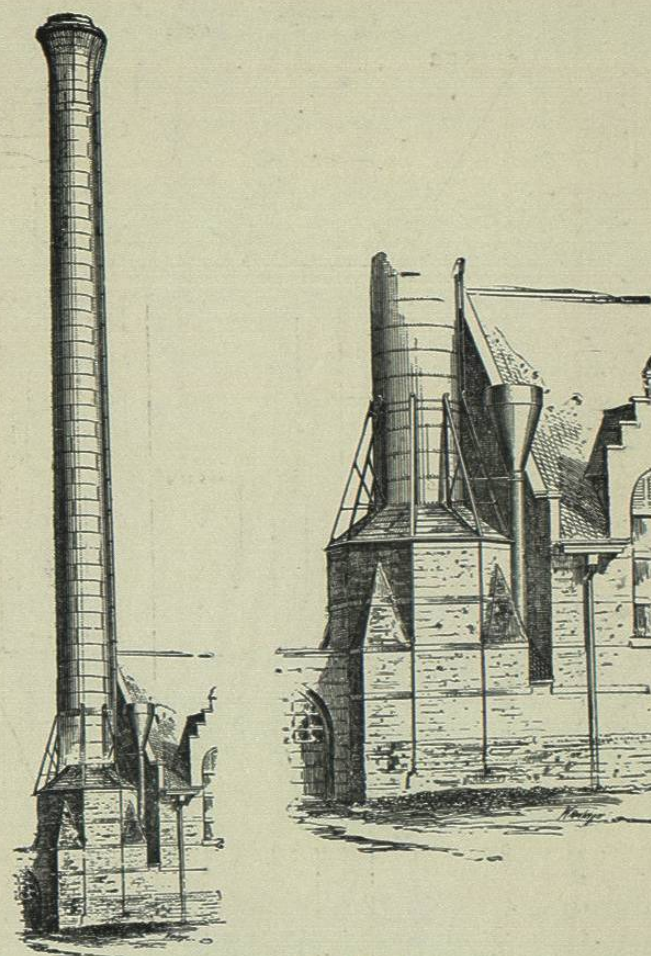
When the large blast-furnace plant of the Maryland Steel Company, at Sparrow's Point, Md., was designed it was deemed advantageous to operate the eight 22 x 75-foot Whitwell blast stoves, and the eight batteries of Babcock & Wilcox water-tube boilers, aggregating 2,000 horse-powers, serving each pair of furnaces by means of one brick-lined steel chimney. Two such chimneys were constructed of 13 feet 9 inches internal diameter and 225 feet in height. Set upon masonry about 16 feet above the surface of the ground, and standing in an exposed situation, independent of guys or bracing. The weight of the metal in each stack is about 77 tons, of the brick about 900 tons, and of the masonry pedestal and foundations about 1,600 tons, making a total of about 2,600 tons, as against 7,400 tons, which a structure of the same height and internal diameter is estimated to weigh if made entirely of brick, stone, and concrete.

The soil on which the chimney was constructed consisted of compact clay, which was excavated to a depth of 6 feet. The first course of stone was laid dry immediately on the clay. No piling was resorted to, and the foundation was built of good masonry in courses to a height of 16 feet above ground level. The base of the stack was made 40 feet square. The load per square foot of foundation area was thus 1.62 tons, and no settlement or irregularity has yet been observed. The masonry was large dimensioned stone, quarry-faced, with dressed arrises, set in a mortar of 1 Portland cement and 3 sand. The inside of smoke tunnels and the shaft was lined with brick offset to form walls of diminishing thickness, decreasing every 40 feet in height by one ring of brick, or in all from seven to two rings of brick.—See Kent, p. 741, for further description.



ILLUS. No. 9.

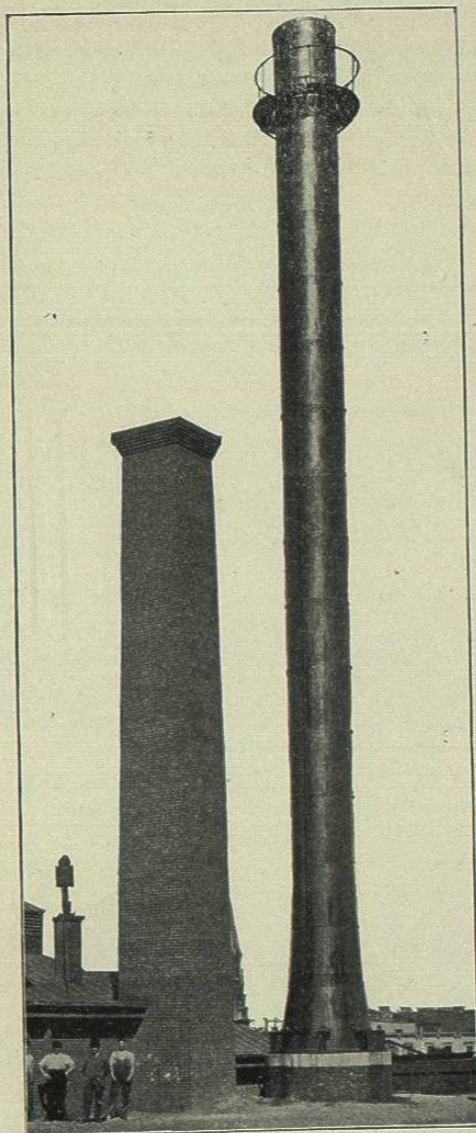
STEEL CHIMNEY, MARYLAND STEEL COMPANY.



ILLUS. No. 10.

STEEL CHIMNEY, ELECTRIC LIGHT AND POWER CO., GARFIELD PARK, CHICAGO, ILL.

Flue, — diam. by 164 feet high.



ILLUS. No. 11.

SELF-SUSTAINING STEEL CHIMNEY (WOOLSON).

Dimensions.—54 inches diameter x 85 feet above foundation, 100 feet from ground.

The chimneys, of which there are to be four, will be constructed of brick to a point 102 feet above the lower boiler-room floor, and extended 98 feet higher by self-supporting steel stacks, making the height of the complete stack 200 feet. The brick portion is to be built into the building and treated as part of such, and is shown in section in illustration No. 12. The internal diameter is 12 feet. The lower section of the steel portion will be belled to 17 feet in diameter, the body diameter being 12 feet 9 inches, and be mounted upon a heavy cast-iron stack-plate 18 feet 8 inches in diameter. Eight steel brackets 24 inches in height will be riveted to the first ring to take the anchor-bolts.

The entire chimney is to be lined with ordinary brick laid in lime mortar rendered hydraulic with Portland cement. The top is to have a locomotive type ornament of copper and a Z-bar painting ring. A steel ladder will run up the outside and over the top of each stack.

The rated boiler horse-power of this station is 31,200, or 2.09 square inches of chimney-flue area per boiler horse-power.

The Metropolitan station has a single chimney of 22 feet diameter for a rated boiler capacity of 21,700 horse-power, or about 2.5 square inches per horse-power. The four chimneys of 12 feet diameter are equivalent to one of 24 feet diameter for a rated capacity of 31,200 horse-power, or about 2.09 square inches per horse-power.

The Metropolitan chimney* is, moreover, 353 feet in height, against 200 for those of the station under consideration. Intensity of draft and increased capacity are obtained in the latter instance by fans, instead of by excessive chimney height, two fans, each capable of handling the gases from 4,000 horse-power of boilers, being attached to each chimney.

These fans are to be capable of producing a draft equivalent to that of a stack 500 feet in height. They are to be overhung in heavy steel-plate housings, the main bearings are to be water-jacketed, and each fan is to be provided with a large sliding damper, by means of which it may be isolated from the hot gases when not in use.—*Power.*

* See p. 123.

The Pueblo, Col., chimney, p. 87, is made of the following weights of steel plates, beginning from the top down:

30 feet of 10 pounds per square foot, $\frac{1}{4}$ inch thick.

25 feet of 13 pounds per square foot, $\frac{5}{16}$ inch thick.

25 feet of 15 pounds per square foot, $\frac{3}{8}$ inch thick, scant.

25 feet of 18 pounds per square foot, $\frac{7}{16}$ inch thick.

25 feet of 20 pounds per square foot, $\frac{1}{2}$ inch thick, scant.

Diameter of main shell 13 feet 8 inches, enlarging at the bottom to 19½ feet diameter, with an inch of sand between the shell and brick lining, which lining extends throughout the chimney, leaving a flue 12 feet in diameter from the concrete sub-base upward.

The concrete sub-base is 30 feet square by 12 feet deep.

The brick frustum of a cone 28 feet square at the bottom, 25 feet square at the top, by 20 feet high.

Flue door 7 feet wide by 16 feet high.

The approximate costs are as follows:

Steel shell erected	\$7,000
Brick lining	1,400
Foundation and pedestal masonry...	3,600
Total cost.....	\$12,000

Built by the Coatesville Boiler Works.

W. W. C's rating of this chimney is 4,186 horse-power.

Following this, we have a list of steel chimneys on page 79.

1. Pennsylvania Railroad Company, at Jersey City, N. J., built 1892.

Base-plate, cast iron.

Flue, 4 feet 8 inches in diameter by 125 feet high.

Upper half of shell, $\frac{1}{4}$ -inch steel.

Lower half of shell, $\frac{5}{16}$ -inch steel, except bottom sheet of $\frac{3}{8}$ -inch steel.

Diameter outside at bottom, 12 feet 6 inches.

Diameter outside at top, 6 feet 10 inches.

Lined throughout with 12 inches of brickwork.

Vertical seams—rivets, $\frac{3}{8}$ -inch diameter, 3-inch pitch.

Horizontal seams—rivets, $\frac{3}{8}$ -inch diameter, 3½-inch pitch.

2. Cleveland Electric Illuminating Company, Cleveland, O.

Lined chimney, 11 feet 6 inches diameter by 225 feet high.

(See *Engineering Record*, vol. xxxv., p. 386.)

3. Westinghouse Air Brake Company, Wilmerding, Pa.

Flue, 11 feet 6 inches diameter by 200 feet high. (See description and cut, pp. 67 and 68.)

4. Bronx Company, Bronxville, N. Y.

Flue, 4 feet 6 inches diameter by 100 feet high.

5. Hartford Street Railway Company, Hartford, Conn., and

6. Manhattan Street Railway Company, Brooklyn, N. Y.

Height, 165 feet.

Diameter at top, 10 feet 9 inches.

Diameter at bottom of bell, 15 feet 10 inches, tapering to 10 feet 9 inches in straight part of chimney.

The foundation is a 20-foot cube.

7. Burden Iron Company, Troy, N. Y.

6 feet 3 inches diameter; 150 feet high.

8. Ridgewood Pumping Station, Brooklyn, N. Y.

8 feet diameter by 217 feet high. (See description and cut, p. 64.)

9. Potomac Light and Power Company, Washington, D. C.

9 feet diameter by 200 feet high.

10. City and Suburban Railway Company, Baltimore, Md.

Two chimneys, 11 feet diameter by 118 feet 9 inches high.

Two stacks are provided, one for each 2½ batteries. These stacks are of steel plate, lined with fire-brick. The metal

stacks rest upon brick piers 18 feet square, of sufficient height (21 feet 6 inches above the boiler-room floor) to take in brick smoke-flues, thus avoiding any cutting of the metal stack, which is weakening and also an unsatisfactory detail to some designers.

The stacks are 11 feet in diameter by 118 feet 9 inches high above the top of the brick pier. The lower section of 14 feet 3 inches is cone-shaped, 15 feet 2 inches in diameter where it rests upon the brick pier. The base-plate is of heavy cast iron, anchored to the pier with seven 2-inch bolts each 24 feet 6 inches long, built into the pier with large anchor-washers; these bolts are up-set $2\frac{1}{2}$ inches for the nut.

The cone-shaped section is $\frac{5}{8}$ inch thick, and the heights of the other sections and the thickness of the steel are as follows: second, 15 feet, $\frac{9}{16}$ inch thick; third, 15 feet, $\frac{1}{2}$ inch thick; fourth, 15 feet, $\frac{7}{8}$ inch thick; fifth, 20 feet, $\frac{3}{4}$ inch thick; sixth, 20 feet, $\frac{5}{8}$ inch thick; balance, 33 feet 9 inches, $\frac{1}{4}$ inch thick. Around the top is riveted a heavy angle-iron stiffening.

11. Cleveland Rolling Mill, Cleveland, Ohio.
11 feet diameter by 190 feet high. (See description, p. 83.)
12. East Boston Electric Railway Power Station, Boston, Mass.
5 feet diameter of flue by 130 feet high.
Outlet for furnaces of 4 Corliss boilers with a total of 8,672 square feet of heating surface. (*Engineering Record*, November, 1894.)
13. Creusot, France.
7 feet 6 inches diameter by 279 feet high. (See description, p. 60, *Engineering News*, May 10, 1890.)
14. Maryland Steel Company, Sparrow's Point, Md.
13 feet 9 inches diameter by 225 feet high. (See description and cut, pp. 73 and 74.)
15. Hartman General Electric Company, Duluth, Minn.
7 feet 6 inches diameter by 200 feet high.
16. Etna Iron Works, Ironton, Ohio.
9 feet diameter by 200 feet high. (Built in 1874.)

17. East River Gas Company, Long Island City, N. Y.
6 feet diameter by 150 feet high.
18. United Glass Company, Chicago, Ill.
6 feet diameter by 125 feet high.
19. Aspinook Company, Jewett City, Conn.
6 feet diameter by 100 feet high.
20. Consolidated Gas Company of New Jersey, Long Branch, N. J.
Not lined; 5 feet diameter of flue by 130 feet high, built in 1896.
21. Consolidated Gas Company of New Jersey, Long Branch, N. J.
6 feet diameter of flue by 120 feet high, built in 1897.
22. Arnold Print Works, North Adams, Mass.
Built in 1896. 42 inches diameter by 100 feet high—guyed.
23. Arnold Print Works, North Adams, Mass.
60 inches diameter by 130 feet high—guyed.
24. Arnold Print Works, North Adams, Mass.
88 inches diameter by 128 feet high—guyed.
Of the latter the lower 23 feet is $\frac{3}{8}$ -inch steel,
the next 50 feet is $\frac{1}{2}$ -inch steel,
the upper 55 feet is $\frac{1}{4}$ -inch steel.
Base-plate is of cast iron, 14 feet diameter, $2\frac{1}{2}$ inches thick, with a shoulder-ring $3\frac{1}{2}$ inches high by 2 inches thick to go inside of the chimney, and with rivets through same.
Total weight of chimney and base-plate, 22 tons.
Through the base-plate were eight $1\frac{1}{2}$ -inch bolts for anchorage.
Each of these chimneys was erected in one piece. (*Power*, November, 1896.)
25. Darwin and Mostyn Iron Company.
Height above foundation, 260 feet.
Depth of foundation, 15 feet.
External diameter at base, 27 feet 6 inches; external diameter at top, 11 feet.
Weight of chimney with foundation, 1,100 tons; weight of equivalent brick chimney, 3,000 tons.

26. Kineshmia, Russia.
170 feet high.
27. Middlesborough, England.
165 feet high.
28. Gottfried Brewing Company, Chicago, Ill.
Outside diameter 9 feet 5 inches by 175 feet; lined.
Steel varies in thickness from $\frac{5}{8}$ inch at the top to $\frac{3}{8}$ inch at the bottom.
The lower 75 feet is lined with fire-brick 8 inches deep, formed to fit the shell; above this is a hollow-tile lining.
The lining is supported at intervals of 25 feet by an angle-iron riveted to the shell.
The foundation is one layer of cement, then two layers of steel rails in cement, then one layer of I-beams, on which the cast-iron base-plate rests.
This chimney furnishes draft to 12 boilers, 60 inches diameter by 20 feet long.
29. Straight-Line Engine Works, Syracuse, N. Y.
Unlined, of No. 10 iron, self-supporting; 79 feet high.
38 inches diameter at top, and 40 inches at bottom.
It has stood gales which demolished large trees, and is built with the top end of the first piece outside of the bottom end of the piece above. (*Power*, December, 1896.)
30. Toledo Traction Company, Toledo, Ohio.
Lined with fire-brick and tile; self-supporting.
Flue 13 feet inside diameter by 213 feet high.
Furnishes draft for four 300 horse-power Sterling boilers.
Furnishes draft for four 200 horse-power Heine boilers.
To run four 1,200 indicated horse-power Green-Wheelock engines.
Thirteen pounds steam per indicated horse-power is guaranteed. (*Electrical Engineer*, January 6, 1897.)
31. Schneider's, Creusot, France.
Top diameter, 27½ inches, by 98 feet 6 inches high.
London *Engineering*, p. 419, 1898, gives an illustration of these chimneys, or one of them being erected in one piece.

32. Dublin (Ireland) United Tramways Company.
2 steel-lined self-supporting chimneys, 10 feet diameter by 200 feet high, on brick bases, which are 26 feet high. Total height of chimney, 226 feet.
33. Metropolitan Street Railway Company, Kansas City, Mo.
Self-supporting steel chimney; flue, 8 feet 4 inches diameter by 175 feet high; shell, 10 feet 6 inches diameter. (*Engineering News*, April 8, 1897.)
34. Edison Lighting Station, New York City.
Two steel-lined chimneys.
Flue, 12 feet diameter by 139 feet high, from ceiling or base to top.
The upper 74 feet 9 inches is self-supporting, the cast-iron base of which is secured by eight 1½-inch anchor-bolts passing down 32 feet in wall.
The *Engineering Record*, vol. xxx., p. 44, contains a detail cut of these chimneys, showing a very ingenious expansion-joint, at the place where cast-iron cap above-mentioned is set.
35. Elevated Railroad Company, Chicago, Ill.
Self-supporting steel chimney.
Flue, 5 feet diameter by 120 feet high, lined.
To furnish draft to three 150 horse-power Heine boilers.
36. Cleveland Rolling Mill Company, Cleveland, Ohio. Engineers and constructors, Messrs. Witherow & Gorden, Pittsburg, Pa.; built September, 1881. About 50 days were occupied in its erection, apart from the building of the foundation proper.

Dimensions.—

Height, including foundations.....	213 feet 6 inches.
Height, from ground line to top.....	190 feet 0 inches.
Height of bell-shaped base.....	21 feet 0 inches.
Outside measurement of foundation.....	30 feet 6 inches.
Outside diameter at foot of bell-base..	21 feet 2 inches.
Outside diameter at top of bell-base ..	13 feet 0 inches.
Outside diameter at top.....	12 feet 0 inches.
Internal diameter throughout.....	11 feet 0 inches.

Foundation.—Stone, laid in cement, and is situate in what is termed the "Bottom," next to Cuyahoga River, where the ground is all of alluvial formation. For such a load as this

chimney the foundation required close piling; the piles were driven 23 feet to 24 feet in depth, and almost in contact with each other; through the stone foundation eight $2\frac{1}{2}$ -inch bolts were passed, connecting a circular cast-iron foundation-plate of T-section, 18 inches by $8\frac{1}{4}$ inches at bottom of stonework, to similar casting upon the top of stone foundation; this top circular ring or base-plate is formed with a projecting flange placed at an angle of sixty degrees to receive plates forming bell-shaped base, 2 feet above ground.

Construction.—The chimney was constructed by inside scaffolding, and built up one plate high at a time; the workmen hanging what is called a "cage" on the plates, to serve as a stand for the "holder on" while riveting the plates *in situ*.

Bell-shaped Base.—The plates forming the base are bolted to the flange of chimney base-ring by $\frac{3}{4}$ -inch bolts, and when completed to a height of 21 feet form a bell-shaped base 21 feet 2 inches diameter at bottom, and 13 feet 6 inches at top.

Shaft.—From the top of bell-shaped base the wrought-iron outer casing is continued to height of 21 feet from below top; from this point the cap is formed as shown in drawing.

Rivets and Riveting.—The plates are all riveted together with a lap of two inches; the constructors used conical-shaped rivet-heads, and the diameter of rivets for this class of work is as near as possible twice the thickness or upward of plate, and the pitch of rivets is 5 diameters.

Ladder.—A wrought-iron ladder is fixed to the outside.

Fire-brick Lining.—A fire-brick lining was built up through the entire height of the chimney, commencing at junction of flues at foundation with a thickness of 18 inches, and finishing at top 5 inches thick. The internal diameter, when finished with lining, is 11 feet, and constant throughout its height; the radiated fire-bricks were of five sizes, purposely made.

Stability.—The chimneys built on this plan are calculated to withstand 50 pounds wind-pressure per square foot with safety; the constructors say the climate of America is dry, and no doubt better for such structures than the climate of England; they believe that no one alive at the present time will see the end of a wrought-iron chimney, lined with brick; the oldest ones in America show no material deterioration. Cost, complete, \$13,000.

CHAPTER VII

BRICK CHIMNEYS—THEORY PERTAINING TO SAME, AND EXAMPLES FROM EXISTING STRUCTURES

RULES FOR BRICK CHIMNEYS.

MOLESWORTH'S "Pocket Book" gives the following: "Diameter outside of the base, not less than one-tenth the height; batter of outside, 0.3 inch per foot; thickness of brickwork, one brick from top to 25 feet down; one and one-half brick from 25 feet to 50 feet, etc. If inside diameter exceeds 4 feet at the top, the top thickness should be one and one-half bricks; if less than three feet it may be one-half brick for the first 10 feet down."

The Metropolitan Board of Works Rules for furnace chimney shafts contain this: Brickwork should be at least $8\frac{1}{2}$ inches thick at the top, and for 20 feet below, and must be increased $4\frac{1}{2}$ inches every 20 feet of additional height measured downward. There should be no cornice or projection of more than $8\frac{1}{2}$ inches at the top of the shaft.

Lang gives for thickness of upper wall of chimneys:

If built of ring stone, at least 7.08 inches.

If built of bricks, at least 9.84 inches.

For quadrangular chimneys, $\frac{1}{2}$ brick thickness may be used in upper section, but the chimney must then be built from the exterior, and well braced by scaffolds.

The more steam there is contained in the smoke gases and the cooler they are, the larger the thickness of the upper wall should be chosen.

The old rule that the upper wall thickness should be $\frac{1}{10}$ of

