CHAPTER VIII

CHIMNEY PERFORMANCES.—SPECIAL TYPES.—STRAIGHTENING CHIMNEYS.—FLUES

CHIMNEY PERFORMANCES.

Brick chimney, Dwight Manufacturing Company, Chicopee, Mass.

Flue, 4 feet square by feet high.

Burned through it 1,587.8 pounds anthracite coal per hour; burned through it 1,459.0 pounds combustible per hour; draft 0.45 inch.

Horse-power developed in boilers, 460.9.

Equivalent evaporation per pound of combustible from and at 212° = 11.17 pounds.

Coal burned per hour per square foot of grate = 10.97 pounds.

Boilers connected to chimney: 4 vertical Corliss boilers 8 feet diameter, and 2 vertical Corliss boilers 10 feet diameter.

A chimney 80 feet high, flue 42 inches diameter, has been found to cause sufficient draft for a rate of combustion of 120 pounds of coal per hour per square foot of area of chimney, or if the grate area is to the chimney area as 8 to 1, a combustion of 15 pounds of coal per square foot of grate per hour, or a total combustion of 1,154.4 pounds of coal per hour.—Kent: "Transactions of the American Society of Mechanical Engineers," vol. vi.

The author's Table No. 10 gives the capacity of this chimney as 1,128 pounds.

A chimney 92 feet high, flue 50 inches diameter.

Area of 13.63 square feet; area of flue inlet = 13.12 square feet; area of grate 48 square feet, with an air space of 21

square feet, with a temperature of chimney gases of 609° Fahr., caused sufficient draft for the combustion of 1,179 pounds of free bituminous coal per hour.—Gale: "Transactions of the American Society of Mechanical Engineers," vol. vi.

The author's formulæ, Table No. 10, gives the capacity of this chimney as 1,141 pounds.

"Transactions of the American Society of Mechanical Engineers," vol. xv., p. 610, says: "Three hundred boiler horse-powers were connected to a chimney 72 inches diameter of the flue by 125 feet high, with poor results; but when chimney was changed to 42 inches diameter by 125 feet high, the boilers worked much better."

The author's Table No. 8 gives the capacity of the latter chimney as 351 boiler horse-power.

Steel chimney, 38 inches diameter by 110 feet high, over a Cahall vertical boiler at Armstrong Cook Co's. Works, Pittsburg, Pa.

Tests by J. M. Whitham. Coal, nut and slack, from Sandy Creek Mine, near Pittsburg, Pa. Efficiency test, 917 pounds of coal burned per hour.

According to the author's formulæ, this chimney capacity is 1,073 pounds; capacity test, 1,702 pounds of coal burned per hour.

Brick chimney, 8 feet diameter flue by 175 feet high, Armour & Co's. plant, Kansas City, Mo.

Coal—Ardmor, Mo., bituminous Mine-Run coal. Tests by F. G. Gasche, M.E.

Flue temperature, 580° Fahr.; out-door temperature, 80° Fahr. (approximate).

Draft in chimney, 0.68 inch of water.

Boiler horse-power is 1,167.

Coal burned per hour, 7,198 pounds.—*Power*, August, 1897.

Steel chimney, 4 feet diameter flue by 100 feet high. Reid & Barry, Passaic, N. J.

Attached to two boilers rated at 250 horse-power each, with

a total of 104.76 feet of grate-surface, gave the following results with different coals used under boiler:

	Anthracite buck. coal.	Bituminous lump coal.
Temperature of external air	45° Fahr.	42° Fahr.
Temperature of gases at base of chimney	372° Fahr.	427° Fahr.
Coal burned per hour, total dry	1,902 pounds.	1,865 pounds.
Force of draft in inches of water	0.48	0.55
Theoretical draft, we might look for	0.556	0.624
Barometer	30.35 inches.	29.9 inches.

Natural draft was used, and the coal burned in both cases coincides with what might be looked for from the author's tables.

An old chimney, 67 feet high, with internal diameter of 19.6 inches to 13.8 inches, and with a total distance from fire to chimney of 98 feet, was taken down, and a new chimney with an intended total distance from fire to outlet of 95 feet, and a minimum internal diameter of 25.5 inches was planned; when the chimney had gone up 39 feet it was tried, already there was a great improvement on the old chimney; again at 46 feet it was still better, and at 52.5 feet the draft was excellent, and there was an economy of 15 to 20 per cent. in fuel. The chimney was therefore finished at that height. Ramdohr of Gotha confirms this, and recommends a uniform internal diameter as being more rational and as protecting the brickwork from the hot and rapid axial stream.—*Journal du Gazet l'Electricitat*, 1897.

A steel chimney, 110 feet high, with flue 42 inches diameter, attached to a boiler rated at 250 boiler horse-power, with 57 square feet of grate-surface, under test, when starting the plant with outside air quiet, and with a temperature of 40° Fahr., showed the following results:

Temperature of gases at base of chimney	300° F.	445° F.	525° F.	575° F.
Force of draft in inches of water	0.36	0.46	0.52	0.56

—Geo. H. Barrus, 1894.

OFFICE-BUILDING CHIMNEYS.

Tall office-building chimneys in the large cities are often made of steel, circular in shape, and placed in the ventilating shaft in many instances to assist it in the purifying of the air throughout the building; these chimneys need no special strength, being braced to the walls of the shaft and easy to support.

The metal and riveting should be proportioned as in guyed steel chimneys.

Other chimneys are of brick in office buildings built like any house chimney, while others of steel are placed in the "open air" or light shaft, as the chimney of the Manhattan Life Building, New York City; this is 4 feet 6 inches diameter of flue by about 360 feet high, and is secured to the wall by wrought-iron straps. It furnishes draft to three internally fired Scotch boilers, with 1,620 square feet of heating surface each, total 4,860 square feet.

The first record of steel chimneys in use in tall office buildings, is that at "the Fair," Chicago, Ill., built in 1890–91, which is described as follows:

Diameter of outside of 4-inch tile lining is 6 feet 9 inches.

Diameter of flue in clear at fire-brick lining, 5 feet 9 inches.

Diameter of flue in clear at tile lining, 6 feet 1 inch.

Height of chimney, 172 feet 6 inches.

Starting from the basement floor, the chimney rests on a brick base 2½ feet high; at the base two 4 by 4 by $\frac{2}{16}$-inch angles are riveted, one inside and one outside of the ¼-inch shell, and they in turn rest on a cast-iron ring 1¼ by 8¼ inches in section, through all of which the ¾-inch anchor or foundation bolts pass; thickness of shell is ¼ inch throughout, the first 40 feet is lined with fire-brick 6 inches thick, above which a 3 by 4 by $\frac{7}{16}$-inch angle-iron is riveted thus $\frac{3''}{\lfloor 4''}$ to the shell, and similar ones above this about every 15 feet, which carry the 4-inch tile-lining which goes to the top of shell.

The cap is made of ¼-inch steel shaped like an inverted U, fitted outside of shell, and inside of tile riveted to shell.

The chimney is braced to the building by two 3 by 3 by ½-inch

angles fastened to columns. Space around the chimney is utilized for purposes of ventilation.—*Engineering Record*, vol. xxix., p. 157.

REMOVING BRICK CHIMNEYS.

A brick chimney octagonal in section, 135 feet high, external diameter 12 feet, base 17 feet square by 16½ feet high, with walls 3 feet thick, at a brick works in Lörincznyaralo, Hungary, was blasted by Lieutenant-Colonel Tangl of the army and his men.

Bricks were removed for about three feet in height, directly above the base, leaving two openings—one in front, one in the rear; this work being done by four men in nine hours.

The structure was to fall to the ground close to the base on account of nearby buildings.

A mine of 15 pounds of "ecrasite" was placed in one opening, and two of 11 pounds in the other, all placed 10 inches above the base in order to spare it.

They were fired simultaneously, and the chimney fell in a bottle-shaped mass just away from the base, occupying a length of 190 feet, height of 10 feet, and the greatest width was 56 feet at 66 feet from the base.

Observers did not feel the rush of air, but in the direction of the fall windows were broken at a distance of 260 and 500 feet.—*Engineering*, p. 658, 1898.

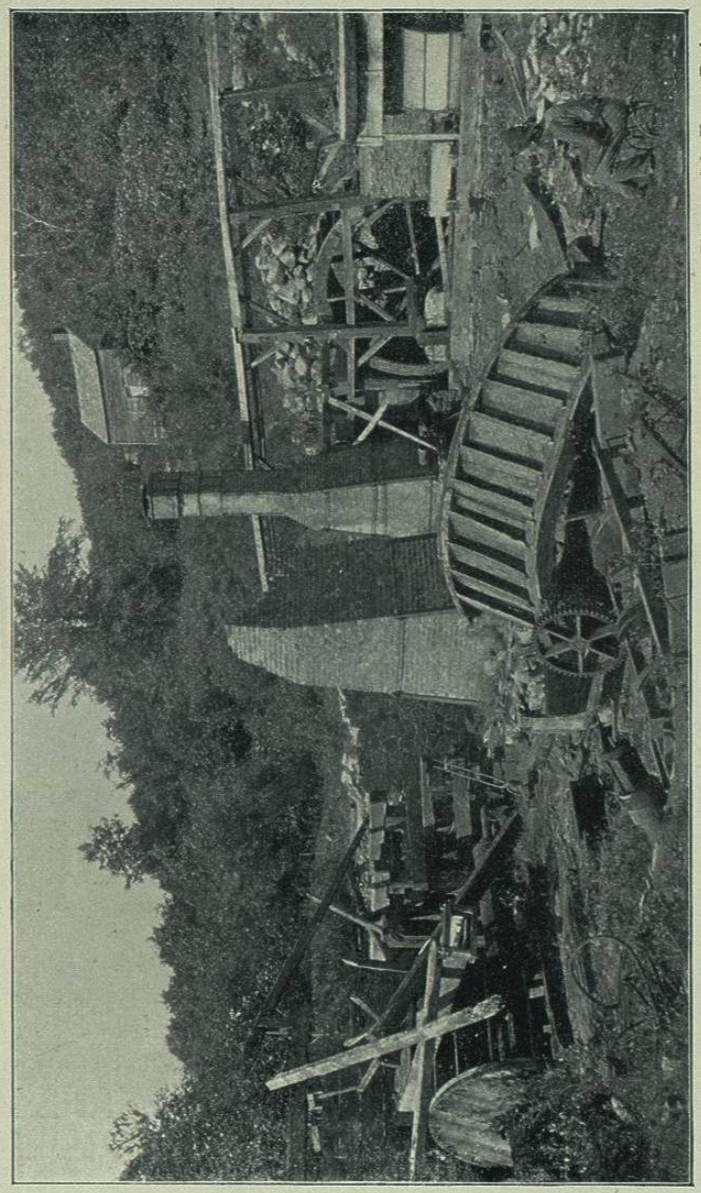
CAST-IRON OFFICE-BUILDING CHIMNEY.

University Block, Syracuse, N. Y., eleven-story steel-cage building.

Boilers, 470 boiler horse-power.

Chimney, 172 feet high; flue, 4 feet diameter.

Foundation, a bed of concrete 16 inches thick; on this 20-inch brick wall about 6 feet high, capped with a circular cast-iron shoe or base-plate. From this plate six sections of flanged cast pipe 4 feet 10 inches diameter are placed, lined with 4-inch fire-brick, capped again with a cast-iron plate on which stands the spigot end of the 4-foot inside diameter cast-



Photograph by Vernon Royle.

ILLUS. No. 42.

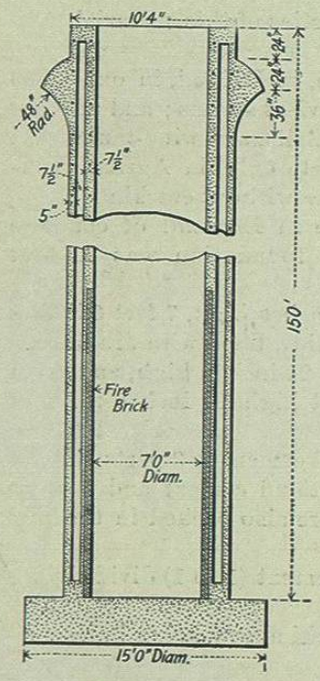
IRON FURNACES, STOCKHOLM, N. J.

Wheel and wood cylinder at the right of the picture.

Built about 1781, for forge using forced draught generated by water-power.

iron water-pipe, which, with bell ends and spigot ends, makes the balance of height of chimney, excepting the upper section, which tops out in a moulding above which is a serrated edge. The chimney is anchored to the floor-beams by $\frac{3}{4}$-inch bolts.

In the building this chimney is surrounded by a double tile wall each 3 inches thick, 3-inch air-space between them, and greater air-space between tile and cast-iron chimney pipe. —*Engineering Record*, vol. xxxviii., p. 190.



ILLUS. No. 41.

PACIFIC COAST BORAX COMPANY, CONSTABLE HOOK, N. J.

MONOLITHIC FACTORY CHIMNEY.

Pacific Coast Borax Company, Constable Hook, N. J., 1898.

The entire mill is built of concrete and iron after E. L. Ransome's patent and by him, as is also the chimney.

Only the hottest zone of the chimney, bottom to 20 feet up, is protected by a fire-brick lining.

The reinforcement of this stack consists of $\frac{3}{4}$-inch rings two feet apart vertically and eight $\frac{3}{4}$-inch vertical bars in each wall of the chimney.

This chimney is built inside the factory, which protects it from wind strains up to a height of 70 feet, above which it rises 80 feet exposed to the elements.

The flue is 7 feet diameter by 150 feet high. Between the inner and outer shell are eight concrete and iron brackets, 6 inches wide, running the entire height of the chimney.—*Engineering Record*, vol. xxxviii., p. 189.

A light-house was erected in 1874 on the Isle of Jersey, of concrete, but built up of moulded blocks as ordinary masonry.

Its height is 135 feet on a rock 109 feet above the level of the sea.

Designed and erected by Sir J. Coode. It is recorded as a successful application of concrete.

Fr. Von Emperger, Proceedings *American Society of Civil Engineers*, 1894, says: "Two concrete structures which give the best proof of the elastic properties of this material (concrete) may be mentioned.

"One is a chimney 160 feet high, in Ireland, in one piece of concrete, which has stood the heaviest storms; and another example which is cited by Mr. A. Rella, are wine-tanks of a capacity of 80,000 gallons (of concrete only) in Agram, Hungary, which stood the last earthquake without cracking."

Sutcliff* says the first example in England of concrete chimneys was at Sutherland; the foundation was 12 feet square by 6 feet thick of concrete.

The chimney-base was 24 feet 9 inches high, 7 feet 6 inches square outside, and 4 feet square inside, lined with fire-brick.

Above the base was a moulding 21 inches high, and from this rose an octagonal shaft 30 feet high 15 inches thick at the bottom, and 9 inches at the top.

Concrete for base, 1 part Portland cement to 8 parts shingle and sand; for the shaft, 1 part Portland cement and 5 parts gravel and sand; rubble stones were also packed in the concrete as it was laid.

The finish was $\frac{1}{4}$-inch coat of cement (1 to 1) divided into ashlar.

Sutcliff speaks also of concrete chimneys being built elsewhere before this one.

Chemical Works Chimneys.—Chimneys used to carry off acid gases should be provided with exterior iron bands, and the interior have proper protection to the bricks, especially at the joints; the author would use only the best Portland cement, laid with close joints, for this class of work.

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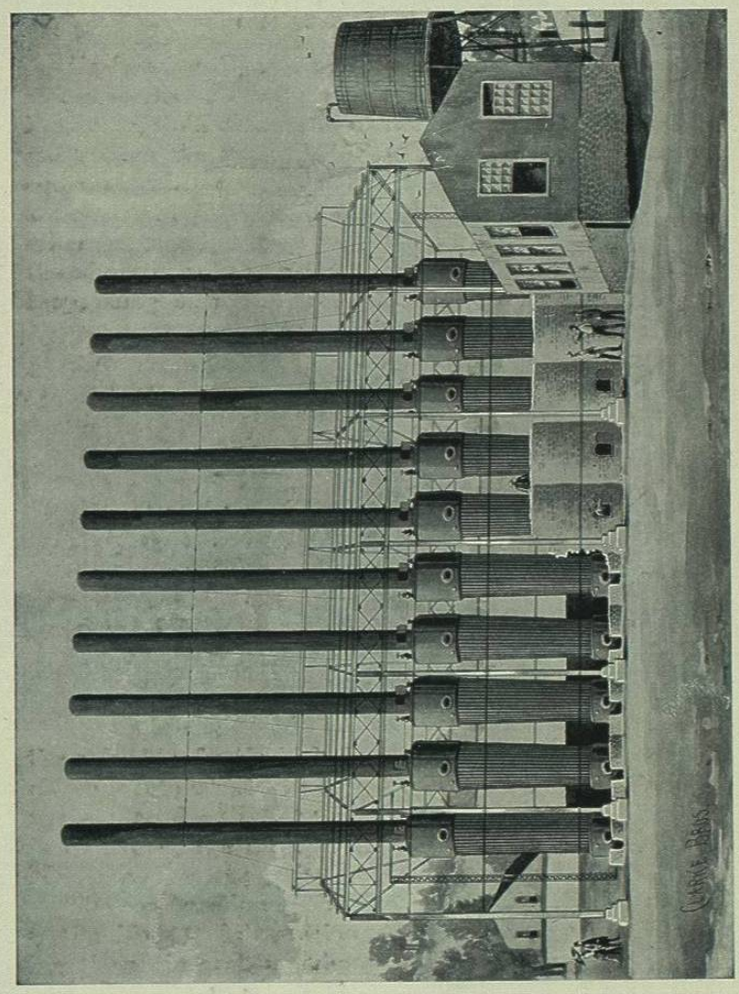
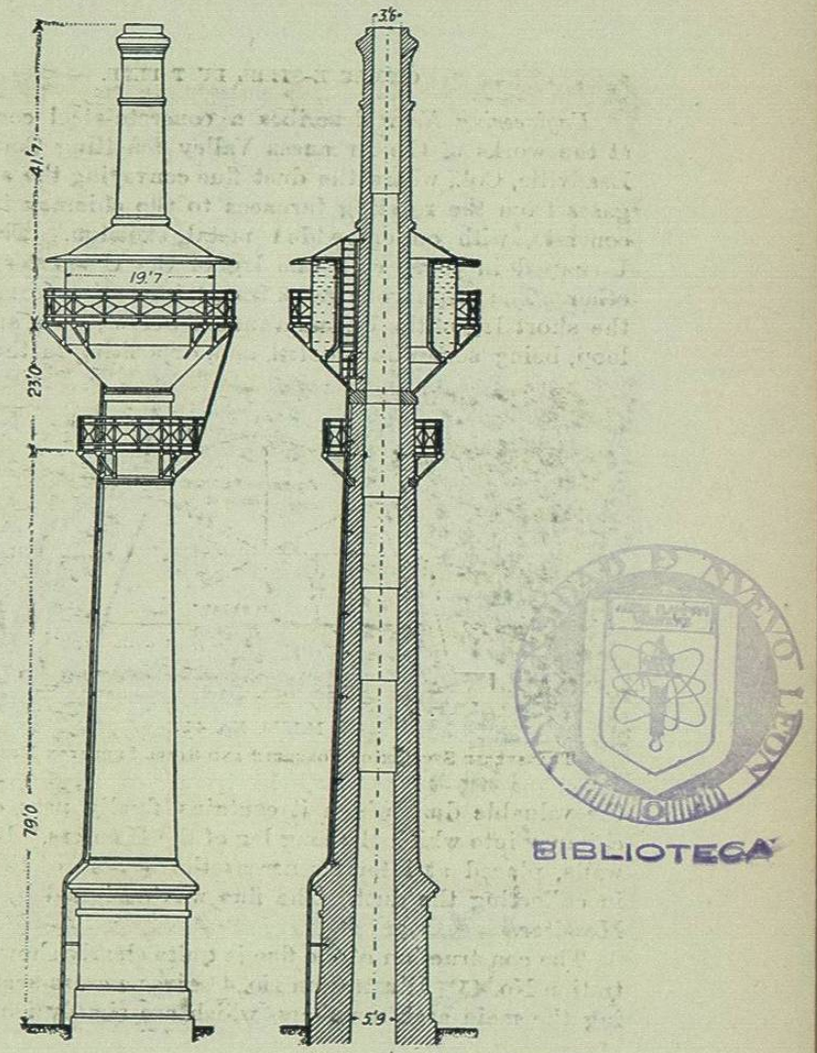
* "Concrete, Its Nature and Uses," published 1893.



ILLUS. No. 44.

Carnegie Gas Company's Bagdad Plant. Cahall Boilers.



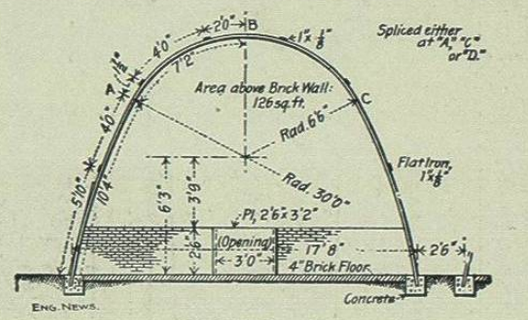
Engineering News.

ILLUS. No. 43.

A Water Tank Supported upon A Brick Chimney.

CONCRETE-STEEL DUST FLUE.

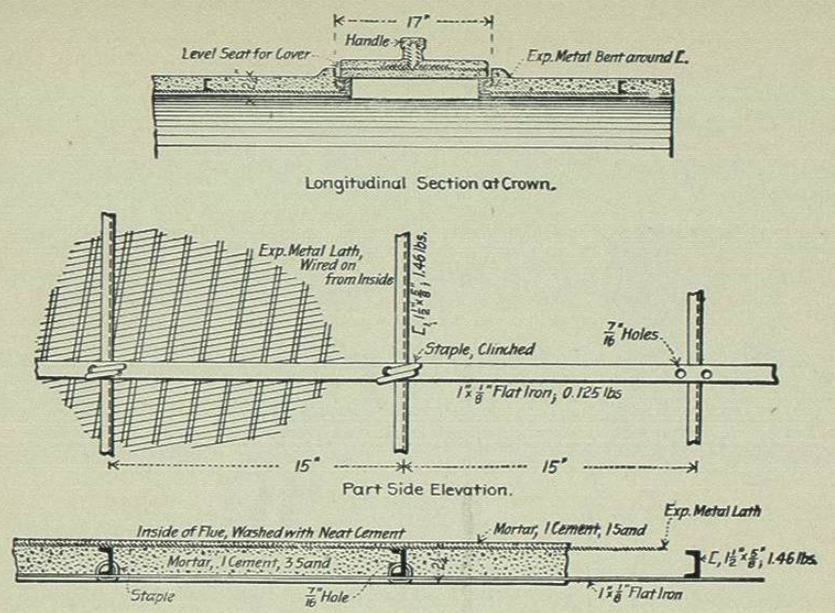
Engineering News describes a concrete-steel construction at the works of the Arkansas Valley Smelting Company, at Leadville, Col., where the dust flue conveying the smoke and gases from the roasting furnaces to the chimney is built of concrete, with an embedded metal skeleton. The flue is U-shaped in plan, with one leg of the U shorter than the other. The sulphurous gases from the roasting furnaces enter the short leg of the U from a tunnel below; pass around the loop, being somewhat cooled, and, depositing in the passage



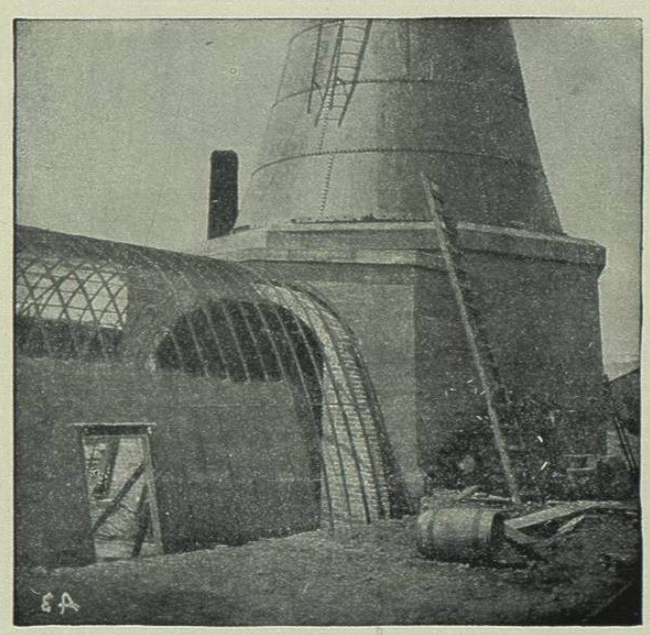
ILLUS. No. 46.
TRANSVERSE SECTION OF CONCRETE AND STEEL SKELETON DUST FLUE.

the valuable dust which it contains, finally pass out of the chimney into which the long leg of the U enters. Brick riffle-walls, placed at intervals across the bottom of the flue, aid in collecting the dust. The flue was designed by Mr. E. H. Messiter.

The construction of the flue is quite clearly shown by illustration No. 45. Illustration No. 46 gives a cross-section showing the main arch members, which are simply iron channel hoops bent to an arch and having their ends set in a concrete base wall. Between the base walls is a concrete floor resting directly on the ground. The channel iron arches are connected longitudinally by flat iron members connected to the



STRUCTURAL DETAILS OF CONCRETE AND STEEL SKELETON DUST FLUE.



ILLUS. No. 45.
CONCRETE AND STEEL DUST FLUE.

channels by clinched staples. Illustration No. 45 shows this connection, and also shows the arrangement of the lathing of expanded metal, which was fastened to the inside of the main flat and channel iron skeleton. The lathing and main skeleton were finally embedded in mortar composed of 1 part German Portland cement to 3 parts sand, to make a wall $2\frac{1}{4}$ inches thick, except at the crown, where a furnace slag concrete was employed. The inside of the wall was given a wash of neat cement paste. In one side of the wall a space was left for an iron plate door. The various other details of the construction are clearly shown by the drawings.

CHIMNEY AS TANK TOWER.

Professor O. Intze and F. A. Neumann, of Aachen, Germany, have patented such an arrangement. It consists of a brick chimney built as usual to where a tank is to rest, where a capstone is placed upon it; from there upward the outside size of the chimney is smaller, leaving a shoulder for tank brackets.

In an illustration in the *Engineering News*, vol. xxxix., p. 287, the total height of the brick chimney is 143 feet, the base for the tank being at 102 feet elevation.

Diameter of flue is 3 feet 6 inches at the top, and 5 feet 9 inches at the bottom. The steel tank has a capacity of 26,400 gallons, and space is left between it and the chimney for a ladder.

Several of these structures have been built of the capacity of the above, or less.

OTHER USES FOR CHIMNEYS.

The Coe Brass Company, formerly Wallace & Sons, at Ansonia, Conn., use an old square brick chimney as a clock tower.

The Richardson Manufacturing Company, at Newark, N. J., utilize their steel chimney to carry an exterior spiral staircase from an enclosed court to each floor of the factory building.

At the power-house of the Massachusetts General Hospital, Boston, Mass., scarcity of room and the smoke flues entering

"the chimney at a high level," allows of the interior of the lower part of the chimney being "used to contain a spiral stairway to connect the ground level and the floors."

COMPARATIVE COST.

Based upon figures given in the table, a chimney of 2,000 horse-power, if built of red brick, would cost about $8,500; of steel, self-supporting, full lined, about $8,300; of steel, self-supporting, half lined, about $7,800; of radial brick, about $6,800; of steel, self-supporting, unlined, about $5,820; of steel, guyed, about $4,000.

The following list is one which has been made up from actual costs, and may prove interesting in this connection:

Description.	Horse power, W. W. Christie's rating.	Cost, dollars.		Remarks.
		Total.	Per rated horse-power.	
Radial brick, Circ.....	1,645	6,000	3.64	American.
Radial brick, Circ.....	13,484	40,000	3.00	Foreign.
Red brick, Circ.....	4,040	16,000	4.00	
Red brick, Circ.....	6,000	18,500	3.00	
Red brick, Rect	450	2,192	4.87	
Red brick, Hex.....	12,211	55,000	4.50	
Red brick, Circ.....	4,859	10,000	2.06	Single shell, firebrick lining half height.
Red brick, Circ.....	2,925	15,000	5.13	
Red brick, Circ.....	5,772	40,000	6.93	
Red brick, Circ.....	6,300	18,500	3.00	
Red brick, Circ.....	6,000	25,000	4.25	
Red brick, Circ	1,100	4,950	4.50	
Red brick, Rect.....	517	1,900	3.80	
Steel, self-supporting..	2,400	10,000	4.15	Lined throughout.
Steel, self-supporting..	2,350	8,000	3.40	Half-lined, price without foundation.
Steel, self-supporting..	240	700	2.91	Unlined.
Steel, guyed.....	240	400	1.66	Unlined.

An 80-inch centrifugal blower, 48-inch wheel, 4 × 3 inches double engine, blower and engine on beam platform, was erected in New England in 1899, connected with a 48-inch diameter chimney of No. 12 steel, 22 feet high, 10 feet of it above the roof, 1 inch thick cast base plate. The total cost for apparatus, frame work, and mason work was $856. The boilers used in the plant, in connection with the blower, were horizontal tubular, one 80-inch diameter by 17½ feet; two 72-inch diameter by 17½ feet.

In the same year a self-supporting steel chimney, unlined, 3½ feet diameter by 105 feet high, was erected, with foundations and flue connections, at a cost of $1,013. The chimney was made of $\frac{3}{16}$, $\frac{1}{4}$, and $\frac{3}{8}$ inch steel. The blower outfit works satisfactorily in the part having two boilers with a total of 75 square feet of grate. The chimney gives a very satisfactory draught for 93 square feet of grate surface, and if it had been made 48 inches diameter, as in the blower outfit mentioned, and been guyed with wire rope, with a light foundation, $800 would easily have met the expense.

A CHIMNEY ON LOOSE SOIL.

An interesting description is given in *Dingler's Polytechnisches Journal*, vol. cclxvii., p. 194, of a chimney built on loose soil; thus rendering a light structure necessary, says the London *Builder*. From the foundations four upright, and somewhat tapering, lattice-girders were carried up, and connected together by cross bracing. On the inner edge of the frame thus formed the chimney proper was built of tiles, about five inches in thickness, and having lap joints. Angle-iron bands were introduced at intervals to bind the whole firmly together. The total height of the chimney is 140 feet, and the inside diameter 8 feet 6 inches. The total weight is 543 tons, which gives a pressure of 17 pounds per square inch on the foundation, 2.2 tons per square foot. This would be about equal to half the weight and pressure per square inch of an ordinary chimney. The whole chimney was erected in thirty-nine days, the iron-work occupying thirty-one days of the time. The cost is set down at 19,200 francs,* and it is estimated that a brick chimney of the same height and size would have cost 14,300 francs.†

* $3,698. † $2,752.