was comparatively sound at the expiration of ten years.

The cedar block pavement, possessing the advantages of noiselessness, cheapness, and durability, would be my preference for a suburban street with light traffic, but the blocks should all be sound, well and thoroughly laid and rammed, and the pavement sprinkled and cleaned.—*Journal A. E. S.*

TWO MODERN CHIMNEYS — A STUDY OF THEIR DESIGN AND CONSTRUCTION.

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I.

THE primary object of a chimney is to create a draught, to obtain a current of air by means of a difference in density of the air contained within from that without the shaft. The force exerted is really caused by the continuous formation of a partial vacuum in the shaft and a constant effort on the part of the surrounding air to fill that vacuum. This movement of the air is a ponderable force, and can be measured in various ways, either by the velocity of the current, by the dials of pressure gauges, or by the quantity of air evacuated in a given time.

Chimneys are made square, hexagonal, octagonal, or circular in section, the latter form being considered the most economical in chimneys of large section, and from an engineer's point of view are the most secure as to stability. Chimneys are noted for their plainness, not to say ugliness, of shape and poverty of ornament, and the question is often asked, Have chimneys any claim to architectural treatment? The writer will try to answer that query in this article.

The two chimneys before us are taken as types of their class; they represent the care, thought, and years of experience of two of the best known mechanical engineers of the country. The square and round section have been chosen in order that both types may be studied by contrast. Comparisons are said to be odious, but the odium does not extend to the principles upon which the comparisons are based. The two stacks are situated in the town of Kearney, a suburb of Newark, New Jersey. They are placed about five hundred feet back from the Passaic River, are within hail almost of each other, and are the respective steam factory chimneys of two of the largest thread works in the United States. The Clark stack was built in 1882 for the Clark Thread Company of Newark, New Jersey. It was built by days' labor. The care attending its construction necessitated a much longer time to complete it than would have been permitted had it been let to a contractor. In drawing, Fig. 6, we show a sectional elevation of the foundation as originally designed before the soundings had been completed, and also in drawing No. 6 the foundation as it now exists, and decided upon after the soundings were completed. This evolution of the foundation is worthy of study. The surface soil was removed and a good bed of river gravel struck; beneath the gravel, however, the sounding rod revealed a bed of quicksand, beneath the quicksand a bed of clay. The rod was driven down some thirty feet. Upon striking what is called water level, the engineer determined to widen the concrete base from twenty-four feet to twenty-eight feet square. It was necessary to distribute the load over a greater area. No separate accounts having been kept of the construction of the chimney from that of the mill to which it belongs, the writer has been obliged to calculate approximately some of the elements of the chimney. It stands entirely alone, and free from masonry connection with any of the adjoining buildings. The connecting flues from the boiler houses are built underground, and have an underground entrance into the chimney, as shown in the general drawing. All of the flues are of the differential order, and where two flues are so situated as to combine and form one flue, the combination is made and a division plate of iron placed in the center, just far enough to give direction to the outgoing current of heated air. The final differential is calculated so that its greatest sectional area is a trifle larger than the sum of the areas of all the flues which discharge into it. The underground flues may be protected from convection and radiation either by air jackets or linings of a mineral nature.

The stack is one hundred and ninety-two feet high, and is estimated to contain about 600,000 bricks. One thousand brick, with one-quarter inch joints, laid in Portland cement mortar will weigh about 5,412 lb. Upon this basis the brick alone will weigh 1,624 tons. The concrete bed will be obliged to sustain two tons per square foot of area. If the foundation had been put in as originally planned, the load would amount to 2.8 tons per square foot of area.

The cost of the structure is based on the use of good, selected North River brick both inside and out, laid in good cement mortar. Such brick masonry can be laid at twenty dollars per thousand, and the concrete at six dollars per cubic yard. The chimney will contain 600,000 brick and 297.6 cubic yards of concrete. At these figures the chimney could be built for about fourteen thousand dollars. The brick externally and internally are laid in Portland and Rosendale cement, with the exception of the chapter and the courses below grade; the excepted portions are laid wholly in the best Portland cement. As the designer of the stack believes that the temperature in steam chimney flues never exceeds 400° Fahr., and is generally much lower, he has come to the conclusion that it is unnecessary to line any steam chimney with fire brick, and that good hard burned North River or other equally good brick are sufficiently refractory to withstand all the heat they will be exposed to in a steam chimney.

The Clark chimney was designed for a working horse power capacity of 2,400, although but 1,800 horse power is used, on account of the last nest of boilers not yet having been placed in position. There are twelve boilers of 150 horse power each in use, and each boiler has a grate area of 42 square ft. In general it has been thought better practice to calculate from the cubic capacity of the chimney flue its evacuation power than to depend upon the height and the area of the discharging mouth. The practice of European engineers is to depend upon the two last elements. In this stack the difference between the area at grade and that at the mouth is so slight as not to be essential. The area of the chimney mouth is made equal, nearly, to one-tenth

of the total grade area. About thirty-five feet above grade the reader will observe a contracted cross sectional area, called a *vena contracta*, and its application is based upon the well-known principles of hydraulics in regard to the discharge of any fluid through an orifice. Great improvement in the draught has been effected by the *vena contracta* throat. Another object has been served in this case by making the brick, as they rack inward, cover the open space between the internal

THE MARSHALL.

THE CLARK.

TWO MODERN CHIMNEYS.

flue and the exterior wall. The design of this is to prevent the accumulation of soot and dirt between the outer and inner shell. This deposit of soot or dirt filling in the air space promotes the convection and radiation of heat from within outward and the transmission of sudden changes of temperature in the external air, and involves a loss of power in the chimney.

In the various contractions of the chimney flue, care has been taken that the area of the outlet shall be maintained as a minimum. The thickness of the outer shell at any given point has been made commensurable with some known brick dimension as a unit; thus the

independent of each other after leaving the foundations. Vertical ribs are built inward from the outer shell, approaching to within three-eighths of an inch of the inner shell. Should there be a slight deviation of the outer shell from the perpendicular, owing to a concentrated pressure of the wind or unequal settlement, the outer shell will receive some support from the inner shell. The inner shell may be depended upon to give warning of a collapse of the chimney. The intention in construction is to build the two shells separate, in order to keep the inner shell from being chilled by a sudden lowering of the external temperature. Air being

The drawings show the structure according to the original design. Beginning at the gradeline, the excavation was carried down eleven feet in the form of a circular pit twenty-four feet in diameter. Water level was struck at the bottom of the excavation; no soundings were taken. The soil is similar to that at the Clark stack. In the leveled bottom of the pit, a circular bed of concrete, three feet in depth, was laid to the full diameter of twenty-four feet. On this bed the brickwork was laid to grade, battering from twenty-four feet at the bottom to sixteen feet and six inches at grade. Operations were suspended for two weeks, in order to give the concrete and brick foundation time to set. The opening at the discharging mouth of the chimney was first designed to be 7 feet 6 inches, as shown in the general drawings, and in accordance with which the horse power capacity has been calculated; but in order to conform to the construction required by the contraction of the base, the opening was narrowed to 6 ft. Its height from grade to top of cap was designed to be 176 ft. 6 in., but this was reduced to just 175 ft. The chimney as constructed is reported to contain about three hundred and thirty thousand brick, and to have cost about seven thousand dollars. The face brick are Wood & Keenan's A. W. K. Haverstraw brick, and the backing brick are the B. J. A. brand of the same firm. No fire brick has been used in the structure. In regard to the load on the foundations, the following estimate has been made. The figures are approximations. One thousand Haverstraw brick, size $8 \times 3\frac{1}{2} \times 2\frac{1}{4}$, laid in Portland cement mortar, will weigh 5,412 lb., hence $330,000 \times 5412 = 892$ tons. The concrete bed weighs (140 lb. per cubic foot) 95 tons, making the total weight 987 tons. The area of the foundation bed is 452,389 square feet, and the pressure upon this foundation, therefore, is 1.97 tons per sq. ft. The ensuing calculation pertains to the Marshall stack as designed originally, with a diameter at the base of 17 ft. $7\frac{1}{2}$ in. The outer and inner shells have been determined separately, and two and one-half per cent. allowed for waste. Taking up the outer shell first, beginning at the chapter, we are to regard it as an inverted truncated cone with a cylindrical flue opening. For the sake of the builder and contractor, who may wish to know how such matters are calculated, we give the work for the chapter, the first section of the outer shell, and one of the ribs in full. The method of calculating the remaining sections will be indicated and the results given; the factors of all the shells and ribs are to be found in the diagrams.

In the diagram drawings, let Fig. A represent the vertical section of the Marshall chapter. The external diameter at the top is 12 ft. 9 inches, at the bottom it is

DIAGRAMS
OF
OUTER SHELL, RIBS,
INNER SHELL AND BASE

thickness at the bottom may be said to be four bricks, the second thickness three and one-half bricks, the unit being four inches. The width of the chimney at grade is 17 ft., and at the top of the shaft proper, just below the chapter, 10 ft. 9 in. The batter of the exterior faces is about twenty-two one-hundredths of an inch to the foot, making the total batter 6 ft. 3 in. From the grade line to the beginning of the chapter the distance is 170 ft.

The arcade openings in the chapter are 1 ft. 4 in. wide, 4 in. deep, and 8 ft. 8 in. from the belt course to the intrados of the arches, and from the belt course to the spring lines 8 ft., thus making the radii 8 in. The chimney is capped with a 1 in. cast iron hood, anchored to the masonry by an inch and a half iron bolt some four feet long. The top face of the iron cap has a slope of one to two. This is designed to direct any current of wind upward that strikes the top of the plate normal to its surface. The consequence of this would be to pro-

duce an induced upward current in the chimney, and a current of air striking this plate at any angle would be deflected either upward or downward, and thus produce a good result or not impede the draught. The objection to an arcaded chapter is the tendency to promote eddies and swirls of wind, and thus conflict with the calculated effect of the chimney.

FIG. 1 CHAPTER.

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By an examination of the drawings, it will be observed that the outer shell and the inner shell are built

II.—DESCRIPTION OF THE ILLUSTRATIONS.

We have first two vertical and sectional elevations of the Clark and Marshall stacks, the first half showing an external elevation, and the other half showing a vertical elevation and section combined, giving at a glance the interior arrangement of the shells, flues, and ribs, and foundations.

In this vertical elevation the foundation of the Marshall is shown as it now stands, but the foundation of the Clark is shown in one of its transitional stages, it being neither the original design nor the last.

The vertical elevation of the Marshall above grade is just as it was planned, but not as executed, the base in the executed design being one foot and half an inch less in diameter, and a proportionate decrease ensuing all the way up to the chapter, and one foot and six inches lower in height.

Fig. 1 is an enlarged elevation of the Marshall chapter. The recesses are about 4 in. in depth, 4 in. wide, and 3 ft. from top to bottom.

Fig. 2 is a horizontal section on the line A—B (see Fig. 3), showing the relation of the ribs to the external and internal shell.

Fig. 3 is a vertical elevation of the base of the Marshall shaft, showing the principal opening for the flues from the furnaces, its dimensions, and distance from grade.

Fig. 4 is a vertical elevation of the Marshall foundation as originally planned, but owing to the character of the ground and change of dimensions, the stone was replaced by brick and the bed of concrete made deeper and contracted in area.

Fig. 5 is a transverse section of the Clark stack at the top of the *vena contracta*, showing its throat, the dimensions at that point, and the depth of the outer shell.

Fig. 6 is an attempt to show the original and final design of the Clark stack foundation. The full line, showing a width of 24 ft. and a depth of 6 ft., incloses what was originally designed to be the foundation. The broken line, 28 ft. by 12 ft. 3 in., is the final design. The irregular masses marked C and D were put in after the chimney proper was erected, and may be technically described as grouted concrete, or, in other words, the refuse from the cement barrels. Some cement that was rejected for the chimney proper, brick bats, broken stone, etc., were shoveled into this part of the excavation and grouted, the whole forming a solid mass, and after the lapse of several years is apparently in good condition.

The diagrams serve to show the thicknesses of the shells at various points, and are arranged in sequence, beginning at the chapter and going down to grade.

Fig. 7 is a vertical elevation and section combined of the Clark stack, showing dimensions and structure of iron cap recesses and ornament.

III.—QUANTITY CALCULATION OF THE MARSHALL STACK.

The Marshall stack was built for Marshall & Company, linen thread manufacturers of Leeds, England. The work was done by the Flynt Building and Construction Co. It was begun in July and finished in August. It was originally designed to be 17 ft. $7\frac{1}{2}$ in. in diameter, but was finally reduced to 16 ft. 6 in.

FIG. 2. SECTION ON A—B

FIG. 3. VERTICAL ELEVATION.

10 ft. 4 $\frac{1}{2}$ inches. The diameter of the cylindrical flue is 7 ft. 6 inches. Altitude of the figure, 8 ft.

To determine the volume of the chapter, supposing it to be a solid body, we note that it is the truncated frustum of a cone; it is to be obtained by adding together the squares of the diameters of the upper and lower base and the product of the two diameters; multiply this sum by 0.7854 and this product by the height, and divide this last product by 3.

To shorten the work, we shall use the conventional signs to indicate operations, and write results. Reduce all dimensions to decimal parts of a foot. 12 ft. 9 in. = 12.75 ft., 7 ft. 6 in. = 7.5 ft., 10 ft. 4½ in. = 10.375 ft. After the volume of the frustum is obtained, the volume of the cylindrical flue is calculated, and subtracted from the frustum; the remainder is the shell of brickwork which constitutes the chapter. To obtain the volume of the cylindrical flue referred to, we find the area of the base, which is the lower cross section of the flue, and multiply this area by the height of the flue. The operation is as follows. See the diagram A.

$$\begin{aligned}(10.375)^2 &= 107.6406 \\ (7.5)^2 &= 56.25 \\ (10.375 \times 7.5) &= 77.8125\end{aligned}$$

$$402.4843$$

$$\frac{402.4843 \times 0.7854 \times 8}{3} = 842.961 \text{ cu. ft.} = \text{volume of frustum.}$$

The area of a circle whose diameter is 7.5 is = to

areas = 324 sq. in. + 144 = 2.25 sq. ft.; $23 \div 6 = 4\frac{1}{2} \times 2.25 = 10.5 \text{ cu. ft.}$; but as there are four such ribs, the volume of all the ribs in E becomes 42 cu. ft., and in the same way F = 32 cu. ft., G = 165 cu. ft., H = 110 cu. ft., and I = 374.16 cu. ft.; total volume of ribs = 723.16 cu. ft.

To determine J, the volume depends upon the contents of two cylinders. The inner cylinder subtracted from the outer cylinder will leave the brickwork shell. Reduce all dimensions to decimal parts of a foot as before, thus 8 ft. 2 in. = 8.1667 ft. and 7 ft. 6 in. = 7.5 ft.; hence $(8.1667)^2 \times 0.7854 \times 30 = 1571.464 \text{ cu. ft.}$ = outer cylinder. Inner cylinder, which is the flue space, is obtained in the same way; $(7.5)^2 \times 0.7854 \times 30 = 132.5358 \text{ cu. ft.}$, hence, by subtraction, the volume of the brick shell of J is equal to 246.106 cu. ft. Pursuing the same method with regard to K and L, their respective contents are found to be 1163.060 cu. ft. and 2002.77 cu. ft. The base is a solid cylinder, and is equal to 313.531 cu. ft. Total volume of inner shell and base above grade line is 3725.521 cu. ft. Total volume of both shells, ribs, chapter, and base above grade line is therefore

Fig. 4. FOUNDATION AS FIRST PLANNED.

44.1786. $44.1786 \times 8 = 353.429 \text{ cu. ft.}$ = volume of cylindrical flue, hence 842.961 cu. ft. minus 353.429 cu. ft. = 489.532 cu. ft. = volume of brick shell of the chapter. This is approximative, because the offsets and recessions were not summed up, and it is near enough for all practical purposes.

To determine the first section of the Marshall chimney proper, see diagram B. It is perceived that the supposed vertical section shown in the diagram is the frustum of a cone the same as the chapter; the flue, however, is also a frustum of a cone. Subtract the inner frustum from the outer frustum, and the contents of the outer shell are obtained. By diagram B, we see that the inner frustum is 8 ft. 4½ in. diameter at the top, 10 ft. 4 in. at the bottom, and the altitude is 42 ft. Pursuing the same course as above, we have volume of entire frustum = 4264.1787 cu. ft., and the flue frustum is 2896.784 cu. ft.; the difference is 1367.3947 cu. ft., which is the volume of the brick shell. The volume of C obtained in the same way is 3634.73 cu. ft., and of D is 3853.07 cu. ft. Total volume of outer shell including chapter is 9344.73 cu. ft.

The ribs of the outer shell are five in number, and are denoted by the letters E, F, G, H, and I. To determine E, we first decide what kind of a geometrical figure it is. The face on which the letter is marked is parallel to the face opposite it; it is a six-sided figure, the top and bottom faces are parallel to each other; there are two faces, however, indicated in projection by the two upright lines which bound the face of E, and which are not parallel to each other nor are the planes in which they lie parallel to each other; the figure may then be called the frustum of a wedge, or a prismoid. The prismoidal formula reads thus: The volume of a prismoid is equal to the sum of the areas of the upper and lower faces, and four times the area of the middle

13,792.35 cu. ft. In a cubic foot of solid masonry, with one-quarter inch joints, using North River brick ($8 \times 3\frac{1}{2} \times 2\frac{1}{4}$), and allowing 2½ per cent. for waste, the results obtained are as follows: $13,792.35 \times 22.34 = 308,121.099 \div 0.975 = 316,021$ brick above grade. The calculations just made are based on a much larger stack than was actually built. To arrive at the total amount of brick in the chimney, the brick used in the foundations must be added to those just obtained, and the amount will be calculated further on. To arrive at the weight on the foundations, as everything below grade line is considered foundations, it would be safe to take the weight of the chimney as the weight of 308,121 brick and their mortar. Thus, the area of the cross-section of grade is 243.9765 sq. ft., and suppose all of the weight above this plane to be concentrated with this area, the weight will be nearly 13,792.35 cu. ft. $\times 118 \text{ lb.} = 814$ foot tons; this divided by 243.9765 = 3.33 tons per square foot at grade. To find what the pressure would be on the concrete base, the contents of a solid cone frustum must be calculated. The diameter of its upper base is 17 ft. 7½ in., the same as the diameter of the chimney at grade; as the joints here coincide, the diameter of the lower base is 24 ft., because the lateral face of the frustum slopes to the exact transverse dimensions of the concrete bed. The height of this frustum is 8 ft.; its volume is found to be 2742.9 cu. ft. The number of bricks in the foundation, then, is approximately 61,276, and the weight in round numbers 160 tons. Conceive a prismoid whose upper and lower bases are squares, one side of which at the top is equal to the diameter of the upper base of the cone frustum, and one side of which at the bottom is equal to the diameter of the lower base of the cone frustum, and whose altitudes are equal, using the same figures for the prismoid that are used for this cone frustum, and it is found that it will require 10,000 more brick to lay the prismoid than the cone frustum.

The total weight of the chimney can now be deter-

general, in a symmetrical chimney, the joint of least stability may lie in the plane where the base and chimney proper coincide, and in the writer's opinion a chimney should be so proportioned, and its relation to all its parts should be such, that the joint of least stability will be found in this coincident plane.

The Marshall stack was designed to have a capacity of 1,500 horse power, but has not been tested yet as to capacity. They have a grate area in use equal to 1,200 horse power. This capacity was based on nearly the same grate area as the Clark. In the former hard coal, and in the latter soft coal, is used to make steam. A great advantage in the use of hard coal over soft is a lower percentage of soot formation, but, on the other hand, a greater amount of water is evaporated per pound of fuel when soft coal is used.

In both stacks the brick are laid in cement mortar, as the engineers believe that lime mortar is readily attacked and crumbled by constant contact with sulphurous and sulphuric vapors and creosote from the fuel. The temperature in the stacks is so low that the cement is not affected.

In the Marshall stack no provision is made to prevent the accumulation of soot, dust, and the products of combustion between the two shells. The top of the inner shell should be covered by a projection of brick or by an iron plate. The Clark mills are using double-condensing Corliss engines, and under favorable circumstances have developed 1 horse power to 2.4 lb. of coal burned. The boilers are of the horizontal tubular type, by the Hartford Steam Boiler Co. The Marshall mills are using compound tandem engines, and expect that a horse power will be developed by something less than 2 lb. of fuel.

The Clark boilers evaporate about 11½ lb. of water to one pound of fuel; the feed water is heated to 150° or 200° Fahrenheit by Green's economizers before entering the boilers.

To the courtesy of Messrs. R. Kerr Clark, R. K. McMurray, Messrs. Lockwood and Greene, and the Flynt Building and Construction Co. the writer is greatly indebted for the drawings, details of construction, estimates of cost, and other information which they cheerfully furnished.

IV.—HORSE POWER CAPACITY.

The capacity of a chimney may be measured by the draught expressed in a given period. Various formulas are in use to determine this quantity, but two of them will be referred to, as all of them are approximative, and must be considered indicative rather than positive. The real capacity must be determined by experiment. The maximum capacity may be determined by the following formulas:

$$(X.) \begin{cases} H = 3.33 E \sqrt{h} \\ E = A - 0.6 \sqrt{A} \end{cases}$$

In which H = horse power capacity; E = effective area of the chimney's mouth; h = the height of the chimney proper; A = actually area of mouth in square feet.

Suppose it is required to find the maximum horse power capacity of a chimney which is 192 ft. above grade and whose actual area at the top is 64 square ft. Then $E = 64 - 0.6 \sqrt{64} = 59.2$, and $H = 3.33 \times 59.2 \sqrt{192}$ then H = 2,732 horse power, the maximum capacity.

To find the economical working capacity we suppose the following conditions to hold good: Let 3½ lb. of coal per horse power be the desired consumption, and the temperature of the gas within the chimney to be 550° Fahr. above that of the surrounding air. Let 2½ lb. of coal be consumed per second, and 300 cubic ft. of air at 32° Fahr. be the volume of air supplied per lb. of fuel, and the effective area of the chimney mouth be 59.2 square ft., the same as before, then we may use the following formula of Prof. Rankine:

$$(Y.) V = \frac{W \times q \times t}{a \times V_1}$$

In which V = velocity of the current in the chimney in feet per second; W = the weight of fuel consumed in pounds per second; q = quantity of air in cubic feet supplied per pound of fuel and at a temperature of 32° Fahr.; t = the absolute temperature of the gas discharged by the chimney; a = the effective area of outlet in square feet; and V₁ the temperature of the free-

Fig. 5. SECTION AT THROAT.

section between the top and bottom faces. Multiply this sum by one-sixth of the perpendicular distance between the top and bottom planes. The dotted arrows in the diagrams indicate the uniform widths of the ribs; the figures adjoining them, the depth of the ribs at the bottom and top. There are four ribs to each section shown in the diagrams, or twenty in all.

To determine E, the method is as follows: Area of top face = 12 in. $\times$ 12 in. = 12 square inches; bottom face 8 in. $\times$ 12 in. = 96 sq. in.; $96 \div 12 = 108 \div 2 = 54$ sq. in. = area of middle section; $54 \times 4 = 216$. Sum of

mined. The weight of the brick base added to the chimney proper brings the total weight to 974 tons. This amount is distributed over an area of 452.3893 square feet, and the pressure on the concrete therefore is 2.15 tons per square foot. The weight upon the ground itself distributed over the area of the concrete bed is 2.3 tons per square foot. By these calculations it can be seen, in the nature of the proportions of the chimney, the weakest point as to stability is on a horizontal section passing through grade line. One of the purposes in view in comparing these weights is to show that in

ing point reckoned from absolute zero. By substitution the formula becomes $V = \frac{\frac{1}{2} \times 300 \times 1011.2}{59.2 \times 493.2} = 24.24 \text{ ft.}$ per second per square foot of section.

The absolute temperature of the gas within the chimney is $550 + 461.2 = 1011.2^\circ \text{ Fahr.}$ The amount discharged per hour then is 87,344 ft. per square foot of effective area; the total amount discharged is 5170764.8 cubic ft.; but when 3½ lb. of coal per hour is equivalent to a horse power, there is 2100 cubic ft. of gas dis-

Fig. 6.

charged per horse power; hence $\frac{5170764 \cdot 8}{2100} = 2462$ H. P.
or the effective working horse power of the chimney, and the result agrees closely with the tested capacity of the Clark chimney.
Using the same formulas and same conditions for the $\frac{1 \cdot 4583 \times 300 \times 1011 \cdot 2}{40 \cdot 191 \times 493 \cdot 2} = 22 \cdot 31$ ft. per second. $22 \cdot 31 \times 3600 \times 40 \cdot 191 \div 2100 = 1537$ H. P., which is its economical effective horse power. By formula X the maximum horse power is found to be 1769.
The Clark stack is using what is known as the "Cumberland" soft coal from Maryland.

V.—ARCHITECTURAL TREATMENT.

It is admitted that the architectural treatment of a chimney is of secondary importance, and it may be a matter of opinion whether it is even that, but if it is, then something can be said as to the manner of this treatment. In regard to the effect, for example, of the

In the very nature of things, a chimney cannot be modest and hang its head below surrounding buildings; and if it must tower aloft and outline its face or form against the sky, it should be made worthy of the commanding position it fills. Any prominent object erected by man should be shapely, well arranged, and consistent with the principles of design. It requires more skill to originate a positively ugly stack than to build a graceful one. The slender obelisk form of a chimney naturally lends itself to architectural treatment, and who would be so bold as to deny the charm that lurks about a chimney whose faces are clothed by "shadows fringed with light," where "form is substance, substance form," and grace the hood of beauty.

VI.—REFERENCE TABLE OF DIMENSIONS.

Heights.	Marshall.		Clark.	
	Ft.	In.	Ft.	In.
Above grade.....	175	0	192	0
Total, including foundation.....	186	0	204	3
Of chapter.....	16	6	22	0
From grade to chapter.....	158	6	170	0
Batters.....	$\frac{2}{15}$ in. to 1 ft.		$\frac{2}{15}$ in. to 1 ft.	

FIG. 7. VERTICAL ELEVATION AND SECTION OF CHAPTER.

two chimneys under discussion, it may be said of the Clark that its general outline is good. It stands on a level plateau, between two large mills, high enough, however, above them to escape being dwarfed by the association, and it may be that their horizontal extension, great in comparison to their height, adds something to the chimney's real height. It has two striking disadvantages, one of which is attendant upon every stack of its kind, and that is the impression of a breadth too great for its batter when viewed diagonally. The other is the heavy appearance of the chapter in contrast to the total height of the chimney, and not to its lateral extension.

The recesses of the arcaded chapter are not deep enough to obtain the proper intensity of shade, a remark which will apply equally well to the recesses of the Marshall. Deeper shades in the arcades and longer shadows from the modillions would have a tendency to lighten the entire effect of the chapter.

In the Marshall stack, the outline is not so sharply defined against the sky, because of its convex surface. The shadowy uncertainty of its contour makes it picturesque. From no point of view can the stack be seen without that delicate balancing of light and shadow which baffles all analysis. A chimney with such parts may have expression, and this may be found perhaps in the conjunction of two circumstances. Its utility is unquestioned; if added to this it commands instant admiration, the reason must be sought for in the universal love of beauty united to truth.

In one sense a chimney may be considered as a monument to industry. Wherever it may be seen, it is the evidence of energy transformed into work. In the case of dismantlement, it is the last fragment to be torn down; in the event of a conflagration, it is the last block of masonry to fall, and who ever saw a chimney fall without a sigh of regret? Generally, it may be said, it alone outlives its usefulness, unless it be unseemly to commemorate the industry which gave the chimney birth.

<i>Diameter or Widths.</i>			
External at grade.....	16	6	17 0
External at foundation.....	24	0	19 0
External at chapter.....	10	9	10 9
Flue at grade.....	6	0	8 2
Flue at mouth.....	6	0	8 0
<i>Outer Shells.</i>			
Thickness of chapter at low- est point.....	1	0	1 4
Height of shell.....	42	0	18 0
Thickness of second section..	1	4	1 8
Height of same.....	70	0	36 0
Thickness of third section...	1	8	2 0
Height of same.....	55	0	38 0
Thickness of fourth section..			2 4
Height of same.....			42 3
Thickness of fifth section...			2 8
Height of same.....			35 9
All recessions.....	0	4	0 4
<i>Inner Shells.</i>			
Thickness of first section...	0	4	0 8
Height of same.....	30	0	18 0
Thickness of second section.	0	8	1 0
Height of same.....	68	0	22 0
Thickness of third section..	1	0	1 4
Height of same.....	75	0	20 0
Base proper, height.....	2	0	4 4
Foundation depth below grade.....	11	0	12 3
<i>Weights.</i>			
As erected.....	Tons.		Tons.
	987		2,187
Brickwork.....	892		1,624
Concrete.....	95		563
Load on concrete foundation per square foot.....	1'97		2
Load on ground per square foot.....	2'18		2'8

Horse Power.	Marshall.	Clark.
Working capacity as planned.....	1,500	2,400
Original available capacity.....	1,769	2,732
Maximum power as executed.....	1,105	2,732
Cost.		
Per horse power as planned, working capacity.....	\$5 23	\$5 83
Per horse power as executed.....	6 33	5 53
Total, as erected.....	7,000 00	14,000 00

THE RAFFARD SYSTEM OF BAND WHEELS.

M. RAFFARD in the construction we are about to describe, proposes to balance as well as possible the strains upon the bearings of such arbors as are to be driven at high angular velocity. The arrangement which he uses is designed to reduce to a minimum the work of the wasteful resistances and to diminish the portion, always too great, of the work of the motor which they absorb.

In transmission between parallel arbors a high ten-

FIG. 1.

sion is generally given at first to the belt as necessary to prevent it slipping on the band wheels. This initial tension is preserved on the average through the system while the movement continues, but is unequally divided between the driving and driven pulley. It causes a disproportional pressure on the journals, and produces a friction proportional to the tension developed.

M. Raffard, it may said, doubles the transmission by supplementing the two original arbors by a third and auxiliary one. Suppose, for example, referring to Fig. 1, that the movement of the arbor, O, is to be transmitted to the parallel arbor, O1. M. Raffard adds to the system a third arbor, O2, parallel to the two first, and lying in the plane of the axes of O and O1, and above them both as represented.

Two pulleys with double grooves, whose radii are determined by the angular velocity it is proposed to develop, are mounted on the three axes, O, O1, and O2,

FIG. 2.

and a single endless cord or belt connects them all together, lying in lines tangential to the three circles taken in pairs, following the lead denoted by the following letters:

A B C D E F G H I K L M A.

In the notation which we have adopted here for denoting the different points of contact of the six tangents, the large letters denote the grooves of the pulleys situated in front of the plane of middle section parallel to the plane of the paper, and the small letters those situated behind the same. It is at once evident,