ON A NEW METHOD OF STRAIGHTENING HIGH CHIMNEYS.

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It is a well-known fact that high chimneys, however carefully built, often lose their original straightness soon after their erection, and assume an inclined position or a curved shape. This frequently takes place to such an extent that the stability of the chimney is endangered so that it becomes necessary to straighten it. This is generally done by making an incision, or several, in the chimney on the side opposite to that to which the chimney is inclined. This operation is performed by means of large saws. Recently, however, a very high chimney erected by Messrs. Wesenfeld & Co. in their chemical establishment at Barmen (Prussia) was straightened successfully by a different method.

This chimney is 331 feet high. Its exterior shape is octagonal, with a clearance of 8 feet throughout its whole length. This gives it an interior sectional area of 53 square feet. The socle is quadratic in section, 20 feet wide and 40 feet high. The upper, or pyramidal part of the chimney is octagonal, 291 feet high. The exterior diameter of the latter is 17 feet at the base of the pyramidal part. This diameter is reduced 2½ inches on every ten feet upwards. The masonry is 7 bricks thick in the basement, 5 at the base of the pyramidal part, and 2 at the top.

For the sake of comparison we here add the following table:

TABLE CONTAINING THE MOST IMPORTANT DIMENSIONS OF SOME REMARKABLE CHIMNEYS (br.=length of brick)

Number.	Height, including foundation. h	Height, exclusive foundation.	Exterior diameter. below. $\varnothing$	Exterior diameter. above.	Thickness of masonry. below.	Thickness of masonry. above.	Decrease of diameter on every 10 feet of hight.	Relation of the hight to the diameter of base. $\frac{h}{\varnothing}$	LOCALITY
	ft.	ft.	ft.	ft.			Inches.		
1	= 434	441	31.	12 3-8	5' 1 ft.	1 1-2 br.	5·09	14·19	Port Dundas, near Glasgow (Scotland).
2	345	420	29 1-3	13 1-6	3' 1-2 br.	1 1-2 br.	7·49	10·67	St. Rollox, near Glasgow (Scotland).
3	317	331	33	11 1-2	5 ft.	1 1-2 ft.	7·47	18·39	Chemical Works at Barmen (Prussia).
4	285	330	18 1-2	10 3-4	6 1-2 ft.	1 1-4 ft.	2·36	11·83	Cast Steel Works at Bochum (Prussia).
5	178	221	17 5-6	7 1-4	4 br.	1 br.	9·4	12·42	Dye Works, Hagen (Prussia)
6	167	175	20	7 1-4	3 1-2 br.	1 br.	8·58	8·44	Pontasser's Chemical Works (England)
7	162	155	17 1-2	6 1-4	3 br.	10 in.	9·07	9·14	Alois Iron Works (France).
8	144	159	16 2-3	5 2-3	3 br.	10 in.	7·91	8·14	Hepburn's Tannery on the Tyne (England).
9	133	138	11 1-3	6	2 1-2 ft.	10 in.	6·66	11·63	Dye Works, Barmen (Prussia).
10	131	136	9 1-3	4 1-3	2 1-2 ft.	1 br.	8·0	9·0	"Elner Graben", hemical Works, Barmen (Prussia).
11	130	135	10 1-3	4 1-3	2 br.	1 br.	5·90	11·50	Eisengarn Factory, Barmen (Prussia).
12	133	138	9 1-3	4 1-3	2 br.	1 br.	4·54	13·86	Dye Works Ochde, near Barmen (Prussia).
13	130	135	10 1-3	4 1-3	1 1-2 br.	1 br.	5·45	12·43	St. Ouen, near Paris (France).
14	131	136	15 1-2	6 1-4	2 br.	1 br.	8·31	8·14	White's Factory (England).
15	130	191	11 1-2	6 1-2	4 br.	1 br.	4·82	10·61	Rolling Mill, Hagen (Prussia).

In looking over the table it might appear strange that the proportions of the hight to the diameter of the base has been taken so very high in the construction of the chimney No. 3, which is the subject of the present paper. For, by comparing this proportion to those used in the construction of any of the other chimneys mentioned, it becomes evident that this high proportion has been chosen against all previous experience and practice. The explanation of this is found in the circumstance that this chimney was to have, according to the original design, a hight of 260 feet only, which by a later resolution was changed to 331 feet. As the construction had then been commenced, and was proceeding in a very satisfactory manner, it was considered best and sufficiently safe to increase the hight without altering the dimensions of the base. The consequence, of course, was that every square foot of a section through the masonry of the lower part of the chimney was subjected to a very high, and indeed, abnormal pressure.

An exact calculation has shown that one square foot of masonry in the lowest part of the chimney proper carries a weight of 21,335 lbs. or 149 lbs. per square inch.

For comparison the highest pressure existing in the chimney No. 4 (see table) erected at the Bochum cast steel works, was calculated and found to be 18,429 lbs. per square foot, or 128 lbs. per square inch. The difference amounts to 21 lbs. per square inch, or little below 1½ atmospheres, which constitutes the excess of pressure in the masonry of the chimney at Barmen over that of the Bochum chimney.

The chimney at Barmen (the straightening of which we propose to describe hereafter) was built with the greatest possible care. A good underground was available, consisting of a stratum of hard and coarse gravel. The foundation and the socle were built in the summer of 1866, the pyramidal part in the summer of 1867. The foundation was made of large, flat quarry stones with terrace mortar (1 lime, 1 river sand, 1 terrace, which is a kind of puzzolana). The socle was made of brick with ordinary mortar (1 lime on 2 river-sand).

The mortar was prepared fresh every morning by the masons themselves. Cement mortar (1 cement on 2 river sand) was used on rainy days. The crown of the chimney was built with cement exclusively. The joints of the masonry were flushed up with cement, and gradually as constructions proceeded.

The three masons who did the whole work daily changed their positions on the chimney so as to equalize any unevenness in the masonry that might be caused by imperceptible differences in the manipulations of the different individuals. At distances of fifty feet single layers of brick work were painted black outside to afterward facilitate an estimate of the hight of any point of the chimney above ground. The chimney was built from the inside without a scaffold, the materials being hoisted by a steam engine put up temporarily near the place of construction. The motion was transmitted by three rollers or drums. The frame which supported the upper drum was moved higher up after the completion of every three or four layers of brick, and was at the same time turned horizontally from one side of the octagon to the next one to equalize the effect of the pressure of the frame on the masonry. The holes made into the masonry to support the frame, were filled up with brick and mortar immediately after the removal of the frame to a higher level.

The construction of this chimney was thus successfully completed in October, 1867, and answered perfectly the requirements for which it was erected. It was perfectly vertical and straight.

However in the spring of 1868, remarkable for vehement and long-continued gales and storms, this chimney suddenly assumed an inclined position toward the north-east. The injurious action of the south-west wind was probably favored by the bold proportions of the structure, by the yet subsisting softness of the mortar, and by the large size and the shape of the richly ornamented chimney crown. This crown caught the wind, and thereby caused it to act as on a long lever. The chimney was thus bent, and the mortar not perfectly dry, the brickwork did not yet possess the necessary elasticity to return to its original shape.

The deflection of the chimney was considerable at the end of May, and seemed yet to increase, and threatened an overthrow.

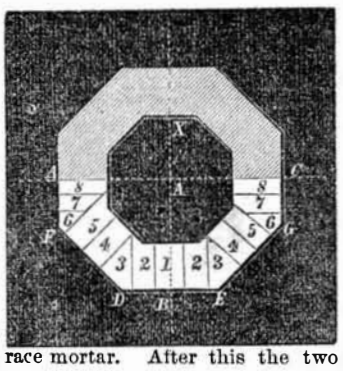
As above mentioned, some layers of bricks in the chimney at distances of fifty feet from each other, were painted black outside. The hight of these black lines above the socle being known, these lines were, by means of a theodolite projected on a plank situated on the socle of the chimney to find the deviation from the vertical line at these different hights. It was thus ascertained that the chimney at a hight of

251 feet	was out of line	.....	45 inches.
210 feet	" "	.....	30 "
160 feet	" "	.....	16 "
110 feet	" "	.....	5 "

The socle stood perpendicular. As the deviation was still increasing, and as it would have done too serious an injury to the manufacture of the establishment to set the chimney temporarily out of use, it was necessary that immediate action should be taken in the matter. The ordinary method of straightening chimneys was at first resorted to. A hole was made through the whole thickness of the masonry on that side of the chimney which required lowering four feet above the top of the socle. Into this hole a saw was introduced with which a horizontal cut through one half of the chimney was attempted. But as the thickness of the wall was considerable and the bricks hard; and as the saw could be manipulated from one of its extremities only, the effect of sawing, after two hours' work, was scarcely perceptible.

The hole through the chimney having been made without trouble, and the difficulty experienced in sawing led to the idea to gradually remove a whole layer of bricks, replacing it by a thinner layer thus to produce the desired slit. Before, however, this operation was performed, the experiment was made with an old inclined chimney 120 feet high. When the method had there proved practicable and successful, it was concluded to treat the new chimney in the same way.

A layer of bricks was broken out by means of pointed cast-steel bars, from 1½ to 5 feet in length. The annexed figure shows a horizontal section of this layer, the inscribed numbers, 1, 2, 3, 4, etc., indicating the succession in which the different parts or divisions of the layer have gradually been removed. When the division, 1, was broken out, it was replaced by thinner bricks covered with terrace mortar. After this the two divisions, marked 2, were broken out and replaced by thinner bricks, then the two divisions, marked 3, and so on until one half of the whole layer was thus exchanged.



Flat shovels with long handles were used to lay those bricks which had to be placed near the inside of the chimney. A space of 5 inches was left each time between the newly-laid bricks and the old ones of the next division, to break out the latter with greater facility.

The width of each single division was 2 feet to 2½ feet. The masonry was sufficiently dry above not to give way when a layer of that width was removed below it. The replacing bricks were taken thicker gradually as the operation drew nearer the points, A and C (see engraving), so as to get the slit wide in the middle and gradually extenuating towards it two extremeties at A and C As soon as the slit reached these points, the chimney began to move, and by slight oscillations slowly settled down on the new layer of bricks, and when it had reached it, remained quiet.

The act of settling by oscillations lasted from 18 to 36 hours, corresponding to the width of the slit which was different in the different cuts performed in a similar way at different hights of the same chimney. The oscillations were the greater and the livlier the higher up the cut was, which produced them.

At the highest cut, 100 feet from the top, the oscillations were such that the masons became frightened and left the place, the slit became alternately wider and narrower by ⅜ of an inch. The facts before mentioned seem to prove the elasticity of the whole structure. Four cuts were made into this chimney; the

1st.	4 feet	above the socle,	greatest	width.	⅜
2d.	100 feet	"	"	"	1¼
3d.	140 feet	"	"	"	1½
4th.	191 feet	"	"	"	1¾

After the completion of these operations the chimney continued during several weeks to settle slightly in the direction opposite to its former inclination, the brickwork on that side being now subjected to a higher pressure than before.

This circumstance has to be carefully considered beforehand, or else the slits would be made too wide and produce an inclination of the chimney in the opposite direction. A severe storm which occurred on the 6th and 7th of December, 1868, and which threw over several chimneys in the neighborhood, did not affect the above. The result of the straightening operation before described is perfectly satisfactory, and the structure is now stronger and steadier than ever.

We have yet to speak of the means by which the upper parts of the chimney were made accessible to perform the upper cuts. This was done on a new and interesting plan. Standing on the lowest platform, the masons made a number of holes all on the same level, 4 feet above the platform, into the exterior wall of the chimney. They stuck iron bars into these holes and fixed boards to them so as to form another platform. Standing then on the latter, they made another one four feet higher up in the same way, and so forth. Every second platform was again removed, so that the remaining platforms were 8 feet apart. They were then joined by ladders, to make the ascent possible and easy. This method is, however, only practicable when the chimney has a considerable diameter, and when the mortar is sufficiently dry not to give way under the one-side pressure of the bars and platforms, which would make the arrangement loose and unsafe.

In December, 1868, another chimney at Duisburg was straightened by the method above described. But as the diameter of the chimney was not as large as that of the Barmen chimney, and as the mortar was yet soft, a wooden scaffold was erected around the chimney to get at the upper points which required cutting. The breaking out and replacing of the bricks could not be done there in divisions wider than 5 to 10 inches, otherwise the upper masonry not being dry, would have settled down. When the chimney was straight, a further settling towards the side of the cut was prevented by driving iron wedges covered with mortar into the slit.

We shall finally not omit to remark that it is advisable to straighten a chimney as soon as there is a decided evidence of its deviation from the vertical position. For while the mortar is not hardened, the deviation gets worse and worse, and the operation more difficult and more expensive.

Varnish for Iron.

The following is a method given by M. Weiszkopf, of producing upon iron a durable black shining varnish: Take oil of turpentine, add to it, drop by drop, and while stirring, strong sulphuric acid, until a sirupy precipitate is quite formed, and no more of it is produced on further addition of a drop of acid. The liquid is now repeatedly washed with water, every time refreshed after a good stirring, until the water does not exhibit any more acid reaction on being tested with blue litmus paper. The precipitate is next brought upon a cloth filter, and, after all the water has run off, the sirupy mass is fit for use. This thickish magma is painted over the iron with a brush; if it happens to be too stiff, it is previously diluted with some oil of turpentine. Immediately after the iron has been so painted, the paint is burnt in by a gentle heat, and, after cooling, the black surface is rubbed over with a piece of woolen stuff, dipped in, and moistened with linseed oil.

According to the author, this varnish is not a simple covering of the surface, but it is chemically combined with the metal, and does not, therefore, wear off or peel off, as other paints and varnishes do, from iron."

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