LETTER TO THE EDITOR.

The Design of Steel Stacks.

Sir,—Referring to an article by Mr. W. A. Hitchcock, instructor in engineering mathematics in the University of Colorado, published in your issue of September 28th, the results as given seem very misleading.

The loads and working stresses are those usually used in structural design, except the unit compression stress, 16,000 lbs. per square inch. However, since the unit tension stress is limited to 16,000 lbs. per square inch and this is on the *net* section at a circumferential splice, the maximum compression is not more than about 11,000 lbs per square inch, (this being based on an efficiency of 69 per cent.) which is quite reasonable.

The equations given under the heading "Minimum Thickness of Plates" are evolved from those usually used in the design of Stacks, the equations being simplified by the elimination of all unknowns but two, by neglecting some and expressing others accurately, or approximately in terms of the remaining two. The errors introduced by these approximations are relatively small and the result as given in the curves is in a very convenient form for use. However, since the diameter of the stack is not always constant the value of S^1 which the author gives as

$$S^1 = 0.053 \frac{PH^2}{D} \qquad (4)$$

is more conveniently expressed

$$S^1 = .106 \frac{M}{D^2} \qquad (4a)$$

In which S^1 = minimum stress in pounds per lineal inch along circumference.

M = overturning moment in ft.-lbs.

D = diameter of stack in feet at the section being considered.

The value of S^1, as given in equation (4a) clearly demonstrates that the stress per lineal inch along the circumference of the stack varies inversely as the *square of the diameter* and not inversely as the *diameter*, as would appear from a casual glance at equation (4). That the form given by the author in equation (4) invites this wrong conclusion is made evident by the fact that he himself has twice fallen into error, *viz.*, in equations (40) and (44) when deriving formulæ for the size of anchor bolts and the riveting in the anchor angle. Under the heading "Minimum Size of Foundation," the author discusses the subject and evolves his equations by what he apparently considers two methods. The first of these methods is theoretically sound and except for the approximations which he mentions, the results are correct. In his second solution he falls into serious error. The first solution rightly assumes that for the minimum size of foundation the resultant pressure on the foundation is at the leeward edge of the kern or $\frac{D}{8}$ from the centre.

Since the structure is in equilibrium the centre of gravity of the supporting upward pressure of the soil is this same distance, $\frac{D}{8}$, from the centre, and is on a straight line, at right angles to the direction of the wind, *i.e.*, the structure would be in equilibrium if supported on this line. Clearly, then, to calculate the maximum resisting moment of the foundation, moments must be taken about an axis $\frac{D}{8}$ from the centre and, expressed as a fraction, this resisting moment equals $W_t \times \frac{D}{8}$. But the author, continuing after equation (18), says: "Taking moments about an axis tangent to the leeward side of the foundation, and neglecting the resisting moment due to W_0 and W_1 as small compared with equation (17), the resisting moment is $M = W_t \times \frac{D}{2}$." This is decidedly at variance with the result just derived from the first solution, and clearly indicates the first error in this second solution.

The next sentence, regarding a "safety factor," is hardly reasonable enough to invite comment. The author is, apparently, endeavoring to make the result for the second solution correspond to the first solution and introduces this ludicrous statement to cover the error already mentioned. His conclusion, after equation (22), that a "safety factor" of approximately 2¼ gives identical results with the first solution, has not even the justification of arithmetical accuracy. To obtain the same result as the first solution a "safety factor" of 4 must be introduced, which is what one would expect since the moment of resistance is calculated in this second solution on a moment arm $\frac{D}{2}$ instead of $\frac{D}{8}$. The second solution, then, is not a different solution from the first, but rather the same one incorrectly applied.

In both the first and second solutions under the heading "Minimum Size of Anchor Bolts," the author has fallen into error similar to that referred to above in the second solution for minimum size of foundation, *i.e.*, he has calculated the moment of resistance about the wrong axis. In the first solution the moment of resistance is taken about the centre of the stack, which would be correct only if the total pressure on the foundation, which balances the pull of the anchors, were concentrated on a line, at right angles to the wind pressure, passing through the axis of the pipe. In the second solution the moment is taken about the leeward edge of the pipe, which assumes the pressure on the foundation, due to overturning, concentrated at a point on the edge of the pipe. Clearly these assumptions are both wrong. What would be reasonable to expect is that each bolt-pull is balanced by a pressure the centre of which is an equal distance on the other side of the centre line of the bolt circle. Then the moment of resistance of the anchors is $t\Sigma X^2$, where X is *twice* the distance of the bolt from the centre line in feet and t is the stress on a bolt for which X = 1 foot. For the case considered in equation (24), *i.e.*, 12 bolts in the circle,

$$M = t\Sigma X^2 = t\left[\left(2\frac{B}{2}\sin 30^\circ\right)^2 \times 2 + \left(2\frac{B}{2}\sin 60^\circ\right)^2 \times 2 + B^2\right] = 3B^2t$$

but $M = \frac{1}{2}PDH^2$ (25) and $t = \frac{M}{\Sigma X^2}$

$$\text{Therefore, } t = \frac{PDH^2}{6B^2} \qquad (26a)$$

The stress in bolt 3, which is the maximum stress in the group of bolts, is $t \times B$, and is therefore equal to

$$\frac{PDH^2}{6B} \qquad (27a)$$

If unit stress in a bolt = f lbs. per square inch

$$0.7854 \times f \times b^2 = \frac{PDH^2}{6B} \qquad (28a)$$

Solving for b

$$b = .46\, H\left(\frac{PD}{fB}\right)^{\frac{1}{2}} \qquad (29a)$$

Equation (29) was incorrectly derived from (28) in the original. Correctly calculated from (28) it should have read $b = .652\, H\left(\frac{PD}{fB}\right)^{\frac{1}{2}}$