BRACING BOILER HEADS.

We commend the following article, which we glean from a late impression of the Hartford Steam Boiler Inspection and Insurance Co's. *Locomotive*, to the attention of Boiler-makers:

The proper bracing of flat surfaces exposed to pressure, which are necessarily present in almost all forms of boilers, is a matter of the greatest importance, as the power of resistance to bulging possessed by any considerable extent of such a surface, made as they must be in the majority of cases of thin plates, is so small that practically the whole load has to be carried by the braces. This being the case, it is evident that as much attention should be given to properly designing, proportioning, distributing, and constructing the braces as to any other portion of the boiler. This is not, however, always done, and it is no uncommon thing to subject new boilers to hydrostatic pressure well within the limit of strength of the shell, and so strain the bracing that the heads are bulged to quite an appreciable extent, and when the pressure is released the braces are found to be loose and badly strained. The prevalent idea regarding bracing is, that it should be just sufficient to prevent "vibration" of the heads. There is no objection to regarding it in this light if we consider properly just what is required to effectually do it.

The subject might profitably be discussed in a general manner, but we think more advantage will be derived from the consideration of an actual example, such as would arise in daily practice. Suppose, for example, we are designing a boiler 72 inches in diameter. How many braces shall be put on the heads above the tubes? We first arrange our tubes. Let us assume that they are 3½ inches in external diameter; then a good arrangement of them, paying due regard to a free circulation of the water, will admit about 86, and will leave a clear hight from the top of the upper row to the top of the shell of 29 inches. (See Fig. 1). Then it is evident that this segment, 29 inches high, of a circle 72 inches in diameter, constitutes the surface to be braced, and we must next ascertain the strength of bracing required to render it safe.

Let us consider first just how much of the pressure on this segment must be carried by the braces, and how much shall be allotted to the flange of the head and the top row of tubes. For it is evident that as the area to be braced is bounded by these parts, and they possess ample strength, they may be calculated to sustain their due share of the load.

The flange of the tube sheet may be assumed to have a radius of two inches. This curved portion will take care of itself, and, if it had a chance to do so, a great deal more besides. So we draw the line A-A′ with a radius of 34 inches, and disregard the portion outside of it.

Now, we know that on heads or flat surfaces of ordinary thickness, the pitch of stays should not be much more than 8 inches from centre to centre. In the fire boxes of locomotives and similar boilers they must be much closer, but the head of an ordinary boiler is not exposed to such intense heat, and they may be placed much further apart, with safety. So we draw the line B B′ B″, with a radius equal to 30 inches, and consider that the load on the area between it and the flange may safely be borne by the flange itself.

Now, how much of the load on the head above the tubes may safely be carried by the tubes themselves? We know by experiments that the tubes, if well put in, have a great holding power when new. We also know that if the water used is corrosive, or the fuel is of such a nature that its gases attack the ends of the tubes externally, they may in time corrode and lose much of their holding power. If this were not so then we should be justified in keeping away from the tubes 8 inches or so with the nearest brace; but for the reasons above stated it would be deemed judicious to brace closer down to the top of the tubes, so that if a portion of them lose their holding power, the boiler will still be perfectly safe. So we would put the line of braces as nearly as might be 4 inches above the top of the upper row of tubes, and drawing the straight line from B to B′, 2 inches above the tubes, put in braces enough to carry safely the pressure on the segment of the head B B¹ B″. The area of this segment is easily computed by means of the table given in the *Locomotive* of December, 1886, page 184. In this case it is a segment 21 inches high, of a circle 60 inches in diameter, and its area is 882 square inches. The braces should be sufficient to carry safely the entire pressure coming on this surface. If the boiler is intended to carry a pressure of 100 pounds per square inch, it would aggregate on this segment 88,200 pounds, and the braces should be sufficient to safely sustain this pressure. The number of braces required will depend upon their form. If, of the ordinary crowfoot pattern, which if well made is as good as anything yet devised, and one inch in diameter, they could safely be allowed to sustain a tensile stress of 7,000 pounds each. This would give 88,200 + 7,000 – 13 braces, which should be distributed as uniformly as possible over the surface to be braced, about as shown in Fig. 1, making the arrangement as symmetrical as possible, grouping them slightly closer to each other near the centre of the heap than we do out toward the flange. The braces should be attached to shell and head by two rivets at each end. The rivets should be of such size that the combined area of their shanks will be at least equal to the body of the brace, and their length should be sufficient to give a good large head on the outside to realize strength equal to the body of the brace. We have seen cases where the rivet used was so short that when hammered down outside, the head was so thin and weak that it stripped off under the test pressure. Such scrimping of material is very poor economy in the long run.

Fig. 2 shows an arrangement for a different form of brace. Four-inch T-irons are riveted to the heads, and the braces, with forked jaws, are attached to the web by a turned pin or bolt. The T-irons are, as far as practicable, so arranged that the rivets which secure them to the heads will fall in about the same position that they would if crowfoot braces were used, that is, they should be distributed as uniformly as possible. This enables a less number of braces to be used, but they should be somewhat larger. Owing, however, to the stiffening of the heads by the T-irons, which act as girders, and transfer the stress due to the pressure to the flange and the tubes, it is usual to make these braces but one inch in diameter. We have never known the least trouble to occur where a boiler was braced in this manner and the work was well done, and recommend it as a very superior form. Fig. 3 shows the detail of this brace and its connection. Two angle irons are sometimes used instead of the T-irons with this form, but the T-irons are to be preferred, as they are free from the "claw hammer" strain which is unavoidable when the angles are used.

Many boiler-makers prefer to arrange the T or angle irons horizontally across the portion of the head to be braced instead of radially. This form is shown in Fig. 4, and there is no objection to it provided the braces are swung horizontally to the point of attachment to the shell. Where they are swung upward, as they are in the majority of cases, an awkward bend is necessitated in the brace, and a square pull on the jaws is impossible, and the consequence is they do not remain taut for any great length of time. They should never