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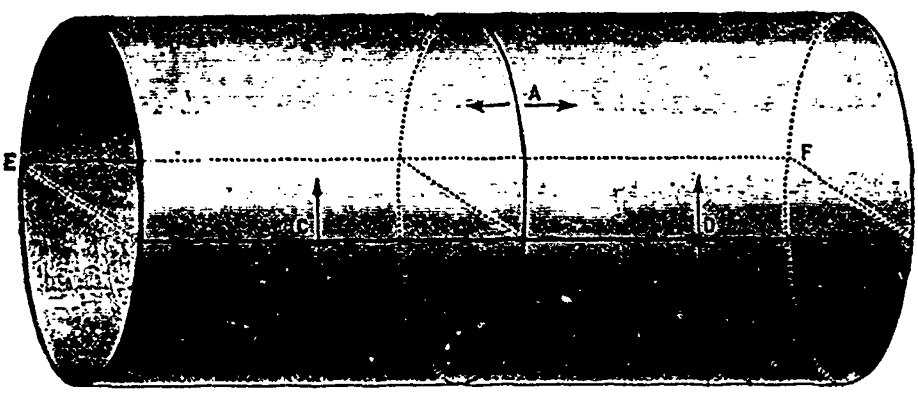
LONGITUDINAL AND GIRTH JOINTS IN BOILERS.

ALL writers upon the subject of steam boiler design devote considerable space to the discussion of the longitudinal joints, but it has appeared to some of our readers that the girth joints have not received sufficient attention. For example, in boilers that are to withstand high pressures, the longitudinal joints are now usually made by abutting the plates, and securing one or two overlapping straps to the plates by means of two rows of double or triple rivetting; while the girth joints on the same boiler are ordinary, single-rivetted lap joints. It is the purpose of the present article to make it plain that this construction is correct, and if the single-rivetted girth joint is properly designed, it is still considerably stronger than the double butt-strap, triple-rivetted longitudinal joint.

The cut represents a hollow cylinder of steel, an ideal boiler shell, without heads or joints. It is 66 inches in diameter, and 14 feet long. The thickness of the metal is ⅜ of an inch, and its tensile strength, let us say, is 55,000 pounds per square inch of section If this shell is burst by steam or water pressure, the fracture can run longitudinally, along the lines *E F D C*, or around the boiler, along the line *B A*.



LONGITUDINAL VS. GIRTH JOINTS IN BOILERS.

Let us first find the bursting pressure, assuming that the fracture takes place longitudinally. At the moment of rupture, the strain on the metal must be just equal to its tensile strength; that is, to 55,000 pounds per square inch. The area of plate to be broken, along the line *C D*, is 168 × ⅜ = 63 square inches, 168 being the length of the boiler in inches, and ⅜ being the thickness. The section along *E F* has the same area, so that the total area to be broken across is 2 × 63 = 126 square inches; and since the strain on each square inch is 55,000 pounds at the moment of rupture, the total strain on the section of rupture will be 126 × 55,000 = 6,930,000 pounds.

The total steam pressure tending to force the two halves of the boiler apart is equal to the pressure per square inch multiplied by the area of the cross-section of the boiler, which area, in this case, is 168 (length of boiler) × 66 (diameter of boiler) = 11,088 square inches. Those who are not familiar with this sort of calculation sometimes find it hard to understand why the surface of the shell is not used, instead of the area of cross-section. The answer is, that the pressure on the half *E A D*, for example, does not all act in the same direction, owing to the curvature of the shell. The pressure on parts that are close to the line *C D* acts almost horizontally, while on the parts lying along the top of the boiler it acts vertically. It would be easy to take these varying directions into account, but the same result can be reached without any figures, and in a very simple way. Suppose, for example, that the lower half of the boiler in the cut should be taken away, and that a flat plate should be bolted to the upper half in its place. If steam is now admitted, experience tells us that the boiler will not move either up or down; and it follows from this that the pressure against the curved half of the structure is precisely equivalent, so far as forcing the halves of the boiler apart is concerned, to that against the flat plate bolted to it. Hence, as was stated in the first part of this paragraph, the total pressure tending to force the two halves of the boiler apart is equal to the pressure per square inch, *multiplied by the* area of cross-section of the boiler (11,088 square inches).

The pressure that would burst a shell like that shown in the cut is of such a magnitude, therefore, that if it is multiplied by 11,088 square inches (the area on which it acts) the product will be 6,930,000 pounds. Hence the bursting pressure is 6,930,000 ÷ 11,088 = 625 pounds per square inch. This is not the bursting pressure of a *boiler* of this size, but simply of a steel shell of the given dimensions; for we have not yet taken account of the joints that occur in boilers.

Let us now see what pressure would be required to force the boilers apart endwise, tearing it along the line *A B* The only thing that can produce a strain acting lengthwise along the boiler, is the pressure on the head, which is equal to the steam pressure per square inch, multiplied by the area of the head in the present case being 66 × 66 × .7854 = 3,421 sq. inches.

To withstand the strain so produced we have a ring of metal at *A B*, which is 207.3 inches in circumference (66 × 3.1416 = 207.3), and ⅜ of an inch thick. The area of this ring is 207.3 × ⅜ = 77.74 square inches; and when the shell is about to break, the strain upon the section *A B* will be 55,000 = 77 74 = 4,275,700 pounds. When the boiler parts, therefore, the steam pressure must be such that, by acting on an area of 3,421 square inches, it produces a resulting strain of 4,275,700 pounds. Hence the bursting pressure per square inch is 4,275,700 ÷ 3,421 = 1,250 pounds.

The results that we have thus far reached are, that it would take a steam pressure of 625 pounds per square inch to rupture a shell of the given dimensions longitudinally, and that it would take precisely twice this pressure, or 1,250 pounds per square inch, to rupture it circumferentially.

If the shell were made up of plates, rivetted together, we should have to modify the foregoing calculation somewhat, so as to take account of the diminished strength due to the existence of the joints. Let us suppose there is a single-rivetted girth joint whose dimensions are as follows: Diameter of rivets, ¾ inch; diameter of rivet holes, 13-16 inch; pitch of rivets, 1¾ inches; tensile strength of plates, 59,000 pounds. It will be found that this joint has 53 per cent. of the strength of the solid plate; so that the pressure per square inch that would rupture such a shell circumferentially, so as to blow the two ends apart, would be 53 per cent. of 1,250 pounds. 1,250 × 53 = 662.5. It would therefore take 662½ pounds to the square inch to pull this girth joint apart. But from our previous calculation it appeared that 625 pounds would tear the *solid plate* apart