

FLUES IN BOILERS.

A boiler shell, with the pressure acting on it from within, is in a state of stable equilibrium ; for if any small deformation is produced in it, for any cause, the pressure tends to remove the deformation and restore the boiler to the form of a true cylinder. A flue, however, with the pressure on the outside, is in a state of unstable equilibrium, for the pressure tends to magnify all deformations and to cause the flue to depart more widely from the cylindrical form. In other words, pressure tends to keep the shell of a boiler in its strongest shape, and tends to force a flue into its weakest shape. Flues, therefore, are elements of weakness in a boiler, and it is particularly important that proper attention be paid to them.

The U. S. Treasury rules for finding the strength of lap-welded flues are as follows (see *Amended Steamboat Rules and Regulations* for 1891): If the diameter of the flue is not less than 7 inches, and not more than 16 inches, and the length not over 18 feet, multiply the thickness of the flue, in

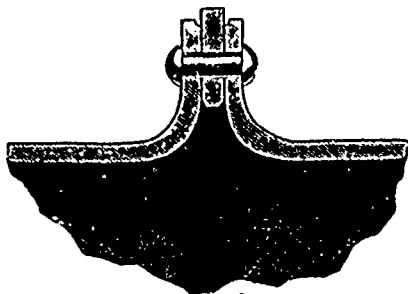


FIG. 1.—THE ADAMSON RING.

inches, by the constant number 4,400, and divide the product by the radius of the flue in inches. The quotient will be the pressure allowable. "For every foot or fraction thereof over 18 feet, deduct 3 pounds per square inch from the pressure allowable on an 18-foot flue ; or, add .01 of an inch to the thickness of material required for a flue 18 feet in length for every three feet or fraction thereof over 18 feet." The thickness of such a flue as is described above is to be determined by the following rule: Multiply the radius of flue in inches by the pressure per square inch that it is desired to carry, and divide the product by the constant number 4,400. The quotient is the required thickness, in inches. "The thickness of lap-welded flues, however, shall in no case be less than the diameter of the flue multiplied by .022."

It is further provided by the Treasury department that "Lap-welded flues 7 inches, and not over 16 inches in diameter, shall be made in lengths of not over three (3) feet and fitted one into the other and substantially riveted ; or in lieu thereof corrugated

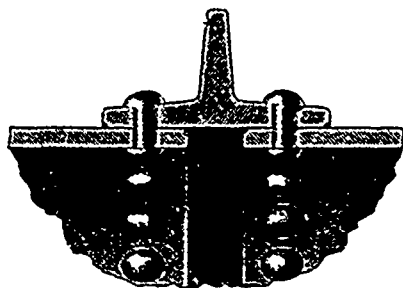


FIG. 2.—T-IRON RING.

to a depth of not less than three-fourths of an inch outwardly and at a distance of not over three feet between such corrugations : *Provided*, such corrugations are made without in any manner reducing the thickness of the material in the flue at the points of corrugation to less than the least thickness of the material in the body of the flue, or that such flues are made in sections of not over three (3) feet in length, and flanged to a width of not less than two (2) inches, and riveted substantially together with a wrought iron ring (see the cut of the Adamson ring), having a thickness of material of not less than the thickness of material in the flues, and a width of not less than two (2) inches riveted between such flanges."

Flues whose diameter is more than 16 inches and less than 40 inches are separately considered. Of such flues it is required that they "shall be made in lengths of not over three (3) feet, fitted one into the other and substantially riveted ; or flanged to a depth of not less than two (2) inches and riveted together with

a good substantial wrought-iron ring between each joint ; and no such ring shall have a thickness of less than half an inch nor a width of less than two (2) inches." The steam pressure allowable on such flues is to be determined by the same rule as that given above for the smaller flues, *except* that in the place of the constant number 4,400 that is given above, we must use the constant number 2,840.

In the *Amended Steamboat Rules and Regulations* for 1892 there appears the following modification for the rule given above as applying to lap-riveted flues not over 16 inches in diameter : "But when such flues are used under a pressure of over 60 pounds and less than 120 pounds to the square inch, they may be made in sections of not over 5 feet in length and connected in the manner prescribed for sections 3 feet in length, and all lap-welded flues and tubes using 120 pounds of steam, and under, shall have a thickness of material of not less than the standard thickness. The following shall be the standard thickness of lap-welded flues and tubes from 1 to 16 inches in diameter using steam under 120 pounds to the square inch :

Outside Diameter.	Thickness	Outside Diameter.	Thickness	Outside Diameter.	Thickness	Outside Diameter.	Thickness
1 in.	.072 in.	2 1/4 in.	.109 in.	5 in.	.148 in.	12 in.	.229 in.
1 1/4	.072	3	.109	6	.165	13	.238
1 1/2	.083	3 1/4	.120	7	.165	14	.248
1 3/4	.095	3 1/2	.120	8	.165	15	.259
2	.095	3 3/4	.120	9	.180	16	.270
2 1/4	.095	4	.134	10	.203		
2 1/2	.109	4 1/4	.134	11	.220		

Although the foregoing regulations of the Treasury department relate to lap-welded flues, they would doubtless be also applied to rolled flues when used in the marine service, notwithstanding the fact that the rolled flue is somewhat stronger, on account of its more perfectly cylindrical shape. Rolled flues are used in land boilers to some extent in this country, and very generally in England and other parts of Europe. Until recent years it was not found practicable to roll them in lengths of more than three feet or so, and where they were fitted together at the ends, and riveted, the double thickness of metal at the joint served as a sort of stiffening ring, and unless the pressure to be carried was high, engineers did not consider it necessary to provide additional rings for securing the necessary stiffness and resistance to collapse.

The method of joining the sections of the flues that is referred to in the Treasury rules above given is illustrated in Fig. 1, which shows what is technically known as the "Adamson ring," from its having been first introduced by Mr. Adamson, in 1851. The ends of the section are flanged outward, as shown, and are securely riveted together with a ring of wrought-iron or steel between. This ring, which should be not less than half an inch thick and not less than two inches wide, is caulked on the outer side of the joint, and if the flue is large enough to admit of it, it is also caulked on the inside, as indicated in the cut. One of the important features of this joint is that both the flanges and the rivets are entirely protected by water. There is also no thickening of the flue by overlapping pieces, so that the joint is not likely to burn out. Mr. Adamson has submitted these flanged joints to severe experimental tests, which they withstood remarkably well. The only serious objection that has been urged against them is, that in case one of the segments of the flue should burn out, either on account of scale or for any other reason, it could not be replaced without removing the head of the boiler. This objection does not seem to us to have any great weight, because in many cases the flue comes so close to the shell that it is almost impossible to do a satisfactory job of riveting or any kind of a joint, without removing the flue from the boiler ; and if there are projections of any sort upon it, it will be necessary, in removing the flue, to take out one of the heads.

Fig. 2 shows a method of uniting the parts of a built-up flue, which may be used with advantage in some cases, though we should prefer the Adamson joint shown in Fig. 1. Fig. 2 shows a ring of T-shaped wrought-iron which is preferably made in one piece and shrunk on the ends of the segments to be united ; though it may be made in halves, if necessary, the two parts being riveted firmly together when in position, by running straps along the web of the flange on both sides near the joint, and