E = Strength of plate between rivet holes in the second row, plus the crushing strength of butt strap in front of one rivet in the outer row.
= $(P-2d)tf+dbc$.

F = Crushing strength of plate in front of two rivets for double-riveted, of four rivets for triple-riveted, or of eight rivets for quadruple-riveted, plus the crushing strength of butt strap in front of one rivet for double-riveted, of one rivet for triple-riveted, or of three rivets for quadruple-riveted.
= $Ndtc+ndbc$.

G = Crushing strength of plate in front of two rivets for double-riveted, of four rivets for triple-riveted, or of eight rivets for quadruple-riveted, plus the shearing strength of one rivet in single shear for double-riveted, of one rivet in single shear for triple-riveted, or of three rivets in single shear for quadruple-riveted.
= $Ndtc+nsa$.

H = Strength† of plate between rivet holes in the third row, plus the shearing strength of two rivets in the second row in single shear and one rivet in single shear in the outer row.
= $(P-4d)tf+nsa$.

I = Strength† of plate between rivet holes in the third row, plus the crushing strength of butt strap in front of two rivets in the second row and one rivet in the outer row.
= $(P-4d)tf+ndbc$.

To obtain the joint efficiency, divide A, B, C, D, E, F, G, H or I, whichever is the least, by A.

The first step in the design of a riveted joint for a given thickness of plate is to assume a rivet diameter within the limits given in Table 8, and with this diameter, various values for the pitch of rivets, within the limits described below, should be tried out until that pitch which gives a maximum joint efficiency is obtained. Having determined the proper pitch for a given rivet diameter, the same process should be repeated using various rivet diameters until that combination of pitch and rivet diameter which will give the maximum efficiency, is obtained. A fairly broad range of rivet diameters may be used, the limits for a given plate thickness being shown in Table 8.

TABLE 3—TRIPLE RIVETED LAP JOINTS

Thickness of Plate	Diameter of Rivet Holes	Efficiency %	Pitch	A	B
3/8"	13/16"	75	3¼"	1¼"	2⅛"
7/16"	15/16"	75	3¾"	1 7/16"	2⅜"
½"	15/16"	75	3¾"	1 7/16"	2⅜"

Pitch of Rivets

The maximum pitch of rivets is controlled by the limits for caulking along the joint having shortest pitch (see Fig. 3). It is evident that if the pitch (or short pitch in the case of butt joints) is very great in proportion to the thickness of the plate or butt strap, there will be a tendency for the plates to spring apart between rivets. This maximum distance is one which is difficult if not impossible to determine analytically, but which has been found in practice to conform very closely to values given in Tables 1 to 6. In the case of lap joints, the maximum pitch for various combinations of plate thickness and rivet diameter is given in Table 7. For butt strap joints, the values for short pitch given in Tables 4 to 6 should not be exceeded except according to the following rules:—

Rule 1.—The short pitch *may* be increased by 1½ times any increase in rivet diameter plus 1½ times any increase in butt strap thickness.

Rule 2.—Should either the rivet diameter or butt strap thickness be decreased below the values given in Tables 4 to 6, the short pitch *must* be decreased by 1½ times the change in rivet diameter plus 1½ times the change in butt strap thickness.

The minimum pitch of rivets for either lap or butt strap joints can be obtained from Fig. 3 for various distances between gauge lines, and vice versa. The distances between gauge lines given in Fig. 7, while not rigidly adhered to in all cases, are based on the recommended minimum distance between rivets for good shop practice. To go below this minimum distance may mean the use of special rivet dies for driving the rivets, for quadruple or quintuple riveted butt joints, tance between gauge lines is usually made greater than the allowable minimum, for convenience in assembling and riveting the joints.

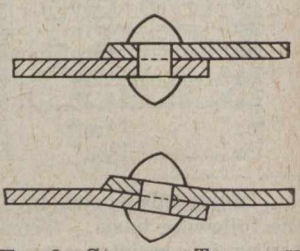

FIG. 6—SHOWING TENDENCY OF SINGLE-RIVETED LAP JOINT TO BUCKLE OR TWIST

On butt strap joints the dimension E is determined by adding to dimension C one-half the diameter of a standard rivet die for the particular size of rivet used, plus 1/16 in. for clearance.

Expressing this as a formula:—

$E = C+(\frac{1}{2}$diameter of rivet die$)+\frac{1}{16}$ in.

The dimension F between the first and second rows of rivets, for quadruple or quintuple riveted butt joints, should not be less than that given in Table 6, for given rivet diameters and butt strap thicknesses.

TABLE 4—DOUBLE RIVETED BUTT JOINTS*

Thickness of Plate	Thickness of Strap	Diameter of Rivet Hole	Efficiency %	Long Pitch	Short Pitch	A	B	C	E
¼"	¼"	1 1/16"	82.8	4"	2"	8½"	4¼"	1 1/16"	2⅛"
9/32"	¼"	1 1/16"	82.8	4"	2"	8½"	4¼"	1 1/16"	2⅛"
5/16"	9/32"	1 3/16"	81.9	4½"	2¼"	9⅞"	5"	1¼"	2 7/16"
11/32"	9/32"	1 3/16"	81.9	4½"	2¼"	9⅞"	5"	1¼"	2 7/16"
3/8"	5/16"	1 3/16"	81.9	4½"	2¼"	9⅞"	5"	1¼"	2 7/16"
13/32"	5/16"	1 3/16"	81.9	4½"	2¼"	9⅞"	5"	1¼"	2 7/16"
7/16"	3/8"	1 5/16"	81.3	5"	2½"	11¼"	5¾"	1 7/16"	2¾"
15/32"	3/8"	1 5/16"	81.3	5"	2½"	11¼"	5¾"	1 7/16"	2¾"
½"	7/16"	1 5/16"	81.3	5"	2½"	11¼"	5¾"	1 7/16"	2¾"

*All joints in above table fail by tearing the plate between rivet holes in the outer row. For convenience in driving rivets, the back-pitch (dimension E) may be increased if desired without affecting the joint efficiency, but it should not be decreased.

Thickness of Butt Strap

The thickness of butt strap should be chosen so that the net section along the inner row of rivets has sufficient area to take in tension the total force carried by the joint. The formula.

$$b = [P/2(P-nd)]te,$$

where n = number of rivets in distance P on inner row, will give the required thickness of each butt strap.

General Remarks

The dimensions for riveted joints given in Tables 1 to 6, both inclusive, are those recommended by the Hartford Steam Boiler Inspection & Insurance Co., and are computed upon the following basis:—

Tensile strength of plate = 55,000 lbs. per sq. in.

Resistance to crushing of plate = 95,000 lbs. per sq. in.

Strength of rivets in single shear = 44,000 lbs. per sq. in.

Strength of rivets in double shear = 88,000 lbs. per sq. in.

In cases where different stresses are used, the efficiency may vary accordingly, and should be computed for the new condition. The dimensions for pitch and spacing between rows of rivets are based on well-recognized standards and should be adhered to as closely as possible.

The formulæ for obtaining joint efficiency are based

†For quadruple-riveted and quintuple-riveted butt and double strap joints only.