Expansion joints of the slip-sleeve, diaphragm, or corrugated types made of copper, rubber, or other gasket material are all used for taking up expansion, but generally only for low pressures or where the inherent flexibility of the pipe cannot readily be used as in underground steam or hot water distribution lines.

Swivel joints are used extensively in low-pressure steam and hot water heating systems and in hot water supply lines. The swivel joints absorb the expansive movement of the pipe by the turning of threaded joints. In many cases the straight pipe in the offset of a swivel joint is sufficiently

TABLE 3. DIMENSIONS OF WELDED WROUGHT-IRON PIPE

Nominal Pipe Size	Outside Diameter	Nominal Wall Thicknesses for Schedule Numbers					
		Schedule 10	Schedule 20	Schedule 30	Schedule 40	Schedule 60	Schedule 80
⅛	0.405	.....	.....	.....	0.070*	.....	0.098*
¼	0.540	.....	.....	.....	0.090*	.....	0.122*
⅜	0.675	.....	.....	.....	0.093*	.....	0.129*
½	0.840	.....	.....	.....	0.111*	.....	0.151*
¾	1.050	.....	.....	.....	0.115*	.....	0.157*
1	1.315	.....	.....	.....	0.136*	.....	0.183*
1¼	1.660	.....	.....	.....	0.143*	.....	0.195*
1½	1.900	.....	.....	.....	0.148*	.....	0.204*
2	2.375	.....	.....	.....	0.158*	.....	0.223*
2½	2.875	.....	.....	.....	0.208*	.....	0.282*
3	3.5	.....	.....	.....	0.221*	.....	0.306*
3½	4.0	.....	.....	.....	0.231*	.....	0.325*
4	4.5	.....	.....	.....	0.242*	.....	0.344*
5	5.563	.....	.....	.....	0.263*	.....	0.383*
6	6.625	.....	.....	.....	0.286*	.....	0.441*
8	8.625	.....	.....	0.283*	0.329*	.....	0.510*
10	10.75	.....	.....	0.313*	0.372*	0.510*	0.606
12	12.75	.....	.....	0.336*	0.414	0.574	0.702
14 O. D.	14.0	0.250	0.312	0.375	0.437	0.625	0.750
16 O. D.	16.0	0.250	0.312	0.375	0.500	0.687	.....
18 O. D.	18.0	0.250	0.312	0.437	0.562	0.750	.....
20 O. D.	20.0	.....	0.375	0.500	0.562	.....	.....

All dimensions are given in inches.

The decimal thicknesses listed for the respective pipe sizes represent their nominal or average wall dimensions and include an allowance for mill tolerance of 12.5 per cent under the nominal thickness.

*Thicknesses marked with an asterisk in Schedules 30 and 40 are identical with thicknesses for *standard-weight* pipe in former lists; those in Schedules 60 and 80 are identical with thicknesses for *extra-strong* pipe in former lists.

The Schedule Numbers indicate approximate values of the expression 1000 x P/S.

flexible to take up the expansion without developing enough thrust to produce swiveling in the threaded joint. This is preferable since continued turning in the threaded joint may in time result in a leak, particularly when the pressure is high. The amount of elongation which a swivel joint can take up is controlled by the length of the swing piece employed and by the lateral displacement which is permissible in the long pipe runs.

Probably the most economical method of providing for expansion of piping in a long run is to take advantage of the directional changes which

must necessarily occur in the piping and proportion the offsets so that sufficient flexibility is secured. Ninety-degree bends with long, straight tangents in either a horizontal or a vertical plane are an excellent means for securing adequate flexibility with larger sizes of pipe. When flexibility cannot be obtained in this manner, it is necessary to make use of some type of expansion bend. The exact calculation of the size of expansion bends required to take up a given amount of thermal expansion is relatively complicated[1]. The following approximate method, however, has been found to give reasonably good results and is deemed to be sufficiently accurate for most heating work.

Fig. 1 shows several types of expansion bends commonly used for taking up thermal expansion. The amount of pipe, L, required in each of these bends may be computed from the following formula:

$$L = 6.16\sqrt{D\,\Delta} \qquad (2)$$

where

L = length of pipe, feet.
D = outside diameter of the pipe used, inches.
Δ = the amount of expansion to be taken up, inches.

This formula, based on the use of mild-steel pipe with wall thicknesses not heavier than extra-strong, assumes a maximum safe value of fiber

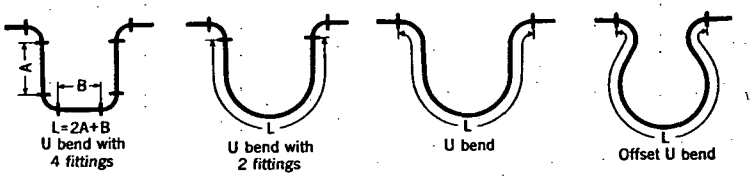

FIG. 1. MEASUREMENT OF L ON VARIOUS PIPE BENDS

stress of 16,000 lb per square inch. When square type bends are used, the width of the bend should not exceed about two times the height. It is further assumed that the corners are made with screwed or flanged elbows or with arcs of circles having radii five to six times the pipe diameter.

All risers must be anchored and safeguarded so that the difference in length when hot from the length when cold shall not disarrange the normal and orderly provisions for drainage of the branches.

It is especially necessary with light-weight radiators so to anchor the piping and so to give it freedom for expansion that no strain therefrom shall be allowed to distort the radiators. When expansion strains from the pipes are permitted to reach these light metal heaters they usually emit sounds of distress which are exceedingly troublesome.

[1]Piping Handbook, by Walker and Crocker, and A Manual for the Design of Piping for Flexibility by the Use of Graphs, by E. A. Wert, S. Smith, and E. T. Cope, published by *The Detroit Edison Company*.