The uncertain IA load should be considered as acting in both axial and lateral directions. The friction force and bellow deformation force at the IA are generally very small when the system is properly supported, making the forces from both sides of the IA balance each other. However, because the piping at both sides of the IA does not necessarily move in synch, EJMA recommends taking the friction force and bellow deformation force from one side only as the design load for the IA. The design specification shall give the specific design load for each specific situation. The intermediate anchor placed close to the bellow, such as the ones shown in Figs. 7.9 and 7.10, is not subject to friction force, which is absorbed by the main anchor or the IA located away from the bellow.

Figure 7.9(c) shows a branch connection with the bellow placed at the branch line, as well as at each of the through runs. The anchor is a main anchor due to the unbalanced pressure thrust force applied at the branch line.

Alignment guides. The guides required in expansion joint installations have to be effective in both up-and-down and horizontal lateral directions. It is popular to use catalog items, termed as alignment guides as shown in Fig. 7.11, for this purpose. However, it should be noted that the alignment guide as offered by the manufacturer's catalog is not capable of taking the weight load. Therefore, the alignment guides are installed in addition to the normal weight supports. The guides do not replace the weight supports. Some designers use a special support detail that combines the weight support with the guide function. In this case, the guide function should include both vertical and horizontal directions. For some liquid lines, the weight hold-down effect is enough to act as a guide in the vertical direction, thus only the horizontal direction guide needs to be added. This can be done by placing guide lugs against both sides of the sole plate of the support shoe, provided the support shoe is strong enough. However, hold-down stops are always recommended for expansion joint installations due to the difficulty of assessing the adequacy of the weight hold-down effect.

In-line pressure balanced expansion joint. From the above discussions, it is clear that an extensive anchor and guide system is required when using an expansion joint to accommodate axial movement. This can be very expensive or difficult to install in some cases. For instance, to provide a main anchor at piping located several stories high in the air would require beefing up of the entire structure from the ground level and up. Because the problem stems mainly from the pressure thrust force acting at the bellow, an expansion joint without this pressure thrust force will make the application much simpler. A joint without this pressure thrust force effect is called a pressure balanced joint. The one that works on axial deformation is called an in-line pressure balanced expansion joint. As shown in Fig. 7.12, the in-line pressure balanced joint uses an ingenious bellow and linkage arrangement, so the pressure thrust force at one bellow is canceled by that of another bellow. Figure 7.12(a) shows the basic arrangement.

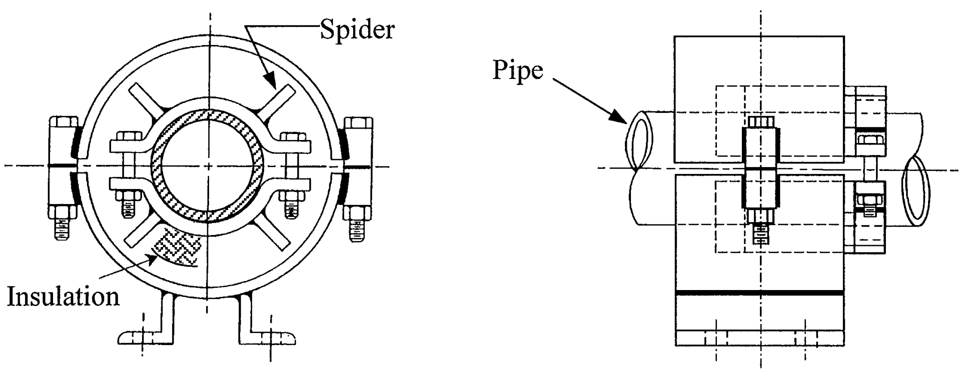

FIG. 7.11
ALIGNMENT GUIDE

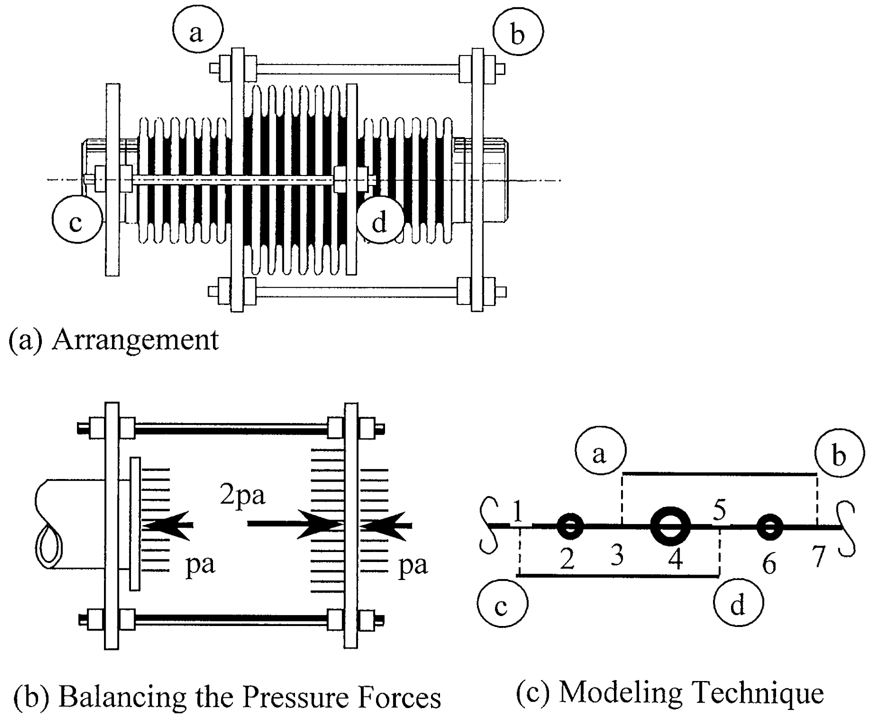

FIG. 7.12
IN-LINE PRESSURE BALANCED EXPANSION JOINT

In addition to the two basic bellows corresponding to the size of the pipe, a bigger bellow is placed in between these two. The larger bellow has twice the effective pressure thrust area of the basic bellow. The larger bellow is also called the balancing bellow. By interconnecting these bellows with linkages as shown in Fig. 7.12(b), the pipe at each end of the joint receives zero pressure thrust force. Each pipe end is subjected to two smaller pressure thrust forces (from the two basic bellows) that is balanced by one big pressure thrust force from the balancing bellow. Although the exact effective area of the bellow is not at all exact, a fairly good balance is achieved by fine-tuning the manufacturer's experimental data.

The in-line pressure balanced joint can be analyzed as one combined equivalent flexible joint with its axial spring rate equal to the sum of the spring rates of the three bellows. By squeezing the overall joint one unit length, it squeezes one unit length on each of the basic bellows, and extends one unit length from the large bellow. Therefore, the spring rate of the overall joint is the sum of the spring rates of the three individual bellows. This combined equivalent joint works well for pure axial movement, but does not offer any clue on lateral and rotational movements. To accommodate the small lateral and rotational movements expected on most joints, the in-line pressure balanced joint can be analyzed using the model shown in Fig. 7.12(c). The two basic bellows can be modeled as bellow elements or generic flexible joints at points 2 and 6. The large bellow is modeled likewise at point 4. The three joints are connected with spools of the main process pipe. The two sets of linkages can be simplified as single rods located at the centerline of the pipe. Linkage a-b is connected to points 3 and 7 at the pipe, whereas linkage c-d is connected to points 1 and 5 at the pipe. Pressure thrust forces are either specified explicitly or by giving the bellow effective diameters.

Corner pressure balanced expansion joint. To absorb axial movement, a pressure-balanced joint can be easily installed at the corner of a change of direction. Instead of using a large balancing bellow as in