tems are becoming increasingly numerous and design experiences reported are the present best guide.[16–23]

For residences and low pressure commercial systems, the values given in Table 5 may be used. As a general guide, design velocities in main ducts are frequently 1000 fpm in residences and 2000 fpm in commercial buildings. For the branch ducts and branch risers, design velocities are usually about two-thirds and one-half, respectively, of the main duct velocity.

DESIGN METHODS

In the design of air duct systems, three methods are employed: (1) *velocity reduction*, (2) *equal friction*, and (3) the *static regain*. The three methods and their refinements represent different design levels of accuracy and complexity, and they should be selected, therefore, to suit the application. Simple duct systems may be designed as quickly and easily as possible, but for large installations the system static-pressure requirement must be determined as precisely as possible, the most accurate method being recommended.

Velocity Reduction Method

This method consists of selecting the velocity at the fan discharge and designing for progressively lower velocities in the main at each branch duct. With the selected velocities and known air-flow rates, the various duct diameters are read directly from Figs. 2 or 3, and the equivalent rectangular sizes are obtained from Table 1. The pressure loss of the run having apparently the highest resistance is determined by adding the straight pipe, elbow, and transition losses; this total value represents the fan static pressure required for the supply-duct system. The return-air system is sized similarly, starting with the lowest velocities at the return intakes and increasing them progressively in the direction of the fan inlet. Dampers are relied upon for balancing the system.

A refinement is to size the several branch ducts to dissipate the pressure available at the entrance to each. The pressure loss of the duct work between the fan inlet and first branch take-off is subtracted from the now known fan static pressure to obtain the available pressure at each junction. By trial, a branch velocity is found that results in the branch pressure loss being equal to, or somewhat less than, that available. The procedure is repeated for each branch.

If the fan is specified so that the static pressure available for the duct work is known, the method consists of finding, by trial, the velocities in the main duct that will require a pressure loss equal to that available. The branch ducts are then sized as previously explained if such a refinement is deemed necessary.

The merits of the *velocity reduction* method are that (1) duct sizes are determined very easily; and (2) velocities can be limited to those known to be safe from causing noise problems. Its weaknesses are: (1) proper choice of velocities requires experience and judgment; and (2) the designer cannot always determine by inspection which run probably has the highest resistance.

Equal Friction Method

The principle of this method is to make the pressure loss per foot of length the same for the entire system. With this method little balancing is required for symmetrical layouts in which all runs have about the same

resistance. For layouts having both short and long runs, the shortest run will require considerable dampering.

Usual practice is to select the velocity in the main duct near the fan from the standpoint of noise for the particular application. Since the flow rate (cfm) is known, this establishes a value of friction loss per 100 ft of duct in Figs. 2 or 3. This same friction loss value is maintained throughout the design. For example, the flow rate in the main after the first branch take-off is reduced by that handled by the branch. Therefore, proceed vertically downward in Figs. 2 or 3 to the new flow rate value, and read the velocity and diameter. Note that the velocity is reduced by this procedure; a merit of this method is that it *automatically* reduces the duct velocities in the direction of flow, thereby insuring that noise will not be a problem. The equivalent rectangular size of any diameter is obtained from Table 1. By continuing the procedure, all sections, including branch ducts, are sized from Figs. 2 and 3 at the same friction loss per foot of actual length.

After sizing the system the pressure loss of the run having apparently the highest resistance is calculated. In so doing, the pressure losses of all elbows and transitions are included, and are expressed in terms of *equivalent length* of straight pipe.

The principal limitation of the *equal friction* method is that it does not differentiate between runs having several transitions, elbows, etc., and runs having none. Only the *actual length* of duct is considered; this and the flow rate fix the duct size. Moreover, when computing the system resistance, care must be exercised that the pressure losses of transitions, elbows, etc., are included and added to the straight pipe losses.

If the pressure available for the duct work is known, as it is for packaged equipment, this pressure can be divided by the total equivalent length of the run apparently having the highest resistance to obtain a design friction loss value per foot, for use with Fig. 2 or Fig. 3. Hence, for these applications, it is not necessary to select an initial velocity. However, the method then has the weakness that the resistances of fittings must be expressed in terms of *equivalent length*. Since transitions, elbows, etc., have predominantly dynamic losses, the equivalent length of a particular fitting varies considerably with its actual size. Note, for example, that the values for elbows in Fig. 7 of Chapter 19 and also that the elbow losses in Fig. 7 of this chapter are given in terms of the number of *diameters*. Hence, when the available pressure is known, the method requires that the duct size be estimated in advance. The calculated duct size should therefore be compared with the initial estimate, and if considerably different, a recalculation should be made using the calculated size.

Less dampering is required if the method is modified so that only the main duct is sized by the equal friction method. The fan is selected for this total duct resistance and the pressure available at each branch take-off is found in the manner described for the *velocity reduction* method. The pressure available at each branch is divided by its equivalent length, in hundreds of feet, to obtain a design friction loss value for use with Fig. 2 or Fig. 3 in conjunction with the branch flow rate. The branch ducts are therefore sized as nearly as possible to dissipate all of the available pressure.

When using this modified method, care should be exercised that the velocities in short branches do not become excessive from a noise standpoint. This is easily guarded against during the design process, because the velocity can be read directly from the friction chart. If it is excessive, move horizontally to the left on the chart and select a diameter which yields a reasonable velocity. The damper for this run will have to dissipate