velocities. Balancing is obtained by use of dampers. The method is illustrated in *Example 4*.

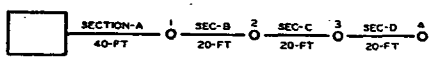

FIG. 10. DUCT LAYOUT FOR EXAMPLE 4

Example 4. (Velocity Reduction Method). A duct layout is shown in Fig. 10. The fan delivers 8000 cfm. Four outlets deliver 2000 cfm each. Find duct dimensions and total pressure loss.

Solution. Select velocity for Section A (2200 fpm) and reduce velocity arbitrarily along run. Find duct areas by using Equation 17. For selection of circular equivalents of rectangular ducts refer to Table 2, and for determination of friction loss in duct refer to Fig. 2 (See *Example 1*). Results are tabulated in Table 5.

TABLE 5. TABULATION OF RESULTS (EXAMPLE 4)

Section	Air Volume cfm	Velocity fpm	Area sq ft	Area sq in.	Duct Size in.	Diam in.	Frict per 100 ft in. H_2O	Frict Loss in. H_2O
A	8000	2200	3.64	524	26 x 20	24.8	0.25	0.10
B	6000	2000	3.00	432	22 x 20	22.9	0.23	0.05
C	4000	1800	2.22	320	20 x 16	19.5	0.24	0.05
D	2000	1600	1.25	180	12 x 16	15.1	0.24	0.05
							Total resistance,	0.25

2. Equal Friction Method

When the equal friction method of design is used, the duct system is designed for equal friction per foot of length. This prevents one section of the duct from having an excessive resistance compared with another. The usual procedure in this method is to select the main duct velocity to be consistent with good practice from a standpoint of noise for a particular type of building. This velocity should be less than the fan outlet velocity. All ducts are then sized for equal friction per unit length by the use of Figs. 1 or 2 and Table 2. The equal friction method has the advantage of automatically reducing the velocities in the various sections of the system, and also of allowing a quick check of the total duct resistance.

In cases where the fan or factory assembled air conditioning unit can operate against only a limited external resistance, it is necessary to divide the permissible total resistance by the total *equivalent* length of the longest or most complicated run of duct to determine the design resistance per 100 ft, and then to size all ducts at this resistance value. This will automatically determine the duct velocities and give the desired total duct resistance. A further refinement, which is sometimes used in large systems, is to size each branch duct so that it has a resistance equal to the resistance of the main system at the point of juncture. Even when this refinement is added, regulating dampers are recommended in each branch.

Example 5. (Equal Friction Method). A duct layout is shown in Fig. 11. The fan delivers 2500 cfm. Outlets No. 1 and 2 deliver 750 cfm each and outlet No. 3 delivers 1000 cfm. Trunk velocity is assumed as 1500 fpm; the area will be 1.67 sq ft (240 sq in.); and the size will be 20 x 12 in. Determine sizes of ducts for sections B, C, D and E and find the total pressure loss.

Solution. The equivalent round diameter of a 20 x 12 in. rectangular duct is 16.8 in. (from Table 2). Referring to Friction Chart, Fig. 2, a volume of 2500 cfm through

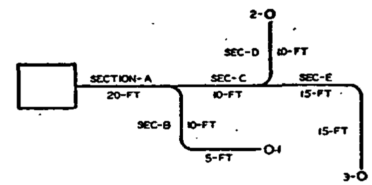

FIG. 11. DUCT LAYOUT FOR EXAMPLE 5

a 16.8 in. duct gives a resistance of 0.2 in. per 100 ft. The amount of air to be handled by each section is known, and the corresponding round duct sizes with equal pressure drop for these values can be located on the 0.2 in. friction line. The equivalent rectangular duct sizes are then selected from Table 2.

Results are tabulated in Table 6.

TABLE 6. TABULATION OF RESULTS (EXAMPLE 5)

Section	Air Volume cfm	Friction per 100 ft. in.	Diam. in.	Velocity fpm	Rectangular Duct in.	Friction per 100 ft. in.	Diam. in.	Velocity fpm	Rectangular Duct in.
A	2500	0.2	16.8	1620	20 x 12	0.2	17	1600	20 x 12
B	750	0.2	10.7	1190	10 x 9	0.286	10	1350	10 x 8
C	1750	0.2	14.8	1400	15 x 12	0.2	14.5	1450	15 x 12
D	750	0.2	10.7	1190	10 x 9	0.4	9.8	1350	10 x 8
E	1000	0.2	12	1300	10 x 12	0.2	12	1300	10 x 12

The total pressure loss in the longest run is the friction loss in Sections (A + C + E), plus the loss in one elbow and the loss through the outlet (3). The additional pressure loss in the elbow will be assumed as $\frac{L}{W} = 12$ (Fig. 5); thus, the additional equivalent length of duct is 10 ft, and the design loss will be 0.02 in.

Friction loss (A + C + E).. 0.12 (Duct length = 20 ft + 10 ft + 15 ft + 15 ft)
Elbow loss.................. 0.02
Loss through outlet....... 0.12

Total pressure loss in duct................. = 0.26 in.

The pressure required at the beginning of the main run is therefore 0.26 in. The fan selected for the duct system must not only deliver the required volume of air against this loss, but also against the losses in all air conditioning apparatus such as washers or spray chambers, heating or cooling coils and filters. The static head required of the fan for the usual air conditioning installation is between 1 and 1.5 in. of water. About one-third of this represents losses in the duct system. The losses in the air conditioning apparatus can be obtained from manufacturers' catalogs.

Resizing of Ducts

In order to equalize the pressure drop in the system, the following additional procedure is recommended:

Assume ΔH_1, ΔH_2, ΔH_3 to be the total pressure loss through ducts (1), (2) and (3); r_a, r_b, r_c, r_d, r_e the friction losses in the straight sections of the system; r_{be}, r_{de}, r_{ee} the elbow losses, and r_1, r_2, r_3 the loss through the outlets. Then,

$$\Delta H_1 = r_a + r_b + 2r_{be} + r_1$$
$$\Delta H_2 = r_a + r_c + r_d + r_{de} + r_2$$
$$\Delta H_3 = r_a + r_c + r_e + r_{ee} + r_3$$

If

$$\Delta H_1 = \Delta H_2 = \Delta H_3 = \Delta H$$
$$r_b + 2r_{be} = \Delta H - r_a - r_1$$
$$r_d + r_{de} = \Delta H - r_a - r_c - r_2$$