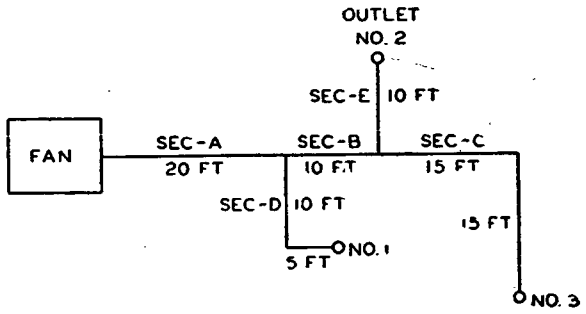


FIG. 11. DUCT LAYOUT FOR EXAMPLES

the excess pressure. Since duct work attenuates noise to some extent, the damper should be located as close to the main as possible. Sound treatment for this branch should also be considered. An alternative solution may be to revise the duct layout to increase the resistance of the run, for example, by relocating the branch take-off so that the total duct length is increased.

Example 5: (Equal Friction Method). A duct layout is shown in Fig. 11. Outlets Nos. 1 and 2 deliver 750 cfm each and outlet No. 3 delivers 1000 cfm. Selecting a velocity of 1600 cfm in Section A, size the duct system and determine its static pressure requirement.

Solution: The total cfm to be handled is 2500 cfm. From Fig. 3, with 2500 cfm and 1600 cfm velocity, read a diameter of 17 in. and a friction loss of 0.2 in. of water per 100 ft. By subtraction, the flow rate in Section B is 1750 cfm. Along the 0.2 friction line in Fig. 3, all of the ducts can be sized immediately because the flow rates are known. Results are presented in Table 6.

The rectangular equivalents were selected from Table 1 with the objective of having the same duct depth for all three branch runs.

The duct run to outlet No. 3 has the highest apparent resistance. It is decided to fabricate the elbow in Section C with a radius ratio of 1.2; hence, from Fig. 7 with $H/W = 1.9$, $L/W = 8$. Since $W = 1.25$ ft (15 in.), the additional equivalent length due to the elbow L is 10 ft. The total equivalent length of the run is therefore $(20 + 10 + 15 + 10 + 15) = 70$ ft. Therefore, at 0.2 per 100 ft the duct resistance is $0.2 \times 70 = 0.14$ in. of water. Adding to this the outlet pressure of 0.12 in., the static pressure requirement of the duct system is 0.26 in. of water. The design is now complete, and dampers will be relied upon for adjusting the outlets to the design flow rates.

If refinement is deemed necessary, the modified method can be applied to Sections D and E. First, the static pressures available at the junctions with the main of the Section D and E branch ducts are obtained. For Section D it is the system pressure of 0.26 minus the friction pressure loss in Section A. The latter is $0.20 \times (20/100) = 0.04$; hence, the pressure at the entrance of Section B is 0.22 in. of water. Deducting the outlet pressure loss of 0.12, that available for the duct work is 0.10. Assume

TABLE 6. TABULATION OF RESULTS (*Example 5*)

SECTION	FLOW RATE cfm	FRICTION PER 100 FT, IN. OF WATER	DUCT DIAM INCHES	VELOCITY fpm	RECTANGULAR DUCT INCHES
A	2500	0.2	17.0	1600	20 x 12
B	1750	0.2	14.8	1480	15 x 12
C	1000	0.2	12.0	1290	15 x 8
D	750	0.2	10.7	1190	12 x 8
E	750	0.2	10.7	1190	12 x 8

the equivalent lengths of the branch take-off and the elbow to be 10 ft each. The total equivalent length of Section D is then $(10 + 10 + 10 + 5) = 35$, and the friction loss per 100 ft required to dissipate 0.10 in. of water is $0.10 \times (100/35) = 0.29$. With this unit friction loss and a flow rate of 750 cfm, Fig. 2 yields a diameter of 10.0 in. and a velocity of 1380 fpm.

Section E is sized in a similar manner. The pressure available is 0.26 minus the friction loss in Sections A and B; hence, 0.20. With the outlet pressure loss of 0.12 deducted, the available duct-work pressure loss is 0.08 in. Assuming that the branch take-off loss is equivalent to 10 ft of duct, the total equivalent length is 20 ft. The required friction loss is $0.08 \times (100/20) = 0.40$. With this unit friction loss and a flow rate of 750 cfm, Fig. 2 yields a diameter of 9.4 in. and a velocity of 1580 fpm. An equivalent rectangular size is 9 × 8 in.

Comparing these results with those in Table 5, it is evident that the modified method has reduced the size of Section D somewhat and that of Section E considerably. The reduced sizes accomplish more economically what would otherwise have to be done with dampers.

Static Regain Method

Consider a straight run of duct with several branch take-offs attached. The flow rate of air along the run is progressively reduced by the amount diverted into each successive take-off. If, for example, the size of the run were the same throughout its length, the velocity would become progressively less in accordance with Equation 3. When velocities are reduced, a conversion of velocity pressure into static pressure occurs (as well as a loss in total pressure). The principle of the *static regain* method is to size a duct run so that the increase in static pressure (regain) at each take-off junction just offsets the pressure loss of the succeeding section of the run.

The method provides a convenient means of designing a long run of duct having several take-offs so that essentially the same static pressure exists at the entrance to each branch. If, instead of branch ducts, supply outlets are connected directly to the run, then essentially the same static pressure will exist behind each outlet. As a consequence, outlet selection and system balancing is simplified. The method is particularly suited to large installations having several long runs of duct, with each run having many take-offs or supply outlets attached. For this type of application, little or no dampering is ordinarily required to balance the system.

The initial velocity in the main duct is selected from noise and pressure loss considerations, and the branch ducts are sized by the modified equal friction method.

If the distance between branch take-offs is either very small or very great, it may not be feasible or economically desirable to design for the same static pressure at each junction. In such cases, the method can be used to size the main for either a progressively lower static pressure (net static pressure loss) or a progressively higher pressure (net static pressure gain).

If no friction or dynamic losses occurred at the junction, there would be no loss in total pressure, and the change in velocity pressure would be completely converted into a regain (rise) in static pressure, which for standard air would be:

$$P_t = \left(\frac{V_1}{4005}\right)^2 - \left(\frac{V_2}{4005}\right)^2 \qquad (12)$$

where

P_t = theoretical static pressure regain, inches of water.
V_1 = velocity in main upstream of branch, feet per minute.
V_2 = velocity in main downstream of branch, feet per minute.