The remaining ducts are proportioned so that the total pressure in each duct is the same as that calculated for the longest duct. The added resistance necessary in the shorter ducts is accomplished by increasing the velocity in these ducts. No duct should be less than 6 in. in diameter, nor should the velocity in any duct exceed approximately 1200 fpm. The final adjustment in a duct system may be made by employing dampers.

Instead of proportioning the ducts as outlined in the preceding paragraph it is more usual in practice to proportion all the ducts so that they have the same velocity as that used in the longest duct and to balance the system by employing dampers in the shorter ducts.

Return duct systems are designed making use of the same principles as those used in the design of supply duct systems. In this case the design may be based on the volume of air corresponding to the density of air existing in the return ducts, or in order to provide a factor for air leakage, it may be based on the same volume as used for the supply ducts.

11. Determine frictional resistance in:

a. Supply side of system as outlined in Item 10.

b. Return side of system as outlined in Item 10.

c. Furnace units, casing or hood, which is usually considered as equivalent to 0.03 to 0.10 in. of water.

d. Accessories such as washers or air filters, from manufacturer's data.

e. Inlet and outlet registers and grilles, from manufacturer's data.

f. Other accessory equipment such as cooling coils, from manufacturer's data.

The requirements in the Tentative Code for Testing Oil-Fired Fan-Furnace Units give static pressure loss requirements, *external* to the units as:

0 to 800 cfm = 0.12 in.
800 to 1600 cfm = 0.20 in.
1600 to 3000 cfm = 0.24 in.
3000 to 6000 cfm = 0.30 in.

Choose a fan which, according to its manufacturer's rating, is capable of delivering a volume of air, expressed in cubic feet per minute, against a frictional resistance, expressed in inches of water, computed by adding together the items listed in the preceding discussion. In practice it is recommended that liberal allowances should be made so that the fan will be capable of delivering air against pressures that may not have been foreseen during the design of the duct system.

12. Select a furnace capable of delivering heat at the register outlets equal to the total heat loss of the structure to be heated. Equation 5 may be used for coal burning furnaces:

$$G = \frac{H}{f \times p \times E_1 \times E_2 [1 + 0.02 (R - 20)]} \qquad (5)$$

where

G = required grate area, square feet.

H = total heat loss from building, Btu per hour.

f = calorific value of coal, Btu per pound.

p = combustion rate, pounds of fuel per square foot of grate per hour.

E_1 = furnace efficiency based on heat available at bonnet.

E_2 = efficiency of transmission based on ratio of heat delivered at register to heat available at bonnet.

R = ratio of heating surface to grate area.

Equation 5 is not applicable to ratios less than 15 to 1. Higher ratios as a rule provide lower flue gas temperatures and higher efficiencies. In practice it is customary to use

TABLE 3. APPROXIMATE DESIGN VELOCITIES THROUGH DUCTS AND REGISTERS

DESCRIPTION	LOW VELOCITY SYSTEM (FPM)	MEDIUM VELOCITY SYSTEM (FPM)	HIGH VELOCITY SYSTEM (FPM)
Main ducts	500	750	1000
Branch ducts	450	600	750
Wall stacks	350	500	600
Baseboard registers (max.)	300	350	400
Wall registers above 5 ft (min.)	500	550	600

these constants: f = 12,000 (for specific values, see Table 5, Chapter 8); p = 7.5 lb; E_1 = 0.65 (lower efficiency must be used with highly volatile solid fuel); and E_2 = 0.85.

The foregoing procedure for determining the size of the furnace to be used applies to continuously heated buildings.

13. Although intermittently heated buildings usually have their heat losses computed according to the standard rules for determining such losses, these rules do not take into account the heat which will be absorbed by the cold material of the building after the air is raised in temperature. This heat absorption must be added to the normal heat loss of the building to determine the load which the heating plant must carry through the warming-up process. It is customary to increase the normal heat loss figure by from 50 to 150 per cent depending upon the heat capacity of the construction material, the higher percentage applying to materials of high heat capacity such as concrete and brick.

14. Follow the same methods for an oil furnace as for coal where a conversion unit is to be used, making sure that the ratio of heating surface to grate area exceeds 20 to 1. If it does not, a size larger furnace should be selected. Use the manufacturer's Btu ratings of furnaces designed for exclusive use with oil.

15. The selection of the proper size gas furnace for a constantly heated building can be easily made by using Equation 6:

$$R = \frac{H}{0.85} \qquad (6)$$

where

H = total heat loss from building, Btu per hour.

R = output rating of the furnace, Btu per hour.

In the case of converted warm air furnaces a slightly different procedure is necessary, as the Btu input to the conversion burner must be selected rather than the furnace output. The proper sizing may be done by means of Equation 7:

$$I = 1.68\,H \qquad (7)$$

where

I = Btu per hour input.

The factor 1.68 is the multiplier necessary to care for a 15 per cent heat loss in the distributing ducts and an efficiency of 70 per cent in the conversion burner.

16. Specify location and type of all dampers in both supply air and return air sides of system. Specify controls including location of all thermostats. Arrange for proper control of humidifying equipment.

HEAVY DUTY FAN FURNACES

Fan furnaces for large commercial and industrial buildings, churches, schools, etc., are available in sizes ranging from 400,000 to 3,000,000 Btu