pressure of 0.20 in. water external to the furnace. This available pressure is usually distributed on the basis of three-fourths (0.15 in. water) on the supply side and one-fourth (0.05 in. water) on the return side. Other systems, such as perimeter crawl-space plenum systems, may be designed by procedures outlined in Manual 4. In addition, procedures for designing 4-in. diameter duct systems are contained[7] in Manual 10 of the *National Warm Air Heating and Air Conditioning Association.*

Other systems of a proprietary nature but utilizing the perimeter concept of diffuser placement are in common use. These systems should be designed and installed in strict accordance with the manufacturer's recommendations. Such systems usually utilize smaller ducts (4 in. or less) and higher pressures (above 0.20 in. water). They also may require special streamlined, low resistance fittings and special diffusers. Some systems also employ higher bonnet temperatures. When either higher bonnet pressures or temperatures, or both, are to be used, care must be taken to ascertain that the furnace employed is capable of meeting the required conditions.

INSIDE WALL DELIVERY SYSTEMS

The concept of warm-air perimeter heating is relatively new. The older methods of introducing warm air into spaces use other outlet locations. One of the most common of these has been using register locations on a warm or inside wall. For such systems, the combinations of parts selected as standard by the *National Warm Air Heating and Air Conditioning Association* are shown in Tables 8 and 9.

A simplified method for selecting the combinations of branches, boots, stacks, and registers, is given[4] in Manual 7 of the *National Warm Air Heating and Air Conditioning Association.* In this method, the sizes of the branch ducts are obtained from two tables giving their Btu capacities. The proper combination of parts for each branch can be determined if the following information is available.

1. Location of room, that is, whether on first or second story.
2. Actual horizontal length of duct from bonnet to boot, in feet.
3. Btu loss from room to be heated.
4. Equivalent lengths in feet of all fittings and of the register. Fig. 7 shows the values of equivalent lengths of fittings commonly used for domestic systems.

This simplified method is applicable to structures having heat losses not in excess of approximately 120,000 Btu per hour. The capacities shown in Tables 8 and 9 are based upon the most reliable data pertaining to friction losses and temperature drops in ducts. They are also based upon a 100 deg temperature rise of the air, and a static pressure available for overcoming friction losses in the external duct system alone of 0.20 in. of water. The use of this method requires that the fan in the fan-furnace assembly will be capable not only of overcoming the resistance of the external duct system alone, but also the resistances imposed by the blower inlet, the filter, and the furnace casing.

Tables 8 and 9 are applicable for the selection of both warm air and return air branches. A depth of 8 in. has been adopted as the standard for trunk ducts, and where a branch joins the trunk the required increase shown in the last line of Table 8 or Table 9 refers to an 8-in. trunk duct.

Where two branches form a trunk the longer branch is considered to be the trunk and its equivalent width (for 8-in. depth) is increased as required.

DESIGN PROCEDURE FOR LARGE SYSTEMS[8]

For buildings having a heat loss in excess of 120,000 Btu per hour, the design procedure[9] given in Manual 9 of the *NWAH & ACA*, may be used. Work sheets 9a, 9b, and 9c are available to simplify calculations.[8] The procedure consists of:

1. Calculation of design heat losses from individual spaces in the structure. The calculation of these losses is explained in Chapter 12.

2. Location of registers and return intakes on floor plan, showing types of registers, with distance from register to opposite wall and deflection of registers desired.

3. Laying out a proposed duct system for both warm air and return air sides of the system, and including details of types of fittings and the actual and equivalent lengths of each branch line from bonnet to register, without sizes. (See Fig. 7, Groups 1 through 6, for equivalent length of fittings.)

4. Determination of bonnet temperature.

If the rating sheet for a furnace-blower unit specifies a *fixed value of bonnet temperature*, find this temperature in the left-hand column of Table 10. If not specified, use the following procedure: Use Table 10 for buildings having a heat loss between 120,000 and 350,000 Btu per hr, or Table 11 for buildings having a heat loss greater than 350,000 Btu per hr. Select *shortest actual length*, including vertical risers and read downward in nearest column in Tables 10 or 11 until lower heavy diagonal line is reached, but do not cross line. Run horizontally to first column of table and note *bonnet temperature*. Also select *longest actual length* including vertical risers, and read downward in nearest column in Tables 10 or 11 until upper heavy diagonal line is just crossed. Run horizontally to left to obtain value for *bonnet temperature* in first column. Select as the design bonnet temperature any value between these two limits.

5. Determination of air volume to be delivered through each register and the respective register air temperatures.

Using Tables 10 or 11 and the design bonnet temperature selected, find the values of cfm per 1000 Btu for each duct length, and the corresponding register temperature.

6. Selection of register sizes and pressure losses to produce necessary throw, for the air volumes handled.

Use Tables 12 or 13 to obtain required free area and pressure loss of register.

7. Design of duct system.
   - A. *Warm air branches.*
     - a. Use Table 14 to select maximum bonnet pressure *usually* required for the trunk carrying the maximum volume of air (cfm). If the maximum bonnet pressure is not high enough to accommodate the pressure loss through the registers, use a higher bonnet pressure. If the register pressure is critically large, it may be necessary to reduce it by either using two registers in place of one, or using smaller deflection angles.
     - b. Obtain actual duct loss by subtracting total register pressure loss, as determined from Tables 12 or 13, from maximum bonnet pressure.
     - c. Obtain the pressure drop in each duct per 100 ft by use of Table 15.
     - d. Determine duct size by means of air friction chart (such as Fig. 1, or Fig. 2, Chapter 31), volume (cfm), and pressure drop per 100 ft of duct.
   - B. *Return air branches.*
     - a. Select a low value of actual duct loss obtained from step b under item A for the suction loss of return duct system.
     - b. Proceed in sizing return air branches by the same method described for the warm air branches.
   - C. *Trunk ducts for warm air and return air sides of system.*
     - a. Add air volumes of branches to be handled by each trunk duct.
     - b. The friction loss per 100 ft of trunk duct is determined by taking the smaller of the two values for friction loss for the two ducts meeting at the junction.
     - c. Determine trunk duct size by using an air friction chart, volume (cfm), and pressure drop per 100 ft of trunk duct.