Substitute in Equation 15. $Q = 2900$ cfm, from solution of Question 5; $\Delta_t = 116 + 4 - 70 = 50$ F; $h_{fg} = 968$ Btu, from steam table in Chapter 1.

$$W = \frac{60\,dQ \times 0.24 \times \Delta t}{h_{fg}} = \frac{60 \times 0.07495 \times 2900 \times 0.24 \times 50}{968} = 161.8 \text{ lb per hour.}$$

**7 ● The same rooms are converted to chemical laboratories, requiring the introduction of 12 changes of outside air, measured at 70 F, per hour to permit the exhaust fans connected to the chemical hoods to maintain only a slight negative pressure in the rooms. At what temperature must the air enter the rooms to maintain 70 F with 0 F outside?**

Substitute in Equation 2. $H = 110{,}100 + 34{,}200 = 144{,}300$ Btu per hour; $Q = \frac{12}{60} \times 27{,}000 = 5400$ cfm; $t = 70$ F; $t_y = \frac{H}{60\,dQ \times 0.24} + t = \frac{144{,}300}{60 \times 0.07495 \times 5400 \times 0.24} + 70 = 94.7$ F.

**8 ● In the preceding question, if the air drops 2 F between the heater and the rooms, how many pounds of steam per hour at 1-lb gage will the heating system condense?**

Substitute in Equation 15. $Q = 5400$ cfm; $\Delta_t = 94.7 + 2 = 96.7$ F, from solution of Question 7; $h_{fg} = 968$ Btu, from steam table in Chapter 1.

$$W = \frac{60\,dQ \times 0.24 \times \Delta t}{h_{fg}} = \frac{60 \times 0.07495 \times 5400 \times 0.24 \times 96.7}{968} = 583 \text{ lb per hour.}$$

**9 ● The combination hot blast heating and ventilating system for the dining rooms of a hotel is to heat the rooms to 70 F with 0 F outside, and permit the exhaust fan from the adjoining kitchen to draw 5000 cfm from the dining rooms. The transmission losses from the dining rooms total 240,000 Btu per hour. The infiltration into the dining rooms amounts to 1000 cfm from outdoors and 1000 cfm from heater rooms. How many cubic feet per minute, measured at 70 F, must be supplied the dining rooms if the air enters at 112 F?**

First find the infiltration loss by substituting in Equation 1.

$t = 70$ F; $t_o = 0$; $M_o = d \times Q = 0.07495 \times 60 \times 1000 = 4497$ lb per hour. In this case $d$ and $Q$ are figured at 70 F. $H_o = 0.24\,(t - t_o)\,M_o = 0.24\,(70 - 0) \times 4497 = 75{,}550$ Btu per hour.

Next by substituting in Equation 3, find the cubic feet per hour to be circulated. $H$ = sum of transmission and infiltration losses in room $= 240{,}000 + 75{,}550 = 315{,}550$ Btu per hour; $t_y = 112$ F; $t = 70$ F;

$$Q = \frac{H}{60\,d \times 0.24\,(t_y - t)} = \frac{315{,}500}{60 \times 0.07495 \times 0.24\,(112 - 70)} = 6950 \text{ cfm.}$$

**10 ● In Question 9, 3000 cfm of outside air will be drawn in by the supply fan and 3950 cfm will be recirculated. What will be the output of the heating sections in Btu per hour if there is a loss of 2 F between the heaters and the room?**

The average temperature of the mixture of outdoor and recirculated air entering the heater $= \frac{3000 \times 0 + 3950 \times 70}{6950} = 39.8$ F. Air leaves the heater at $112 + 2 = 114$ F.

Referring to Equation 15, $W \times h_{fg}$ = amount of heat required per hour $= 60\,dQ \times 0.24 \times \Delta t = H$. $Q = 6950$ cfm; $\Delta_t = 114 - 39.8 = 74.2$ F. $H = 60 \times 0.07495 \times 6950 \times 0.24 \times 74.2 = 557{,}000$ Btu per hour.



Chapter 23

# MECHANICAL WARM AIR FURNACE SYSTEMS

*Fan Furnaces, Fans and Motors, Elimination of Noise, Air Washers and Filters, Cooling Methods, Duct Design, Controls, Selecting the Furnace, Selecting the Fan, Humidity, Provision for Cooling System, Heavy Duty Fan Furnaces*

MECHANICAL warm air or fan furnace heating systems, which are a special type of central fan systems, are particularly adapted to residences, small office buildings, stores, banks, schools, and churches. Circulation of air is effected by motor-driven fans instead of by the difference in weight between the heated air leaving the top of the casing and the cooled air entering its bottom, as in gravity systems described in Chapter 24. The advantages of mechanical systems, as compared with gravity systems are:

1. The furnace can be installed in a corner of the basement, leaving more basement room available for other purposes.
2. Basement distribution piping can be made smaller and can be so installed as to give full head room in all parts of the average basement, or be completely concealed from view except in the furnace room.
3. Circulation of air is positive, and in a properly designed system can be balanced in such a way as to give a greater uniformity of temperature distribution.
4. Humidity control is more readily attained.
5. The air may be cleaned by air washers or filters, or both.
6. Some cooling effect in summer will result from the installation of a properly designed system.
7. The fan and duct equipment may be utilized for a complete cooling and dehumidifying system for summer, using either ice, mechanical refrigeration, or low temperature water for cooling and dehumidifying, or adsorbers for dehumidifying.
8. The use of the fan increases the volume of air which can be handled, thereby increasing the rate of heat extraction from a given amount of heating surface and insuring sufficient air volume to obtain proper distribution in a large room.

Much of the equipment used in central fan systems is the subject matter of other chapters. It is the purpose of this chapter to discuss the coordinated design and to deal in detail only with problems not covered elsewhere which refer particularly to the whole problem of fan warm air furnace heating and air conditioning.

## FAN FURNACES

Furnaces for mechanical warm air systems may be made of cast-iron, steel, or alloy. Cast-iron furnaces are usually made in sections and must be assembled and cemented or bolted together on the job. Steel furnaces are made with welded or riveted seams. The proper design of the furnace