3500 Btu per square foot. A higher rate of heat emission tends to increase the heat loss up the chimney, and raise fuel consumption, to shorten the life of the furnace, and to overheat the air. The ratio of heating surface to grate area on furnaces for this type of work should never be less than 30 to 1 and as indicated previously may run as high as 50 to 1.

Control of temperature is secured through (1) controlling the quantity of heated air entering the room, (2) using mixing dampers, or (3) regulating the fuel supply.

The design of heavy duty fan furnace heating systems is in many respects similar to that of the central fan heating systems described in Chapter 22. Ducts are designed by the method outlined in Chapter 20.

PROBLEMS IN PRACTICE

1 ● A residence furnace, having a ratio of heating surface to grate area in excess of 20 to 1, is to be selected to heat a house which has a computed load of 225,000 Btu per hour. If coal having a calorific value of 13,000 Btu per lb is to be burned, if the furnace will burn 8 lb of coal per square foot of grate per hour, and if the furnace efficiency is 60 per cent, determine the square feet of grate area necessary in the furnace to be selected.

Substituting in Equation 1:

$$G = \frac{225,000}{13,000 \times 0.60 \times 8} = 3.6 \text{ sq ft of grate area.}$$

A furnace having at least 3.6 sq ft of grate area should therefore be selected.

2 ● Why should secondary surface be designed for easy cleaning?

If the combustion is not perfect, soot is formed immediately above the fire and is apt to form a deposit on the secondary surface from which it should be removed. If the secondary surface is so designed that there are horizontal passages, fine gray ash will settle out in these to form an insulation between the hot gases of combustion and the metal of the furnace; consequently, these should be readily cleaned. If the passages are vertical they are largely self-cleaning of ash, but provision should be made for easy and thorough cleaning of the collection chamber below them.

3 ● Why is baffling inside the casing necessary on fan systems?

Because the movement of air is independent of its temperature, air must be guided by baffles of one form or another to bring it in contact with the hot surfaces so it will not pass through the casing unheated. On the other hand, if the air is held against a hot surface too long it might become overheated, for the average register temperature on a fan system should not exceed 120 F.

4 ● What practical points should be observed in designing a fan system in order to eliminate noise?

a. Use a large fan so it can be run at slow speed.

b. Set the fan and motor on a solid foundation.

c. Insulate the fan and motor from the foundation with rubber, cork, or other springy material according to the principles given in Chapter 18, provided, of course, that such insulation is of value.

d. See that the air velocity is not too high in the ducts. Properly designed splitters in the elbows will avoid high velocities at the turns in cases where the velocity through the ducts themselves is not too high.

e. Use canvas connections between the ducts and any running equipment.

f. Be sure the ducts have a relatively smooth interior and are rigid.

Chapter 24

GRAVITY WARM AIR FURNACE SYSTEMS

Procedure for Design, Estimating Heating Requirements, Sizes of Leader Pipes, Proportioning Wall Stacks, Register Sizes, Recirculating Ducts and Grilles, Return Connection to Furnace, Furnace Capacity, Examples, Booster Fans

WARM air heating systems of the gravity type are described in this chapter[1], and those of the mechanical type are described in Chapter 23. In the gravity type, the motive head producing flow depends upon the difference in weight between the heated air leaving the top of the casing and the cooled air entering the bottom of the casing, while in the mechanical type a fan may supply all or part of the motive head. Booster fans are often used in conjunction with gravity-designed systems to increase air circulation.

In general, a warm-air furnace heating plant consists of a fuel-burning furnace or heater, enclosed in a casing of sheet metal or brick, which is placed in the basement of the building. The heated air, taken from the top or sides near the top of the furnace casing, is distributed to the various rooms of the building through sheet metal warm-air pipes. The warm-air pipes in the basement are known as leaders, and the vertical warm-air pipes which are run in the inside partitions of the building are called stacks. The heated air is finally discharged into the rooms through registers which are set in register boxes placed either in the floor or in the side wall, usually at or near the baseboard.

The air supply to the furnace may be taken (1) entirely from inside the building through one or more recirculating ducts, (2) entirely from outside the building, in which case no air is recirculated, or (3) through a combination of the inside and the outside air supply systems.

PROCEDURE FOR DESIGN

The design of a furnace heating system involves the determination of the following items:

1. Heat loss in Btu from each room in the building.
2. Area and diameter in inches of warm-air pipes in basement (known as leaders).
3. Area and dimensions in inches of vertical pipes (known as wall stacks).
4. Free and gross area and dimensions in inches of warm-air registers.
5. Area and dimensions of recirculating or outside air ducts, in inches.
6. Free and gross area and dimensions in inches of recirculating registers.

[1]All figures and much of the engineering data which follow are from *Bulletins No.* 141, 188 and 189, Warm Air Furnaces and Heating Systems, Part II, by Professor A. C. Willard, A. P. Kratz, and V. S. Day, Engineering Experiment Station, University of Illinois.