4. The heat lag of the building complicates the estimation of the cooling load under any specified conditions and makes such estimates, based on the usual methods of computation, of doubtful value.

5. The seasonal cooling requirements are extremely variable from year to year, and the ratio between the degree-hours of any two seasons occurring within a 10-year period may be as high as 7.5 to 1. Hence an average value of the degree-hours cooling per season is comparatively meaningless.

6. The duct system in a forced-air heating installation can be successfully converted to a system for conveying cool air for the purpose of cooling the structure. No condensation of moisture was observed when the duct temperatures were not less than 65 F.

7. Cooling by means of water at a temperature of 60 F is not satisfactory unless an indoor temperature of less than 80 F is maintained.

8. In the selection of cooling coils, the additional frictional resistance of the coil to flow of air must be given consideration.

9. Cooling the structure by introducing large quantities of air from outdoors at night tended to reduce the amount of cooling required on the following day and was a practical means of providing more comfortable conditions in those homes where cooling systems were not available.

METHOD OF DESIGNING COOLING SYSTEM

The general procedure which may be used for the design of a summer cooling system in a forced-air installation is:

1. Calculate heat gain for each room or space to be conditioned. (See Chapters 6 and 15.) Allowance for addition of outside air must be included in this calculation.
2. Select a temperature of air leaving supply inlets. In Research Residence tests a value of from 65 to 70 F was found satisfactory.
3. Determine indoor conditions to be maintained. In Research Residence 80 F dry-bulb and 45 per cent relative humidity were found satisfactory.
4. Determine the quantity of air to be introduced into each room. (See Chapter 43.)
5. Estimate heat loss in duct system between cooling unit and supply registers.
6. Calculate the sensible and latent heat to be removed by the cooling unit.
7. Determine size of ducts in duct system and size of registers, as explained in Chapters 40 and 41.
8. Determine pressure loss in duct system and select fan as also explained in the same section.
9. Select cooling unit from manufacturer's data. Specify temperature and pressure of available cooling water, voltage and characteristics of electrical supply, and method of control of apparatus.
10. Select cooling coils from manufacturer's data to take care of latent heat load and to give required drop in air temperature with the weight of air flowing. (See Chapter 7.)
11. If system is to be used for both winter heating and summer cooling, duct sizes must be checked to insure that velocities and friction losses are reasonable for both conditions of operation. Adjustable dampers will be necessary to make changes in air distribution for the two seasons. Provision must also be made for changing fan speeds for summer and winter operation.

REFERENCES

[1]—Specifications for the furnace unit and the installed duct system are shown in The Yardstick (Textbook Section 8) and the Code and Manual (Textbook Section 7) published by *National Warm Air Heating and Air Conditioning Association.*

[2]—Performance of a Forced Warm-Air Heating System as Affected by Changes in Volume and Temperature of Air Recirculated, by A. P. Kratz and S. Konzo (A.S.H.V.E. TRANSACTIONS, Vol. 48, 1942, p. 393).

[3]—Automatic Controls for Forced-Air Heating Systems, by S. Konzo and A. F. Hubbard (A.S.H.V.E. TRANSACTIONS, Vol. 40, 1934, p. 37).

[4]—Summer Cooling in the Research Residence, by A. P. Kratz, S. Konzo, M. K. Fahnestock and E. L. Broderick (University of Illinois *Engineering Experiment Station Bulletins* Nos. 290, 305 and 321). A.S.H.V.E RESEARCH REPORT No. 1177—Summer Cooling in the Research Residence with a Gas-Fired Dehydration Cooling Unit, by A. P. Kratz, S. Konzo and E. L. Broderick (A.S.H.V.E. TRANSACTIONS, Vol. 47, 1941, p. 203).

CHAPTER 23

Steam Heating Systems and Piping

Classification, Piping for Steam Heating Systems, Steam Flow, Pipe Sizes, Indirect Heating Units, Types of Heating Systems, High Pressure Steam Systems, Boiler Connections, Condensation Return Pumps, Vacuum Pumps, Traps, Control Valves, Connections to Heating Units

STEAM heating systems may be classified according to any one of or combination of the following features: (1) the piping arrangement, (2) the method of returning the condensation to the boiler, (3) the accessories used, (4) the method of expelling or removing the air from the system, (5) the type of control used, and (6) the pressure or vacuum conditions obtained in operation.

In all heating systems, the condensation is returned to the boiler either by gravity or by mechanical means. In *gravity systems* the condensate is returned by gravity due to the static head of water in the return pipes or mains. The elevation of the boiler water line must be sufficiently below the lowest heating unit, steam pipe or dry return pipe to permit the return by gravity. The *water line difference* forming the *static head* must be sufficient to overcome the maximum pressure drop in the system, including the pressure drop due to the condensing effect of the radiation. When radiator and drip traps are used, as in two-pipe vapor systems, the static head must also exceed the operating pressure of the boiler. The pressure drop caused by condensing rate of the radiation is especially important during those portions of the operating periods, when changing pressure conditions prevail, as for example, when the system is being initially filled with steam. In systems where the condensate is wasted to the sewer, no water line difference is required. However, the waste of condensate may introduce conditions which warrant the use of an appropriate mechanical return system. Whenever the conditions of a heating system are such that the condensate cannot gravitate to the boiler, it must be returned by some mechanical means.

In *mechanical systems* the condensate flows to a receiver by gravity and is then forced into the boiler against its pressure. In all instances the preferable practice is to provide for gravity flow even when a vacuum pump is used. The lowest parts of the supply side of the system must be kept sufficiently above the water line of the receiver to insure adequate drainage of water from the system.

There are three general types of mechanical return devices in common use, namely, (1) the mechanical return trap, (2) the condensation return pump, and (3) the vacuum return line pump.

PIPING FOR STEAM HEATING SYSTEMS

The functions of the piping system are the distribution of the steam, the return of the condensate and, in systems where no local air vents are provided, the removal of the air. The distribution of the steam should be rapid, uniform and without noise, and the release of air should be facilitated as much as possible, as an air bound system will not heat readily nor properly. In designing the piping arrangement it is desirable to maintain equivalent resistances in the supply and return piping to and