8. To provide for humidity control.
9. To provide a means of summer control of cooling.
10. To protect against failure of ignition.

Controls which are considered desirable for this system are:

1. A *thermostat* located in a living room where maximum fluctuation in temperature can be expected, in order to secure frequent operation of fans, drafts, and burners. The thermostat location should not be on an outside wall, in a bed room, bath room or sun room, or in a location where it will be affected by direct radiant heat from the sun or from a fireplace, or by direct heat from any warm air duct, register or chimney.

2. A thermostatic blower low-high limit control located in the bonnet to permit blower operation only between the temperatures of 100 F and 150 F. In certain extreme cases it may be necessary, or weather conditions may make it advisable, to adjust the high limit to a higher temperature than that stated.

3. A *protective high limit control* located in the bonnet to stop the system independently of the thermostat if the bonnet temperature exceeds 200 F.

4. On oil and gas burner installations, a protective control should be included which will stop the system if the fire is extinguished or if there is a failure of the ignition system.

5. On automatic stoker installations, a control is usually included which will start the operation regardless of thermostat settings whenever the bonnet temperature indicates that the fire is dying, or a time interval contactor is used that will start the stoker to run a predetermined length of time at predetermined intervals.

6. A *humidistat* to regulate the moisture supplied to the rooms, located either in one of the rooms or in the main return duct near the furnace.

7. A *windowstat* to reduce the humidity as the outdoor temperature drops.

METHOD OF DESIGNING FORCED-AIR HEATING SYSTEMS[6]

1. Determine heat loss from each room in Btu per hour. (See Chapter 6.)

2. Locate warm air registers and return registers on plans of house, beginning with the upper story rooms.

3. Sketch in duct layout to connect all registers and grilles with the central unit.

4. Determine equivalent length of duct for each register, allowing at least 10 diameters of straight pipe as equivalent to each 90 deg elbow having an inner radius not less than the diameter of the round pipe or the depth of the rectangular pipe.

5. Select a value for temperature of the air at the furnace bonnet. It is customary to use some value between 145 to 165 F. Use lower value if larger number of air recirculations is desired. The number of air recirculations should range from three to eight per hour.

TABLE 2. FACTORS CORRESPONDING TO REGISTER TEMPERATURE FOR EQUATION 2

Register Temperature Deg F	Factor
110	0.0221
120	0.0184
130	0.0158
140	0.0140
150	0.0125
160	0.0114
170	0.0105

[6]Technical Code, Second Edition, January 1, 1939, published by the *National Warm Air Heating and Air Conditioning Association*, 145 Public Square, Cleveland, Ohio.

6. Determine approximate value of temperature reduction in each duct caused by heat loss from the ducts. A value of from 0.3 to 0.6 F per foot of duct has been obtained from tests conducted in the Research Residence installation for uninsulated duct lengths up to approximately 60 ft.

7. Subtract this temperature reduction from the assumed bonnet air temperature to obtain an approximate value of the register air temperature for each register.

8. Determine the required air volume for each room from Equation 1, or from the values listed in Table 2:

$$Q = \frac{H}{60 \times 0.24 \times d\,(t_r - 65)} \qquad (1)$$

where

Q = required air volume, cubic feet per minute.
H = heat loss of room, Btu per hour.
d = density of air at register temperature, pounds per cubic foot.
t_r = register temperature, degrees Fahrenheit.
0.24 = specific heat of air.
65 = return air temperature, degrees Fahrenheit.

For any given register temperature the solution of this equation simplifies to:

$$Q = H \times \text{Factor} \qquad (2)$$

in which the values of the Factor may be obtained from Table 2.

9. Determine register size from the air volume delivered to each room:

$$\text{Free area of register, square feet} = \frac{Q}{V} \qquad (3)$$

$$\text{Gross area of register, square feet} = \frac{\text{Free Area}}{R} \qquad (4)$$

where

Q = required air volume, cubic feet per minute.
V = velocity at register face, feet per minute.
R = ratio of free area to gross area of register.

Allowable register velocities to be used in Equation 3 are approximately as follows:

Baseboard, non-deflecting type, maximum = 300 fpm.
Baseboard, deflecting toward floor, maximum = 500 fpm.
Baseboard, deflecting and diffusing = up to 800 fpm.
High side wall = not less than 500 fpm.

In residential applications it is not advisable to handle more than 150 cfm through any single register.

10. Duct systems for forced-air installations may consist of either trunk systems or individual duct systems.

Trunk Systems. Determine duct sizes and friction losses as outlined in Chapter 32, except that for residence applications the velocities in the main duct and in the various parts of the system should approximate the values recommended in Table 3.

Individual Duct Systems. An individual duct system is one having separate ducts extending from the heating unit to each register. In designing such a system select first the duct having the greatest equivalent length. Select a reasonable velocity using Table 3 as a guide. From friction chart in Chapter 32 determine unit friction loss per 100 ft of run, and from this the total friction loss in the duct selected. If this total friction loss exceeds a reasonable value a lower velocity should be used.