the stack will not be excessive and of protecting the pilot flame against back-drafts. The boiler manufacturer generally furnishes a satisfactory device as part of the standard equipment.

The problem of installing a gas-fired warm-air furnace is not greatly different from that of installing a coal-fired furnace. Warm air pipes and registers should be liberally proportioned (see Chap. X, p. 143) so as not to obstruct the free flow of large amounts of air; and recirculation should always be practiced. Thermostatic control should of course be employed. Dual control, that is, control of both room temperature and duct temperature, is becoming popular. It makes for more even heating and provides a sure safeguard against overheating arising from registers being closed while the furnace is in operation.

On account of their small heat storage capacity, gas boilers are particularly adaptable to extremely low pressure (vapor) steam heating systems. The small water capacity and quick steaming ability insure instant response to the sensitive steam pressure regulators.

RATINGS

Gas appliance manufacturers have followed the custom established by coal appliance manufacturers in rating their product in terms of cubic feet of warm air and square feet of steam or water radiation. The capacity of a gas furnace or boiler is subject to smaller fluctuations than a boiler employing solid fuel and the element of length of firing period does not enter into consideration. Gas appliance manufacturers rate their boilers in terms comparable with the usual 8-hour rating of coal boilers. In other words, where a 2400 sq. ft. coal boiler would be chosen, a 2400 sq. ft. gas boiler would generally be appropriate.

It is common practice for gas boiler manufacturers also to rate their boilers in terms of *Available B.t.u. per hour.* To use this rating the calculated heat loss from the building is increased by the usual percentage allowed for piping losses and the appropriate boiler chosen.

A gas furnace or boiler will show essentially the same capacity or efficiency with any gas fuel, provided steps are taken to furnish burner equipment and air regulation appropriate to the fuel burned. Most manufactured gases, although of lower heating value than natural gases, if burned in sufficient volume will produce equivalent results. The heating value of a mixture of gas and air (air just sufficient to burn the gas completely) is almost the same for any typical commercial gas, as is shown in Table 83.

It is a fact, based upon observation, that the user of a gas-fired central heating appliance uses more heat during the course of a year than he does when depending upon solid fuel. The extreme ease of starting and operating a gas burning appliance leads to the pilot light being lighted on the first cool day of the season. Thereafter, the system generally operates entirely under thermostatic control and is left in operation on many days when very little heat is required to keep the inside temperature at 70 to 72 deg.; days when it would be impracticable to keep a coal fire going. On many cold days, the gas unit is kept operating continuously at maximum capacity so that the premises are never permitted to cool below the temperature ordinarily maintained.

A great deal of data is available covering the fuel requirements of steam and hot-water heating systems. Not a great deal is available on warm-air furnace systems, consequently no effort will be made to present any.

In making an estimate of the gas that will be consumed by a gas-fired boiler during the average heating season, two variables must be taken into account. The first is the size of the heating system, usually expressed in terms of square feet of direct cast-iron radiation. The other one is the duration and intensity of the heating season. This is easiest expressed in terms of "degree-days," a unit adopted by the *American Gas Association.* A very complete chart giving the characteristics of the heating season for all parts of the entire Continental United States was published by the *Heating and Ventilating Magazine* in 1925. Table 85, giving values of degree days for several representative cities:

TABLE 85. DURATION OF HEATING SEASON

City	Degree—Days for Heating Season	City	Degree—Days for Heating Season	City	Degree—Days for Heating Season
Atlanta	2880	Denver	5880	Pittsburgh	5327
Boston	6055	Detroit	6202	San Francisco	3450
Buffalo	6750	Jacksonville	1080	St. Louis	4583
Cincinnati	5302	Kansas City	5302	Philadelphia	4950
Cleveland	6096	Minneapolis	7953	Seattle	5156
Chicago	6007	New York	5303	Washington	4562
Dallas	2455	Oklahoma City	3827		

By averaging the records of a large number of gas-boiler installations, the following equations have been derived:

$$\text{For Steam } G = \frac{102 \times R \times D}{H} \qquad \text{For Water } G = \frac{59 \times R \times D}{H}$$

where G = cubic feet of gas per season
R = square feet of direct cast-iron radiation
D = degree-days per season
H = B.t.u. (gross) per cubic foot of gas

Example. To estimate the gas consumption for the average heating season for a 300 sq. ft. steam heating system in Chicago.

From Table 85 it is found that the average heating season in Chicago has 6007 degree-days. The gross heat value of the gas supplied to that city is 535 B.t.u. per cu. ft. Substituting in the equation:

$$G = \frac{102 \times 300 \times 6007}{535} = 343{,}578 \text{ cu. ft.}$$

The requirements of individual installations may vary considerably from an average of several. Generally stores, offices, factories, and other commercial buildings require less heat per season than do residential buildings provided with an equal amount of radiation.

In coal furnaces or boilers, the path traveled by the hot gases is relatively short and the surface with which they come in contact is relatively small as compared to gas heating apparatus. A large proportion of the heat in the coal is given off by the incandescent fuel bed as radiant heat. As a gas flame radiates very little heat, the hot products of combustion must come in direct contact with the heating surfaces. For this reason the use of gas in coal-burning appliances is always wasteful