results for the average residence, but if precise estimates are required, the procedure outlined in Chapter 14 should be used.

In the case of gravity warm air heating installations, the load was formerly expressed in square inches of leader pipe which can be converted into Btu per hour by multiplying the square inches of leader area by 111, 167, and 200 for first, second, and third floor respectively.

Example 4. What would be the total gas consumption over a full heating season of a gas-fired gravity warm air furnace designed according to the Code[2], and with four 12 in. and two 8 in. round leaders to the first floor and six 10 in. leaders to the second floor, if the gas has a heating value of 500 Btu per cubic foot, the plant operates at a 70 per cent seasonal efficiency and is designed to maintain an average inside temperature of 65 F when it is 10 F outside in a city where the average outside temperature is 45 F and the heating season is 5088 hr long?

Solution. The area of the round leaders is: 12 in., 113 sq in.; 10 in., 79 sq in.; and 8 in., 50 sq in. The total Btu transmitted is:

First Floor:	$[(4 \times 113) + (2 \times 50)] \times 111$	= 61,272 Btu per hour.
Second Floor:	$(6 \times 79) \times 167$	= 79,158 Btu per hour.
	Total	140,430 Btu per hour.

Substituting this total heat loss value as H in Equation 1 gives:

$$F = \frac{140{,}430\ (65 - 45)\ 5088}{0.70\ (70 - 10)\ 500} = 680{,}483 \text{ cu ft gas.}$$

DEGREE-DAY METHOD

This method is based on consumption data which have been taken from buildings in operation, and the results computed on a degree-day basis. While this method may not be as theoretically correct as the Calculated Heat Loss Method, it is considered by many to be of more value for practical use.

The amount of heat required by a building depends upon the outdoor temperature, if other variables are eliminated. Theoretically it is proportional to the difference between the outdoor and indoor temperatures. The *American Gas Association*[3] determined from experiment in the heating of residences that the gas consumption varied directly as the difference between 65 F and the mean outside temperature. In other words, on a day when the mean temperature was 20 deg below 65 F, twice as much gas was consumed as on a day when the temperature was 10 deg below 65 F. For any one day, when the mean temperature is less than 65 F, there are as many degree-days as there are degrees difference in temperature between the mean temperature for the day and 65 F. Degree-days may be calculated on other than the 65 F base but are seldom used and are of little value except where the inside temperature to be maintained as, for example, in warehouses, differs greatly from the usual inside temperature range of 68 F to 72 F.

Table 1 lists the average number of degree-days, which have occurred over a long period of years, by months and the yearly totals for various cities in the United States, Canada and Newfoundland. The values for United States cities were calculated by taking the difference between 65F and the daily mean temperature computed as ½ the total of the daily maximum and the daily minimum temperatures. The monthly averages were obtained by adding daily degree-days for each month each year and dividing by the number of days in the month; then totaling the respective calendar monthly averages for the number of years indicated and dividing by the number of years. The total or long term yearly average degree-day value is the summation of the 12 monthly averages. Degree days for Canadian cities were supplied by the Canadian Meteorological Division of the Department of Transport and were computed from the mean temperature normals on record for the various stations.

Any attempt to apply the degree-day method of calculating fuel consumption for less than one month would be of very little value. It should be noted that this method of calculation is based on a long term average and cannot be expected to coincide with any single year in calculating fuel requirement as individual yearly degree-day calculations will vary as much as 20 per cent above and below the long term average.

If the degree-days occurring each day are totaled for a reasonably long period, the fuel consumption during that period as compared with another period will be in direct proportion to the number of degree-days in the two periods. Consequently, for a given installation, the fuel consumption can be calculated in terms of fuel used per degree-day for any sufficiently long period and compared with similar ratios for other periods to determine the relative operating efficiencies with the outside temperature variable eliminated.

Studies made by the *National District Heating Association*[4] of the metered steam consumption of 163 buildings located in 22 different cities and served with steam from a district heating company substantiate the fact that the 65 F base originally chosen by the gas industry is approximately correct.

Formula for Degree-Day Method

The general equation for calculating the probable fuel consumption by the degree-day method is:

$$F = U \times N \times D \qquad (4)$$

where

F = fuel consumption for the estimate period.
U = unit fuel consumption, or quantity of fuel used per (degree-day) (*building load unit*).
N = number of *building load units* (when available use calculated hourly heat loss instead of actual amount of radiation installed).
D = number of degree-days for the estimate period.

Values of N depend on the particular building for which the estimate is being prepared and must be found by surveying plans, by observation, or by measurement of the building. Values of U for use in this equation are the unit fuel consumptions per degree-day and are obtained as a result of the collection of operating information. Certain of this information is presented later but before referring to these data attention is directed to the nature of the unit.

Unit Fuel Consumptions per Degree-Day

The quantity of fuel used per degree-day in a given heating plant can be reduced to a unit basis in terms of quantity of fuel or steam per degree-day per square foot of radiation, per cubic foot of heated building space, or per thousand Btu hourly heat loss at design conditions. A less frequently used basis is quantity of fuel per (degree-day) (square foot of floor area). In fact any convenient unit can be used to relate the consumption to the degree-day and to the building.