is preferable, however, to include these losses in the value of H, and to limit E to the fuel burning equipment.

Automatic fuel burning equipment, whether for coal, oil or gas, will tend to save fuel and will therefore produce a higher efficiency if thermostatically controlled, but on the other hand automatic equipment tends to make the householder prolong his heating season and to maintain a higher temperature in the house in the early fall and late spring.

NON-HEATING PERIODS

Obviously, the theoretical fuel consumption will be reduced considerably by not operating the heating plant at night. Allowance for this may be made in either of two ways: (1) by estimating the average inside temperature (t), or (2) by arbitrarily assuming a certain reduction in the fuel consumption.

The first procedure is, of course, the more accurate. If, for example, the daytime temperature is to be 70 F, and the temperature from 12 midnight to 6 a.m. is to be maintained by thermostatic control at 50 F, then the average daily inside temperature (t) will be $\frac{18 \times 70 + 6 \times 50}{24}$ or 65 F. Strictly speaking, this average inside temperature would only apply when the outside night temperature averages below 50 F, but this fact usually is not of sufficient importance to warrant consideration. If the average outside temperature during the heating season is 30 F, the fuel saving would be approximately $100 \times \frac{70 - 65}{70 - 30}$ or 12.5 per cent. In this case, the additional saving in fuel due to the cooling of the air and structural materials to 50 F would be offset by the heating-up load in the morning.

As to the second procedure, it may be arbitrarily assumed that a saving in the fuel consumption of from 10 to 30 per cent (depending on conditions) will result if the heat is shut off after working hours, and the building heated to the required temperature during the period of occupancy each day. This, of course, is a general statement and wherever possible the average temperature should be estimated from the proportionate lengths of the occupancy and non-occupancy periods and the corresponding temperatures for these periods. Any deviation from the assumed inside temperature will result in a variation in the estimated fuel consumption.

HEAT CAPACITY OF BUILDINGS

The heat required to warm the cold building and contents is a factor to be considered. Under certain conditions, the cooling of the structure and contents will, to some extent, compensate for the heat required to rewarm the building. For example, if the building is under thermostatic control and the day and night temperatures are say 70 F and 50 F, respectively, there will be a period during which no heat will be called for while the building is cooling to 50 F, and the saving resulting therefrom will correspond to the additional heat required to bring the building and contents back to the daytime temperature. If in estimating the fuel consumption the average daily inside temperature is based on the proper day and night temperatures and periods, the heat required to warm the structure may be neglected.

Where irregular conditions are involved it may be desirable to actually calculate the fuel required to warm the building structure and contents for the number of times during the heating season the heating plant would not be in operation and to add this quantity to the fuel required for the number of hours during which the building is heated. The greater the heat capacity of the structure the greater will be the relative importance of this item. For structures of low heat capacity, such as frame buildings, this factor usually may be neglected.

Example 1. A small factory building located in Philadelphia is to be heated to 60 F between the hours of 7 a.m. and 7 p.m., and to 50 F during the remaining hours. The calculated hourly heat loss, based on a design temperature of − 6 F, is 500,000 Btu. If coal having a calorific value of 12,500 Btu per pound is fired, and the over-all heating efficiency is assumed to be 60 per cent, how many tons of coal will be required for a normal heating season, neglecting other heat sources and any loss of heat through open windows?

Solution. Since there are no partitions in this building, the entire heat loss is considered. The average outside temperature during the heating season (t_a) is 41.9 F (see Table 2, Chapter 7); $t = 60$ F; $N = 5040$; $H = 500{,}000$; $(t - t_o) = 66$ F; $C = 12{,}500$; $E = 0.60$. Substituting these values in Equation 1 and dividing by 2000 to change to tons:

$$F = \frac{500{,}000 \times 18.1 \times 5040}{66 \times 12{,}500 \times 0.60 \times 2000} = 46 \text{ tons of coal}$$

Inasmuch as the building will be heated to 50 F at night, the average inside temperature (at the breathing line) will be 55 F, and the percentage saving will be $\frac{60 - 55}{60 - 41.9} = 0.276$ or 27.6 per cent. The net fuel consumption will therefore be $46 - 0.276 \times 46$ or 33.3 tons.

MISCELLANEOUS FACTORS

There are many factors which would be likely to affect the theoretical fuel requirements of a building, such as the opening of windows, abnormal inside temperatures, other heat sources, sun effect, wind, and rain. In many cases it is difficult to evaluate these factors accurately, particularly in the case of open windows, and the results are correspondingly less accurate. The degree of refinement of the calculations should, of course, be consistent with the conditions involved. If the heat loss from the boiler and piping does not warm the building or is not included in H, the proper allowance should be made. In selecting a boiler, this allowance is frequently assumed to be 25 per cent of the total heat loss of the building, but in estimating fuel requirements, the more accurate procedure of computing the pipe and boiler losses should be used, unless this item is likely to be outweighed by other less tangible factors.

Where temperature control is installed the fuel consumption can obviously be predetermined with greater accuracy than where no such control has been provided. In fact the calculated requirements agree to a remarkable extent in many cases with the actual fuel consumption. This has been particularly true of gas-fired installations, with which effective temperature regulation usually is possible.

OTHER HEAT SOURCES

Where other heat sources are available it is quite often possible to make accurate allowance for the reduction in the fuel consumption resulting