manufacturer; *third*, for the quality and kind of fuel furnished; *fourth*, for the proper design of the heating plant when designed by a consulting engineer; *fifth*, for the proper operation of the plant according to the instructions of the heating contractor and the boiler manufacturer.

The heating contractor is responsible: *first*, for the proper construction of the heating plant in a good workmanlike manner according to the plans and specifications; *second*, for the proper design of the heating plant when designed under his own directions.

The boiler manufacturer is responsible: *first*, for the proper rating of the boiler; *second*, for the proper performance of the boiler when operated under standard conditions as to the conditions of the boiler, quantity of draft, kind and quality of fuel, methods of firing and operation, and proper functioning of piping system.

If any one of these nine basic requirements for the successful performance of a heating plant is below par, it is enough to cause failure of a heating plant that otherwise would be a success. A heating plant like a chain is no stronger than its weakest link.

CHAPTER I

HEAT LOSSES FROM BUILDINGS

STRIKING A HEAT BALANCE

THE engineer designing a heating system must strike a balance between the output of heat loss from the building and the input of heat from the heat producing boiler or furnace. The output falls under two main classifications: *infiltration* and *transmission;* and in some cases in the group heating of buildings from line losses. The proper input depends upon the proper size and type of heat distributing units, such as radiators or registers, the proper design or sizes of ducts, piping and other apparatus, and the proper capacity and type of boiler or furnace installed, and with proper and intelligent operating conditions an efficient performance should result. The total heat the heating apparatus must furnish includes the total heat loss plus a heating up factor when the building is to be heated periodically with unheated period in between. The heating up factor is determined by the rate at which the initial heat is required to raise the temperature of the cold building or buildings and their contents to a desired degree in a given time. This heating up factor is often added to the infiltration losses and expressed in terms of *air changes*. The number of air changes per hour which will occur in a room, building or group of buildings depends upon the building construction, exposure, number and type of windows, doors, open fire places, vent registers, and the air admitted by opening and closing doors, and other openings.

Heat loss by transmission is essentially the way in which solid materials transfer heat and is therefore essential that the insulating value of all materials used in building construction be known to the heating engineer that he may calculate the heat loss through these materials when heating rooms or buildings. The rates of this transmission of heat is given in the form of transmission constants and are generally figured for a degree difference between inside and outside temperature.

The heating engineer is confronted with the problem of generating and transmitting heat in a building or group of buildings and delivering that heat to the point or points from which it escapes to the outer atmosphere in quantities equal to the heat loss to the outer atmosphere.

Before going any further, it is proper at this time to say that heat for heating systems is produced at the present time by combustion, that is, such materials as wood, coal and oil are combined with the oxygen of the air into various chemical combinations.

Material for this section was especially prepared for THE GUIDE by P. J. Dougherty, W. L. Durand, W. H. Driscoll and C. V. Haynes. New Infiltration Data by F. C. Houghten.