It will be noted from the example cited that when the efficiency is based on the net or lower heat value, the appliance apparently absorbs 8.21 per cent more of the heat supplied to it than when the efficiency is based on the gross heat value.

Table 3 following, shows the maximum possible efficiencies obtainable when burning a typical manufactured gas with various stack temperatures. These are based on the gross heat value and do not include any correction for radiation from the boiler covering. Radiation would reduce these efficiencies from 2 to 10 per cent depending on the insulating properties of the covering. The gas is assumed to be burned with 35 per cent excess air and has the following composition:

| | |
|---|---|
| $CO_2$ | 8.6 per cent |
| $H_2$ | 52.5 " " |
| $CH_4$ | 31.6 " " |
| $C_2H_4$ | 1.1 " " |
| $C_6H_6$ | 1.1 " " |
| $O_2$ | 0.1 " " |
| $CO_2$ | 1.5 " " |
| $N_2$ | 3.5 " " |
| | 100.0 |

Heat value per cubic foot at 60 deg. fahr. and 30 in. hg., 535 B.t.u.
Specific gravity 0.58 (air = 1)
Air Temperature 60 deg. fahr.
Atmospheric moisture neglected.

TABLE 3. PRODUCTS OF COMBUSTION AND THEORETICAL EFFICIENCIES WITH A TYPICAL MANUFACTURED GAS

| Stack Temperature (deg. fahr.) | 250 | 275 | 300 | 350 |
|---|---|---|---|---|
| Heat in Dry Flue Gas above 60 deg. (%) | 3.57 | 4.05 | 4.52 | 5.48 |
| Heat in Water Vapor above 60 deg. (%) | 9.13 | 9.22 | 9.30 | 9.47 |
| Heat absorbed by boiler, or efficiency (%) | 87.30 | 86.73 | 86.18 | 85.05 |
| | 100.00 | 100.00 | 100.00 | 100.00 |

Flue Gas Analysis

$CO_2$ 11.18% $O_2$ 5.63% $N_2$ 83.19%

## RATINGS

Since a gas appliance has a heat generating capacity that can be predicted accurately to within 1 or 2 per cent, and since this capacity is not affected by such things as chimney draft, condition of fuel bed, and soot accumulation; makers of these appliances have an opportunity to rate their product in exact terms. Consequently, practically all makers give their product an *hourly B.t.u.* rating. This is the amount of heat that is available at the outlet of a boiler in the form of steam or hot water; or at the bonnet of a furnace in the form of warm air. To use this rating it is only necessary to increase the calculated heat loss by an appropriate amount for starting and piping loads and select the boiler or furnace with the proper B.t.u. rating.

The *hourly B.t.u* rating divided by 240 for steam and by 150 for water, gives what is called the *A. G. A.* (*American Gas Association*) rating. It is used in the selection of a boiler just exactly as the *hourly B.t.u.* rating is used.

In addition to *hourly B.t.u.* and *A. G. A.* ratings, some manufacturers also list *nominal* ratings. These are comparable with the nominal 8 hr. ratings of coal boilers and are intended to be used in the same manner.





Furnace manufacturers also rate their product in terms of the square inches of leader area that they can handle, a form of rating that fits in very nicely with the *National Warm Air Heating and Ventilating Association's* Code for calculating leader sizes. (See Chapter X.)

Gas boilers are available with B.t.u. ratings up to more than 2,000,000 B.t.u. per hour, while furnaces with ratings up to about 250,000 B.t.u. per hour are available.

## HEATING COSTS

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 so much seems to be available on warm-air furnace systems.

A study of local climatic conditions is essential in considering gas heating systems for it affects both the design and the size of the equipment as well as the gas consumption. House heating requires gas practically in inverse proportion to the temperature so that on the coldest day there will be greatest use of fuel. The wind velocity and the amount of sunshine are also factors affecting the amount of gas required also whether the house owner wants a constant temperature day and night or desires to have 70 in the day time and 60 at night.

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*. The term "degree-day" means one day of time and 1 deg. of temperature. It has been found that below a mean daily temperature of 65 deg. fahr. people require heat. Therefore each locality has a certain number of degree-days which represents the heating season for that place. Studies of the *American Gas Association* have established the number of "degree-days" for over 300 cities in the United States and Canada and it is easy to calculate the heating demands of a particular city. Gas consumption then will be proportional to the number of degree-days. 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 4, gives values of degree-days for several representative cities: