The heat that is reclaimed by the condensation of the water vapor amounts to about 10 per cent of the total heat value. It is practically impossible to utilize the entire higher heat value of the gas in any house-heating appliance, because to do so it would be necessary to cool the products of combustion down below their dew-point, which is ordinarily in the neighborhood of 130 deg. A stack temperature of 130 deg. is not sufficient to produce a good draft under actual installation conditions.

The heat balance of a gas-burning heating boiler or furnace, therefore, includes the following items:

Heat in the dry flue gas.
Heat in the water vapor.
Heat loss due to incomplete combustion.
Heat loss through radiation.
Heat absorbed by the water or air in the boiler or furnace.

Table 2, shows the maximum theoretical efficiencies when burning a typical manufactured gas with various stack temperatures. These are based on the higher heat value of the gas, and do not include any correction for radiation from the boiler covering. Radiation will reduce these efficiencies as much as 5 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 2. 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
Radiation (not calculated)	0	0	0	0
	100.00	100.00	100.00	100.00

Flue Gas Analysis

CO_2 11.18% O_2 5.63% N_2 83.19%

It will be seen from Table 2 that the maximum attainable efficiency under practical operating conditions, which include the necessity of having a stack temperature sufficiently high to insure a good draft, and with a normal radiation loss, is approximately 80 per cent.

RATINGS FOR GAS-HEATING APPLIANCES

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 condition of fuel bed and soot accumulation,

makers of these appliances have an opportunity to rate their product in exact terms. Consequently, 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 the furnace in the form of warm air. In the case of boilers, this rating can be put into terms of square feet of equivalent direct radiation by dividing it by 240 for steam, and 150 for water. This gives what is called the *A. G. A.* (*American Gas Association*) rating, and is the manner in which all appliances approved by the *American Gas Association* Laboratory are rated. To use these ratings it is only necessary to increase the calculated heat loss or the equivalent direct radiation load by an appropriate amount for starting and piping, and to select the boiler or furnace with the proper rating.

It might be stated at this point that the rating given by the *American Gas Association* Laboratory is not only a safe rating when considered from the standpoint of capacity; but is also a safe rating when considered from the standpoint of physical safety to the owner or care-taker. The rating that is placed upon an appliance is limited by the amount of gas that can be burned without the production of an amount of carbon monoxide that would be dangerous to human life. This same limitation applies to all classes of gas-consuming heating appliances that are tested and approved by the Laboratory. Gas boilers are available with ratings up to 10,000 sq. ft. of steam, while furnaces with ratings up to about 500,000 B.t.u. per hour are available.

HEATING COSTS
(RESIDENCES AND SIMILAR BUILDINGS)

The subject of heating costs will be considered under two divisions. First, the cost of heating the average residence with gas, and second, the cost of heating larger buildings, such as office buildings. A great deal of data are available from which to draw conclusions as to the heating cost for the average residence, but the data pertaining to the cost of heating large buildings are not so extensive.

It is a fact, based upon observation, that the user of a gas-fired central heating appliance in a residence 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. It is in operation on many days when very little heat is required, days when it would be impracticable or inconvenient 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.

For a given building maintained at a given temperature, the curve of gas consumption follows the curve of outdoor temperature very closely. The efficiency of the appliance is almost independent of the load, so that the gas consumption is almost proportional to the temperature difference. This property of the gas-burning heating plant makes it relatively easy to estimate the heating costs once the basic relations have been determined.