jet and the gas burns with a large yellow flame. As the holes in such burners must be small, appliances using them cannot burn gas in large quantities. A gas flame must not be permitted to touch any cold solid surface as this will result in arrested or incomplete combustion, the deposit of soot and the formation of carbon monoxide.

Blue flame or Bunsen type burners are provided with an external mixer in which a portion of the air (about 2 cu. ft. per cubic foot of gas) is mixed with the gas previous to ignition. This is called primary air. The flame issuing from the port of the burner has two distinct parts: a pale blue inner cone and a darker cone surrounding it. The heat of the flame issuing from the burner port draws currents of air past the flame and into it in sufficient quantity to cause complete combustion. This is known as secondary air. The flame should sit squarely on the port and should not have a yellow tip. A yellow tip indicates insufficient primary air, and is corrected by opening the adjustable air shutter.

It should be noted here that the proportions of the orifice at the entrance to the burner tube, and the proportions of the burner ports must suit the heat content of the gas being burned. A burner proportioned for natural gas is not suitable for water gas or coal gas, which are much bulkier in relation to their heat contents.

Table 83 shows the heat values of a cubic foot of gas and air mixture, the gas being mixed with the amount of air theoretically required to burn it. In practice excess air must be admitted to the fire in order to insure complete combustion.

TABLE 83. VOLUME OF AIR REQUIRED FOR COMBUSTION OF DIFFERENT GASES*

GAS	B.T.U. PER CUBIC FOOT	CU. FT. AIR TO BURN CU. FT. GAS	B.T.U. PER CU. FT. OF MIXTURE
Natural Gas	1084	10.27	96.2
Coal Gas—Rich	580	5.21	93.4
Coal Gas—Lean	510	4.43	93.9
Carburetted Water Gas	575	5.02	95.5

*Thomas King. *American Gas Journal*, October 22, 1921.

HEAT VALUE AND EFFICIENCY

A gas may be said to have two heat values; a gross or *higher* heat value and a net or *lower* heat value. The lower heat value is obtained by subtracting from the higher heat value the latent heat of vaporization of the water formed by the combustion of the gas, amounting to about 10 per cent of the higher heat value. Since it is very rarely that the heat of vaporization can be recovered and usefully applied, the efficiency of a gas burning appliance should be based on the higher heat value. When comparing guarantees of efficiency, care should be taken to understand whether the guarantee is based on the higher or lower heat value.

For example.—Take an hypothetical gas having a gross heat value of 550 B.t.u. per cu. ft. and a net heat value of 500 B.t.u. per cu. ft., burned in a steam boiler giving an evaporation of 465 lb. of water (from and at 212 deg.) per 1000 cu. ft. of gas burned:

$$\text{Efficiency} = \frac{\text{B.t.u. in steam}}{\text{B.t.u. in gas}} \times 100 = \frac{465 \times 970.4}{\text{cu. ft.} \times \text{heat value}} \times 100$$

$$\text{With Gross Value Efficiency} = \frac{451{,}235}{550{,}000} \times 100 = 82.04 \text{ per cent}$$

$$\text{With Net Value Efficiency} = \frac{451{,}235}{500{,}000} \times 100 = 90.25 \text{ per cent}$$

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. This is a false conclusion as it is not possible to recover the heat represented by this difference in percentage unless the products of combustion are cooled below 212 deg.

The following Table 84 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

TABLE 84. PRODUCTS OF COMBUSTION AND EFFICIENCIES WITH TYPICAL MANUFACTURED GAS

Stack Temperature (deg. fahr.)	220	235	250	265	280
Heat in Dry Flue Gas above 60° (%)	3.25	3.57	3.90	4.14	4.28
Heat in Water Vapor above 60° (%)	9.95	10.03	10.10	10.16	10.22
Heat absorbed by Boiler or Efficiency (%)	86.80	86.40	86.00	85.70	85.50
	100.00	100.00	100.00	100.00	100.00

Flue Gas Analysis

CO_2 8.04% O_2 5.86% N_2 86.10%

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	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., 580 B.t.u.
Specific gravity 0.418 (air = 1)
Air Temperature 60 deg. fahr.
Atmospheric moisture neglected.

TYPES OF GAS HEATERS

Luminous Flame Reflector Heaters diffuse a large part of their heat by virtue of the radiating power of the bright yellow flame. They are usually backed by a polished copper sheet which reflects radiant heat into the room. The flame must never be so long that it strikes any part of the heater.

Radiant Heaters have a blue flame which heats refractory "radiants" or "glowers" to incandescence. Radiant heaters are quite sensitive to