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 F.

The actual dew point in the chimney is different from the theoretical value because excess air is admitted not only at the burner but also at the backdraft diverter which lowers the dew point.

Natural gas is the richest of the gases and contains from 80 to 95 per cent methane, with small percentages of the other combustible hydrocarbons. In addition, it contains from 0.5 to 5.0 per cent of CO_2, and from 1 to 12 or 14 per cent of nitrogen. The heat value varies from 700 to 1500 Btu per cubic foot, the majority of natural gases averaging about 1000 Btu per cubic foot. Table 4 shows typical values for the four main oil fields, although values from any one field vary materially.

Table 4 also gives the calorific values of the more common types of manufactured gas. Most states have legislation which controls the distribution of gas and fixes a minimum limit to its heat content. The gross or higher calorific value usually ranges between 520 and 545 Btu per cubic foot, with an average of 535. A given heat value may be maintained and yet leave considerable latitude in the composition of the gas so that as distributed the composition is not necessarily the same in different dis-

TABLE 4. REPRESENTATIVE PROPERTIES OF GASEOUS FUELS, BASED ON GAS AT 60 F AND 30 IN. HG.

GAS	BTU PER CU FT		SPECIFIC GRAVITY, AIR = 1.00	AIR REQUIRED FOR COMBUSTION, (CU FT)	PRODUCTS OF COMBUSTION				THEORETICAL FLAME TEMPERATURE, (DEG FAHR)
					Cubic Feet			ULTIMATE CO_2 Dry Basis	
	High (Gross)	Low (Net)			CO_2	H_2O	Total with N_2		
Natural gas—California	1200	1087	0.67	11.26	1.24	2.24	12.4	12.2	3610
Natural gas—Mid-Continental	967	873	0.57	9.17	0.97	1.92	10.2	11.7	3580
Natural gas—Ohio	1130	1025	0.65	10.70	1.17	2.16	11.8	12.1	3600
Natural gas—Pennsylvania	1232	1120	0.71	11.70	1.30	2.29	12.9	12.3	3620
Retort coal gas	575	510	0.42	5.00	0.50	1.21	5.7	11.2	3665
Coke oven gas	588	521	0.42	5.19	0.51	1.25	5.9	11.0	3660
Carburetted water gas	536	496	0.65	4.37	0.74	0.75	5.0	17.2	3815
Blue water gas	308	281	0.53	2.26	0.46	0.51	2.8	22.3	3800
Anthracite producer gas	134	124	0.85	1.05	0.33	0.19	1.9	19.0	3000
Bituminous producer gas	150	140	0.86	1.24	0.35	0.19	2.0	19.0	3160
Oil gas	575	510	0.35	4.91	0.47	1.21	5.6	10.7	3725

tricts, nor at successive times in the same district. There are limits to the variation allowable, because the specific gravity of the gas depends on its composition, and too great a change in the specific gravity necessitates a change in the adjustment of the burners of small appliances.

Table 4 shows that a large proportion of the products of combustion when gas is burned may consist of water vapor, and that the greater the proportion of water vapor, the lower the maximum attainable CO_2 by gas analysis. The table also shows that a low calorific value does not necessarily mean a low flame temperature since, for example, natural gas has a theoretical flame temperature of 3600 F and blue water gas of 3800 F, although it has a calorific value less than one third that of natural gas.

The quantity of air given in Table 4 is that required for theoretical combustion, but with a properly designed and installed burner the excess air can be kept low. The division of the air into primary and secondary is a matter of burner design and the pressure of gas available, and also of the type of flame desired.

PROBLEMS IN PRACTICE

1 ● Differentiate between the general characteristics of hard and soft coals.

Hard coals contain fixed carbon in large proportions and in addition more ash is present especially in the smaller sizes. Soft coals have an increasing percentage of carbon in combination with hydrogen which is volatile and will distill off under high temperature, producing smoke.

2 ● Name several important properties of coal from a utilization standpoint.

a. Caking tendency, whether none, weak, or strong.
b. Quantity of volatile matter.
c. Friability.
d. Fusibility of the ash.

3 ● What are the main data commonly available that fix the qualities of coal, and do these tell the whole story?

a. Calorific value, Btu per pound.
b. Proximate analysis giving percentages of moisture, volatile matter, fixed carbon, ash, and sulphur.
c. Temperature at which the ash softens.
d. Screen sizes.

Other important qualities not usually given are the friability of the coal, its caking tendency, and the qualities of the volatile matter. The percentage of ash and its fusion temperature do not tell how the ash is distributed or how much of it is less fusible lumps of slate or shale.

4 ● Are there available complete and sufficient data on gas and oils to fix their burning properties and furnace requirements?

Yes. Because gas and oils are of simple and uniform composition, data are available to fix their burning properties and furnace requirements, but the ability to control their combustion is somewhat less determinable.

5 ● What effect does moisture in fuels have on their efficiency?

With any solid fuel, latent and sensible heat are lost at the stack when moisture is dried out of the fuel in burning, and when its hydrogen is burned. Therefore, such fuels as sub-bituminous coal and lignite, which are high in moisture content, have a low efficiency. However, these efficiencies may be improved if the stack gases are cooled to room temperature, by heating the feed water, for example.