to require delivery of a gas of specified average or minimum heating value within their respective limits. Any given heating value within reason fortunately may be maintained and yet permit considerable latitude in the composition of the gas distributed. Hence the constituents of city gases are not necessarily the same in different districts nor even at successive stations in the same district. In every community, however, the objective is to maintain variations in composition and gas pressure within limits which will provide satisfactory operation and performance of all common types of gas burning equipment.

Liquefied petroleum gases, such as propane and butane or mixtures thereof have calorific values ranging from 2500 to 3200 Btu per cu ft. These fuels are often supplied as liquids under pressure in tanks or bottles. In such cases the liquid evaporates when pressure is relieved, the heat necessary for vaporization being obtained from the surrounding air or ground. As butane boils at 32 F some provision is necessary, for maintaining the gas above this temperature or for lowering the partial pressure by dilution if the gas is utilized in colder climates. Propane, with a boiling point of −40 F, may be served in localities where temperatures substantially below freezing are encountered. When employed for heating purposes, these gases are usually stored in high pressure tanks and delivered by tank truck in much the same manner as fuel oil. Both gases, mixed with air, or in undiluted form, are also extensively employed by gas companies to augment their base load supplies during peak load periods. In some smaller communities, where gas manufacturing plants are not economically feasible and natural gas is unavailable, liquefied petroleum gases or liquefied petroleum gas-air mixtures are supplied through mains in much the same manner as manufactured or natural gas.

COMBUSTION OF GASEOUS FUELS

Gas burners employed in domestic heating appliances are generally of the non-luminous flame or Bunsen type. Part of the air required for combustion is inspirated as *primary air* into the burner mixing tube where it mixes with gas, and then takes part in combustion at the burner ports. As the amount of primary air is seldom sufficient to support complete combustion, additional air is supplied to the burner flames around the periphery of its ports. This *secondary air* is induced into the appliance and around the base of each separate burner flame by force of the issuing mixture of gas and primary air and by draft inspiration inherent in the heat of the flames. If a Bunsen type burner is properly adjusted, its flames will generally have a clear, blue appearance. Yellow flames are indicative of insufficient primary air supply, and possibly of incomplete combustion. An appreciable updraft is seldom, if ever, present even in flue-connected gas heating appliances, because most appliances of this kind are equipped with a draft hood which reduces the chimney draft at the appliance. It is important to note that gas furnaces and boilers, as well as most other classes of heating equipment, are designed to create their own draft.

The air-to-gas ratio in a Bunsen burner head has a decided effect on the rate of flame propagation. The gas-air mixture must flow from the burner ports faster than the flame burns, otherwise flashback will occur. The flashback condition normally results either from an excess amount of primary air or insufficient gas or both. Conversely, the velocity of the issuing mixture must not be so high that the flame will be blown from the ports, a condition known as *lifting*. Fortunately, contemporary types of such burners have a rather wide range of flexibility in capacity and adjustment. In addition to this characteristic, gas supply is normally so uniform that if a gas heating appliance is properly adjusted when it is installed, its burners, with occasional cleaning, should provide trouble-free service for years. When problems incident to changeover of the gas supply are involved, they are generally assumed by the local utility providing the supply of gas. It should be recognized that a change in fuel gas will change the operating CO_2 value. For example, an appliance operating on carburetted water gas at 20 percent excess air will have 14.2 percent CO_2 in the flue gases. If a change is made to coke oven gas at the same gas input rate, with the excess air maintained at 20 percent, the operating CO_2 would drop to 9.2 percent.

Luminous flame burners are occasionally used in central heating gas appliances. With these devices all air required for complete combustion is supplied to the flames as secondary air. Two fundamental advantages of this type of burner are that the possibilities of flashback are eliminated, and that a much higher gas velocity is needed to blow the flames off the ports. On the other hand, if there is any appreciable amount of flame impingement on any portion of the heating surface, or if secondary air is not effectively supplied to the flames, soot may be formed and also combustion may be incomplete.

In some types of gas burners radiant baffles are used to convert part of the energy formed during the process of combustion to radiant heat. These baffles may also serve to direct the flow of products of combustion along the heat-absorbing surface.

Gas designed furnaces and boilers approved by the *American Gas Association* are certified for operation at the rating shown on the nameplate. Considerations relating to safety, performance, and service life, require that such appliances be adjusted at inputs which do not exceed the nameplate input rating. These appliances normally draw in from 20 to 50 percent excess air, depending on the type and general design. As has been indicated, some excess air is necessary to insure complete combustion at all times and also to provide a reasonable degree of flexibility in performance.

Various types of appliances used for gas space heating purposes are described in Chapter 15.

Care must be exercised to insure adequate air supply for combustion equipment installed in buildings or other structures. Where the equipment is closely confined, as in closets or small furnace or boiler rooms, the air supply must also provide for ventilation. Current recommended practices are:

1. Where the equipment is not closely confined (typical cellar installation or equivalent) provide not less than 1 sq in. of free access to outside air for each 1000 Btu per hr heat release of fuel consumed. Infiltration into conventional frame or brick construction, unless unusually tight with storm windows and tight doors, provides adequate air.

2. Where the equipment is closely confined, provide two openings to outside air or from spaces freely communicating to the outside. One opening should be near the top of the equipment enclosure and the other near the bottom. Each opening should have not less than $\frac{1}{2}$ sq in. of free area for each 1000 Btu per hr heat release of fuel burned, and should communicate to air source or outside by suitable ducts. Where the enclosure is in a building of otherwise conventional construction, and the air source will be the normal infiltration into building, each opening shall have not less than 1 sq in. of free area for each 1000 Btu per hr heat release.

3. Clearances from equipment to closely confining enclosures should conform to local codes and to standards listed by recognized agencies such as *AGA Testing Laboratories*[19] and *Underwriters' Laboratories*.[20] See Fig. 5 for details concerning installa-