pliances. 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.

FUNDAMENTAL PRINCIPLES OF COMBUSTION

Regardless of the type of fuel under consideration, its combustion results in the production of gaseous products. Many kinds of solid fuels contain minerals which cannot be burned and are therefore left as a residue commonly called ash. Moreover, unless sufficiently high temperatures are employed and an ample supply of oxygen properly distributed is present, the combustible constituents of solid, liquid, and even gaseous fuels cannot be completely burned. Incomplete or partial combustion of all fuels produces toxic gases, such as carbon monoxide, with smaller quantities of aldehydes, ketones, and other hydroxylated hydrocarbon compounds. This fact indicates that, while combustion processes involving common types of fuel may be regulated by experienced operators to produce the most efficient results, normal combustion processes can be so unbalanced as to create hazards unless both design and operation are planned with a knowledge of the fundamental principles of combustion.

Combustion may be defined as the chemical combination of a substance with oxygen resulting in the evolution of heat, and usually some light. The rate of combustion depends upon the rate of reaction of the substance with oxygen, upon the rate at which oxygen is supplied, and upon the temperature obtained due to surrounding conditions. This is combustion in its simplest form. All solid, as well as liquid and even gaseous fuels generally contain several combustible elements in combination with others which, depending on their nature, affect oxygen requirements and thus govern the combustion process. For a continuous reaction, as in heating processes, it is necessary to establish an effective balance between rates of removing heat and of supplying fuel and air or oxygen to keep the reaction going. In establishing such a balance, consideration must be given to the removal or venting of products of combustion, so that the entire process is one of flow wherein draft conditions in the combustion space are important.

Complete combustion is obtained when all combustible elements in a fuel

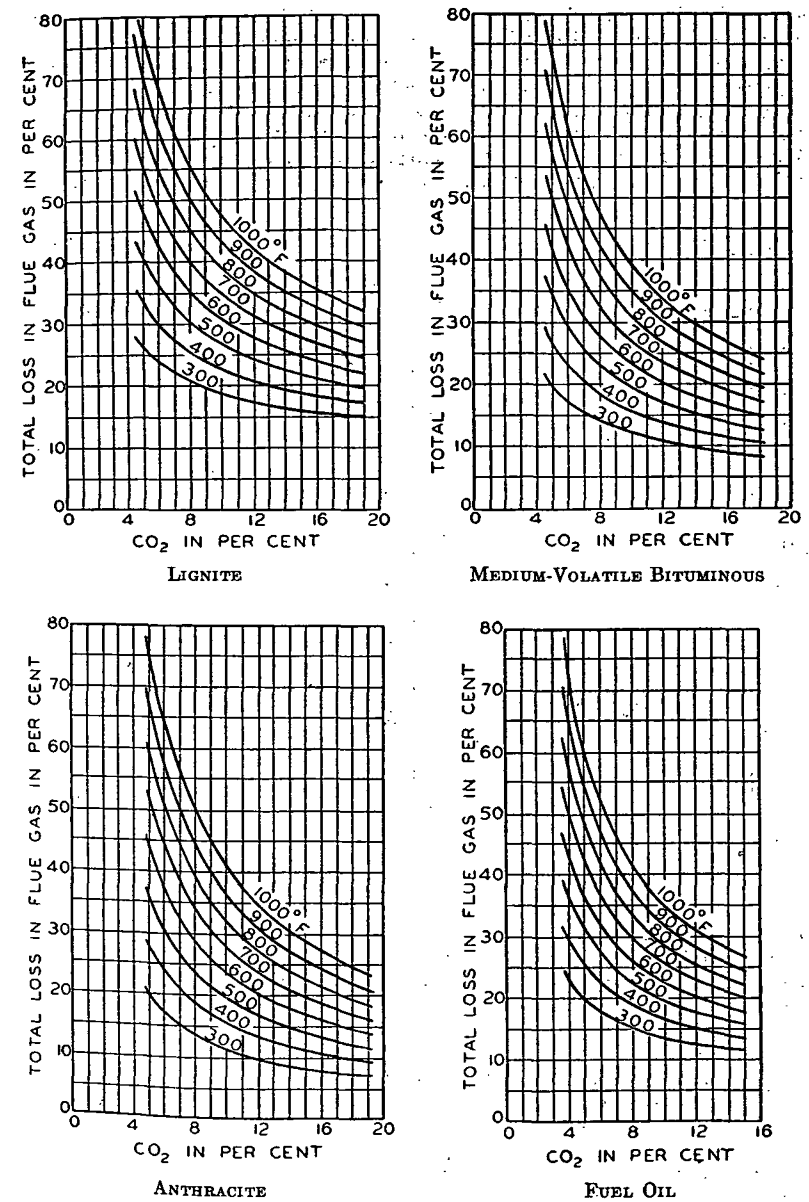

FIG. 5. FLUE GAS LOSSES WITH VARIOUS FUELS[3]

Flue Gas Temperature Shown. Loss is Based on 65 F Room Temperature