door, and by leaks in the setting, whereas the gases leave only through the outlet. By throttling the gases with the damper in the outlet all the air entering by each of the three intakes is reduced in the same proportion, thus maintaining about the same percent of excess air. If inlet air is controlled by the ashpit draft door, the air admitted through the ashpit is reduced, while it is increased through the other two intake openings, resulting in an increase of excess air. A considerable increase in the efficiency of hand-fired furnaces and boilers can be realized by regulating the air supply by means of the damper in the outlet instead of the ashpit damper. Use of the ashpit damper is required, of course, for low rates of combustion. The cold air check damper is to be used only when chimney draft is excessive. It is normally closed unless closing of the

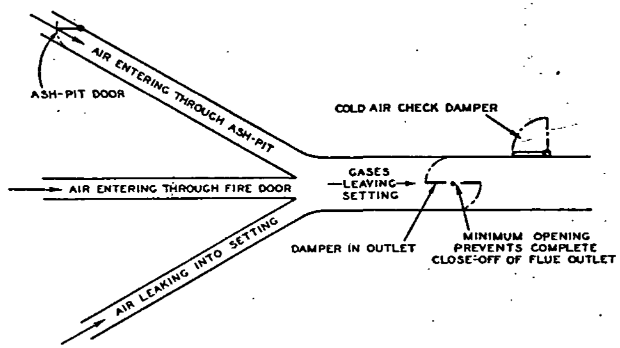

Fig. 2. Methods of Draft Regulation in a Hand-Fired Furnace

outlet damper and ashpit damper is unable to control the rate of combustion.

Furnace Volume for Coal and Coke

The principal requirements for a *hand-fired furnace* are that it shall have enough grate area and correctly proportioned combustion space. The amount of grate area required is dependent upon the desired combustion rate.

The furnace volume is influenced by the kind of coal used. Bituminous coals, on account of their long-flaming characteristic, require more space in which to burn the gases of combustion completely than do the coals low in volatile matter. For burning high volatile coals, provision should be made for mixing the combustible gases thoroughly, so that combustion is complete before the gases come in contact with the relatively cool heating surfaces. An abrupt change in the direction of flow tends to mix the gases of combustion more thoroughly. Anthracite requires comparatively little combustion space.

CLASSIFICATION OF FUEL OILS

Fuel oils are mixtures of hydrocarbons derived from crude petroleum by refining processes. Crude oil is distilled in towers at atmospheric pressure to produce gasoline, naphtha, kerosine distillates, and colored distillates, and leave straight-run residues. The colored distillates are distilled further to produce light distillate fuel oils, some lubricating oil, wax, etc., whereas the straight-run residues are distilled under vacuum to produce heavier distillates. The residual fuels remaining can then be passed through

cracking plants to produce more gasoline, cracked kerosine, cracked distillates, and cracked residual fuel oils. The exact processes used depend on the proportions of the various end products desired, and to some extent upon the composition and characteristics of the crude oil.

Fuel oils may be designated as straight-run, thermally-cracked, catalytically-cracked, or blended, depending on the refining process used to produce them. Straight-run fuels are those produced by distillation under atmospheric pressure or a vacuum without decomposition of the hydrocarbons by cracking. Thermally-cracked fuels are those produced by a cracking process involving elevated temperatures (850–1100 F) to decompose some of the heavier hydrocarbons. Catalytically-cracked fuels are those produced with the aid of an alumina-silica catalyst in the cracking process at lower temperatures than those used for thermal cracking. Blended fuel oils are mixtures of any of the above three types.

Grade Classification of Fuel Oils

Fuel oils are most commonly classified by dividing them into grades in accordance with the *Commercial Standard* (CS12-48) entitled *Fuel Oil* published by the *U. S. Department of Commerce*. These specifications, given in Table 4, conform to *ASTM Materials Specifications for Fuel Oils* D 396 – 48. Table 4 also shows specifications for PS 300 and PS 400 fuel oils which are numbers used in the Pacific coast area. These oils correspond approximately to ASTM designations No. 5 and No. 6 respectively.

Oils may be classified roughly by specific gravity but it is not an adequate index of the suitability of an oil for a given purpose. Other characteristics of fuel oils which determine their grade classification in the *Commercial Standard*, and their suitability for given uses are the flash point, pour point, water and sediment content, carbon residue, ash, sulfur content, distillation characteristics, and viscosity.

The flash point of an oil is important with regard to safety in storage and ease of ignition in systems employing automatic ignition. The distillation characteristics determine whether or not the oil can be completely evaporated in some types of burners, and whether cracking will be likely to occur prior to combustion. A low pour point and low water content are desirable for outdoor storage in cold climates. Sediment, carbon residue, and ash should be low to prevent clogging of strainers and the accumulation of unburned material in the burner. A low viscosity allows the fuel oil to flow through supply lines readily and to be broken up into small droplets in atomizing type burners. The sulfur content is of importance because sulfur compounds corrode the burner and heating system or because undesirable compounds of sulfur may be formed in certain industrial processes. Some of these characteristics of a fuel oil are required to lie within certain limits for each of the grades of fuel oil listed in *Commercial Standard* CS12-48. Some fuel oils do not fall into any of the grade classifications of the *Commercial Standard* because failure to comply with all of the requirements of one grade does not automatically place the fuel oil in the next lower grade, unless it meets all of the requirements of the lower grade.

By ultimate analysis the No. 1 and No. 2 fuel oils contain 84 to 86 percent carbon, 12.0 to 13.5 percent hydrogen, one to three percent oxygen and nitrogen, and 0.5 percent or less of sulfur. The heavier grades of fuel oil, Nos. 4, 5 and 6, may contain as much as 88 percent carbon, as low as 11 percent hydrogen, and considerably more sulfur than is permissible in the domestic grades.

Due to variation in the constituents of different fuel oils and the differ-