slightly in mild weather, and should be shaken only until the first red particles drop from the grates in cold weather. The best size of coke for general use, for small fire-pots where the fuel depth is not over 20 in., is that which passes over a 1 in. screen and through a $1\frac{1}{2}$ in. screen. For large fire-pots where the fuel can be fired over 20 in. deep, coke which passes over a 1 in. screen and through a 3 in. screen can be used, but a coke of uniform size is always more satisfactory. Large sizes of coke should either be mixed with fine sizes or broken up before using.

SECONDARY AIR

When bituminous coal is hand-fired in a furnace, the volatile matter in the fuel distills off leaving coke on the grate. The product of combustion of the coke is CO_2 and under certain conditions some CO may arise from the bed. The combustion of the volatile matter and the CO may amount to the liberation of from 40 to 60 percent of the heat in the fuel in the combustion space over the fuel bed.

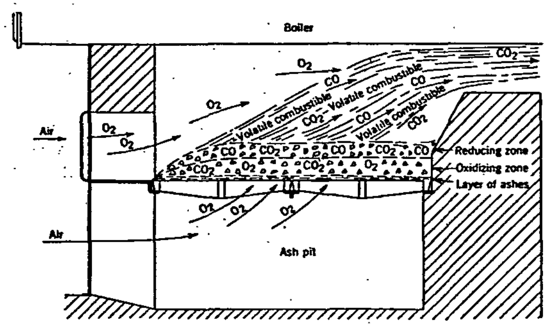

Fig. 1. Combustion of Fuel in a Hand-Fired Furnace

The air that passes through the fuel bed is called *primary air*, and the air that is admitted over the fuel bed in order to burn the volatile matter and CO is called *secondary air*.

This process of combustion is illustrated in Fig. 1.[4] The free oxygen of the air passes through the grate and the ash above it, and burns the carbon in the lower 3 or 4 in. of the fuel bed forming carbon dioxide. This layer noted as the oxidizing zone, is indicated by the symbols CO_2 and O_2. Some of the carbon dioxide of the oxidizing zone is reduced to carbon monoxide in the upper layer of the fuel bed, noted as the reducing zone and indicated by the symbols CO_2 and CO. The gases leaving the fuel bed are mainly carbon monoxide, carbon dioxide, nitrogen, and a small amount of free oxygen. Free oxygen is admitted through the firing door in an attempt to burn carbon monoxide, as well as the volatile combustible distilled from the freshly fired fuel.

The division of the total into primary and secondary air necessary to produce the same rate of burning and the same excess air, depends on a number of factors which include size and type of fuel, depth of fuel bed, and size of fire-pot.

Size of the fuel is a very important factor in fixing the quantity of secondary air required for non-caking coals. With caking coals it is not so important, because small pieces fuse together and form large lumps. Fortunately, a smaller size fuel gives more resistance to air flow through

the fuel bed, and thus automatically causes a larger draft above the fuel bed. More secondary air is drawn through the same slot openings, but, nevertheless, the smallest size of fuel will require the largest secondary air openings. For certain sizes of fuel, no secondary air openings are required, and for large sizes, too much excess air may pass through the fuel bed.

In general, the efficiency of domestic hand-fired furnaces and boilers burning either anthracite or bituminous coal, can be increased for an hour or two after firing, if some secondary air is admitted through the slots of the fire door. However, unless the slots are closed when secondary air is no longer beneficial, the decrease in efficiency during the remainder of the firing cycle, because of excess air, may more than offset the gain resulting from the secondary air at the beginning of the firing period. Unless the secondary air can be readjusted between firings, it is probable that a greater average efficiency will be obtained for domestic hand-fired devices by leaving the secondary air slots closed at all times. There is usually an appreciable amount of air leakage around the firing door and secondary air slots of domestic furnaces and boilers.

When attention is given between firings, the efficiency of combustion can be raised appreciably by admitting secondary air over a bituminous coal fire, to burn the gases and reduce the smoke. The smoke produced is a good indicator, and that opening is best which reduces the smoke to a minimum. Too much secondary air will cool the gases below the ignition point, and prove harmful instead of beneficial.

Secondary air that enters the combustion chamber too far removed from the zone of combustion, will also be harmful, because the oxygen in the secondary air will not react with any unburned gases, unless the mixture is subjected to high temperatures.

Draft Requirements for Coal and Coke Firing

The draft required to effect a given rate of burning the fuel is dependent on the following factors: (1) kind and size of fuel; (2) grate area; (3) thickness of fuel bed; (4) type and amount of ash and clinker accumulation; (5) amount of excess air present in the gases; (6) resistance offered by the boiler passes to the flow of the gases; and (7) accumulation of soot in the passes.

Insufficient draft will necessitate additional manipulation of the fuel bed, and more frequent cleanings to keep its resistance down. Insufficient draft also restricts the control that can be accomplished by adjustment of the dampers. For draft requirements see Chapter 16.

The quantity of excess air present has a marked effect on the draft required to produce a given rate of burning. If the excess is caused by holes in the fuel bed, or an extremely thin fuel bed, it is often possible to produce a higher rate of burning by increasing the thickness of the bed. The thickness of the fuel bed should not, however, be increased too much, because the increased draft resistance will reduce the rate of primary air supply and the rate of burning.

Draft Regulation for Coal and Coke Firing

Because of the varying heating load demands present in most installations, it is necessary to vary the rate of fuel burning. The maintenance of the proper air supply for the various rates of burning is accomplished by regulation of the drafts. Methods of draft regulation used for solid fuel are shown in Fig. 2. The air enters through the ashpit draft door, firing