anthracite fire to the opening of the dampers. This is an advantage in warming up the system, but it also makes it necessary to watch the dampers more closely in order to prevent the fire from burning too rapidly. A deep fuel bed always should be maintained when burning coke. The grates should be shaken only slightly in mild weather and should only be shaken until the first red particles drop from the grates in cold weather. Since coke weighs only about half as much as anthracite coal per cubic foot, and therefore only about half as much can be put in the firepot, it will be necessary to fire oftener; but during the greater part of the heating season this will not be an item of importance. The best size of coke for general use is that which passes over a 1 in. screen and through a 1½ in. screen; for small firepots where the fuel depth is not over 20 in. For large firepots 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 uniform size of coke is always more satisfactory. Large sizes of coke should be either mixed with fine sizes or should be broken up before using.

HAND FIRING

Hand firing is the oldest and the most widely used method of burning coal for heating purposes. To keep the fuel bed in proper condition where hand firing is used, the following general rules should be observed:

1. Remove ash from fuel bed by shaking the grates whenever fresh fuel is fired. This removes ash from the fire, enables the air to reach the fuel and does away with the formation of clinker (which is melted ash).
2. Supply the boiler with a deep bed of fuel. Nothing is gained by attempting to fire a small amount of fuel. A deep bed of fuel secures the most economical results.
3. Remove ash from ashpit at least once daily. Never allow ash to accumulate up to the grates. If the ash prevents the air from passing through, the grate bars will burn out and much clinker trouble will be experienced.

Hand-Fired Boilers

The principal requirements for a hand-fired furnace are that it shall have enough grate area and combustion space. The proper proportion of these features generally will give ample fuel space, which always is desirable for heating boilers.

The amount of grate area required is dependent upon the desired combustion rate, recommendations for which are given for various kinds of coal in Table 1, Chapter 13.

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 completely to burn the gases of combustion 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 more thoroughly the gases of combustion.

Hand-fired furnaces may be classed as follows: Up-draft, smokeless arch (inverted bridge wall) and down-draft furnaces.

The *up-draft* furnace is the usual type provided in heating boilers and is used generally with all kinds of coal. While it is suitable for use with

anthracite, coke, and semi-bituminous coal, the up-draft furnace is decidedly inadequate for burning bituminous coals from a standpoint of economy.

Due to the difficulty in controlling properly and mixing intimately the air supply with the gases of combustion, combustion usually is incomplete within the up-draft furnace. Consequently, high losses occur due to unburned carbon in the chimney gases and the smoke nuisance is a constant annoyance. There are many more or less efficient schemes for introducing heated air above the fire in up-draft boilers. These all when well adjusted, reduce smoke.

The *smokeless arch* is an inverted baffle placed in the ordinary up-draft furnace toward the rear. Its purpose is to aid in mixing the gases of combustion.

In the operation of a furnace which has an arch, a heavy bed of coked fuel is maintained, which at the time of firing is pushed toward the rear of the furnace while the fresh fuel charge is added in front of it. The volatile matter distilled from the fresh fuel and a secondary air supply above the fire are deflected underneath the arch so that mixing, ignition, and combustion occur in the hot zone over the bed of coke.

Admission of the secondary air supply is usually either through registers in the fire doors or through ports located in the sides of the furnace or through a combination of both. With the side port arrangement the air is carried through the hollow arch where it may become heated and from which it is delivered into the combustion chamber through a series of openings along the bottom or rear side of the arch.

By aid of the smokeless arch, high volatile coals can be burned with practically no smoke at moderate rates of combustion.

The *down-draft* furnace (originally known as the Hawley down-draft furnace) consists of an upper grate of water tubes located above the usual rocking grate. The draft draws down through the upper grate and up through the lower grate. Coal is fired above the fuel bed on the upper grate and after the ash and some coke have been worked down on the lower grate a lively fire is maintained on both grates. The volatile gases pass down through the upper fuel bed and become highly heated as they meet in the combustion chamber between the grates, with the heated excess air from the lower fuel bed.

This type of furnace has proved successful for burning bituminous coal with high efficiency and without smoke.

MECHANICAL STOKER FIRING

Mechanical stokers have long been considered essential standard equipment for all major heating installations. They make it possible to burn coal at a high efficiency without smoke. Within recent years the smaller sizes of mechanical stokers have been developed to a remarkable extent, and it is now possible to achieve results with the small sizes which are comparable to those obtained in the large plants.

Advantages of Stoker Firing

With mechanical stoker firing there are a number of advantages over hand firing for burning bituminous coal. A good mechanical stoker instal-