1. Character and condition of fuel.
2. Combustion rate, or amount of fuel burned per square foot of grate area per hour.
3. Thickness of fuel bed.

Insufficient draft will cause the coal to accumulate on the grates, the result being a dead and smoky fire and consequently poor combustion.

The curves (Fig. 2) give the intensity of draft necessary properly to burn several kinds of coal at various rates of combustion.

Secondary Air

Secondary or auxiliary air (air supplied over the fuel bed) should be provided whenever it increases the temperature in the firebox. Soon after each firing, considerable combustible gas rises from any fuel, and enough air for its combustion cannot be supplied through the fuel bed, but must be provided by other means; usually through a slide damper in the fire door. The amount of secondary air required for high volatile coals is often as much as 50 per cent of the total air required for combustion. Too much secondary air will cool the gases below the ignition point, and prove harmful rather than beneficial.

The amount of secondary air required depends on so many variables that it is impossible to establish a set of rules to fit all cases.

The following suggestions will be helpful:

1. In cold weather, with high combustion rates, the secondary air damper should be half open all the time.
2. In very mild weather, with a very low combustion rate, the secondary air damper should be closed all the time.
3. For temperatures between very mild and very cold, the secondary air damper should be in an intermediate position.
4. For ordinary house operation, secondary air is needed after each firing for about one hour.

Secondary air, when used with bituminous coal, serves the purpose of preventing smoke as well as increasing the efficiency by burning the gas escaping from the fuel bed. As a guide to the amount of secondary air required, it may be remembered that the user should supply just enough secondary air to eliminate the smoke.

Preparing for Pick-Up Load

The period of maximum heat demand should be anticipated in order that ash and clinker can be removed and enough fuel fired to have a deep fuel bed well ignited at the beginning of this period. This is even more important with anthracite than with bituminous, due to the slower ignition of the former.

In extremely cold weather, which occurs only during a few days per season, it is advisable, if the reserve output of the heater is small, to keep the room temperature normal continuously, to eliminate the peak demand due to pick-up temperature.

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 15.

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