case the *walls must be air-tight* and there should be *only one smoke opening* into the chimney. Cleanout, if provided, must be *absolutely air-tight* when closed.

The walls of brick chimneys shall be not less than 3¾ in. thick (width of a standard size brick) and shall be lined with fire-clay flue lining. Fire-clay flue linings shall be manufactured from suitable refractory clay, either natural or compounded, and shall be adapted to withstand high temperatures and the action of flue gases. They shall be of standard commercial thickness, but not less than ¾ in. All fire-clay flue linings shall meet the standard specification of the *Eastern Clay Products Association*. The flue sections shall be set in special mortar, and shall have the joints struck smooth on the inside. The masonry shall be built around each section of lining as it is placed, and all spaces between masonry and linings shall be completely filled with mortar. No broken flue lining shall be used. Flue lining shall start at least 4 in. below the bottom of smoke-pipe intakes of flues, and shall be continued the entire heights of the flues and project at least 4 in. above chimney top to allow for a 2 in. projection of lining. The wash or splay shall be formed of a rich cement mortar. To improve the draft the wash surface should be concave wherever practical.

Flue lining may be omitted in brick chimneys, provided the walls of the chimneys are not less than 8 in. thick, and that the inner course shall be a refractory clay brick. All brickwork shall be laid in spread mortar, with all joints push-filled. Exposed joints both inside and outside shall be struck smooth. No plaster lining shall be permitted.

Chimneys shall extend at least 3 ft. above flat roofs and 2 ft. above the ridges of peak roofs when such flat roofs or peaks are within 30 ft. of the chimney. The chimney shall be high enough so that the wind from any direction shall not strike the top of the chimney from an angle above the horizontal. The chimney shall be properly capped with stone, terra cotta, concrete, cast iron, or other approved material; but no such cap or coping shall decrease the flue area.

There shall be but one connection to the flue to which the boiler or furnace smoke-pipe is attached. The boiler or furnace smoke-pipe shall be thoroughly grouted into the chimney and shall not project beyond the inner surface of the flue lining.

The size or area of flue lining or of brick flue for warm-air furnaces depends on height of chimney and capacity of heating system. For chimneys not less than 35 ft. in height above grate line, the net internal dimensions of lining should be at least 7 x 11½ in. for a total leader pipe area up to 790 sq. in. Above 790 and up to 1,000 sq. in. of leader pipe area the lining should be at least 11¼ x 11¼ in. inside. In case of brick flues not less than 35 ft. in height with no linings, the internal dimensions should be at least 8 x 12 in. up to 790 sq. in. of leader area, and at least 12 x 12 in. for leader capacities up to 1,000 sq. in. Chimneys under 35 ft. in height are unsatisfactory in operation and hence should be avoided.

SMOKE TEST

The chimney flue must be smoke tight and shall be subjected to a smoke test by the mason contractor in the presence of the architect or his representative, after the mortar has thoroughly hardened.

The method of conducting this test shall be as follows: With a good fire in the boiler or furnace, or in the base of the chimney, put about a square yard of tar paper on the fire. As soon as smoke appears at the top of the chimney close the top of the flue with a piece of old carpet or wet newspapers held down by a weighted board. Keep the tar paper burning in the firepot for five minutes. The architect or his representative shall sign an acceptance in triplicate, stating that the chimney was tight under the foregoing test, and shall give one copy to the mason contractor, one copy to the heating contractor and one copy to the owner.

Chapter 15

SOLID FUELS

Kinds of Coal, Coke; Combustion of Coal and Coke; Hand Firing; Mechanical Stoker Firing; Storage Space for Coal; Dustless Coal.

COAL, because of its abundance and low price, has been the most commonly used fuel; it gradually replaced wood as coal mines were opened and transportation facilities increased. The use of coke has increased rapidly in recent years. According to estimates of the U. S. Bureau of Mines, the coal and coke used for heating purposes in 1928 was:

Anthracite	46 to 56 million tons
Bituminous	56 to 77 million tons
Cokes	7¾ million tons

All coal originated from vegetation in swampy places. This vegetation decayed as it fell and built up in successive layers, in time forming peat which in turn became lignite and then under the influence of pressure and heat gradually changed into coals of higher carbon content. In America the coals in the East have generally developed further than those in the West. As the coals are less developed their moisture and oxygen content increase and their heating value decreases.

KINDS OF COAL

The complex composition of coal makes it difficult to classify it into clear-cut types. Its chemical composition is some indication but coals having the same chemical analysis may have distinctly different burning characteristics. Users are mainly interested in the available heat per pound of coal, in the handling and storing properties, and in the burning characteristics. A description of the relationship between the qualities of coals and these characteristics requires considerable space; a treatment applicable to heating boilers is given in U. S. Bureau of Mines *Bulletin* 276.

Fig. 1 illustrates the distribution of the kinds of coal by States and shows the average calorific values and the ash and moisture contents of a limited number purchased on the open market. Five hundred tests in a small domestic boiler were made with these coals by the U. S. Bureau of Mines and the lower curves show the averages of the pounds of water evaporated per pound of coal under similar and normally good operating conditions.

A brief description of the kinds of fuels is given in the following, but it should be recognized that there are no distinct lines of demarcation between the kinds and that they graduate into each other: