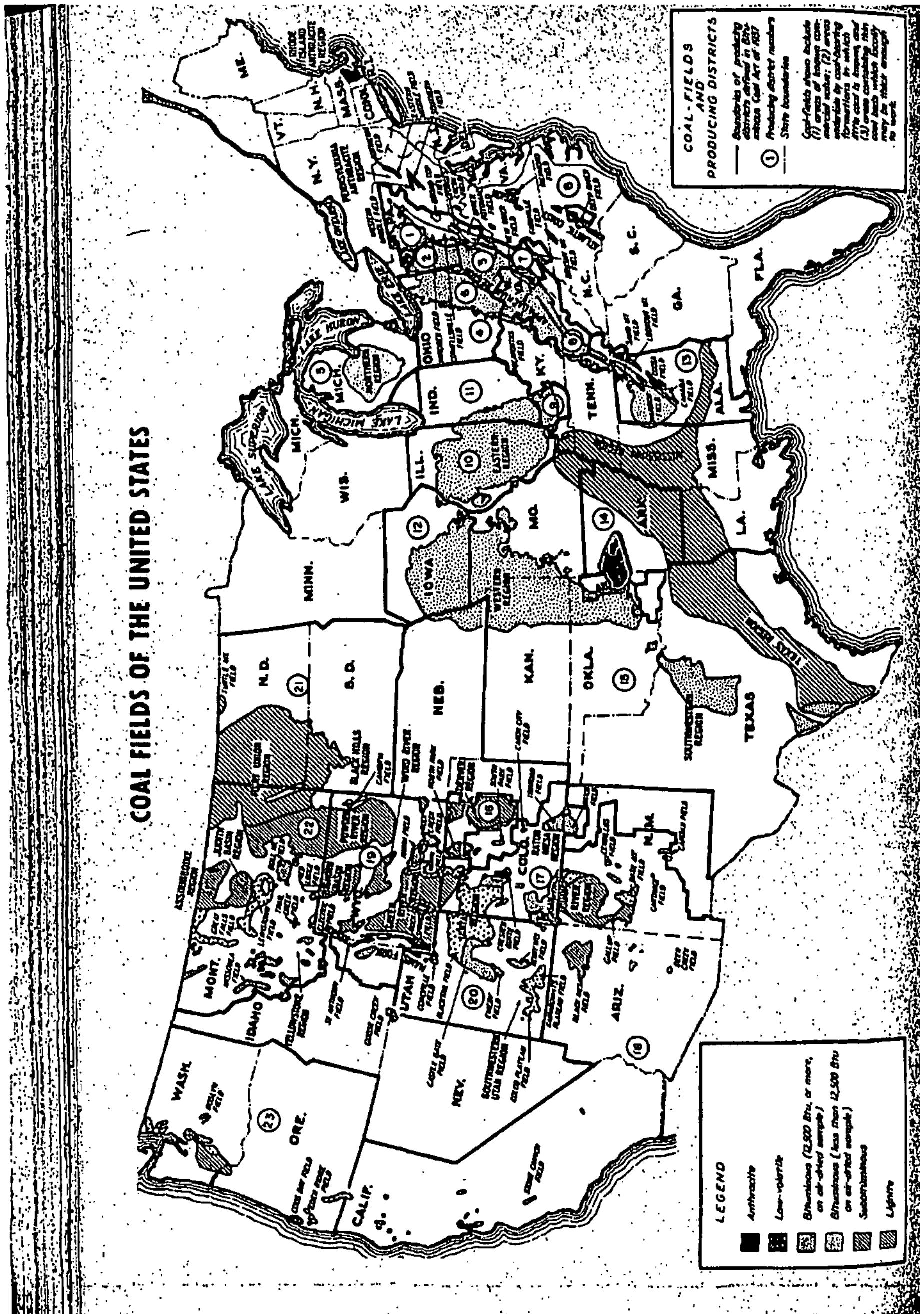

COAL FIELDS OF THE UNITED STATES

sludge in storage; this may be aggravated by mixing oils of different character as when deliveries from two sources go into the same tank. These simple rules avoid trouble when oils are mixed: (1) Straight-run residuals can be mixed with any straight-run product, and cracked residuals with straight-run residual (2) cracked distillate can be added as a third constituent, but (3) cracked residual *cannot* be added to straight-run distillate.

COAL

Three-hundred-million years ago, in swamp forests of the Carboniferous Age, the foundation of our present reserves was laid. For 50 million years, giant trees and ferns grew and fell, to decay and form rich peat bogs. Floods buried the bogs under layers of sediment, only to subside and permit the growth-and-decay cycle to begin again. As millions of years passed, pressure, heat and time worked to drive off some volatile matter, to harden the mass, and to turn it into the carbon-substance we call coal.

Different kinds contain different amounts of carbon substance depending on the age of the deposit and the conditions under which it formed. Next to the original peat, the "youngest" form is *lignite*, high in moisture and low in fixed carbon. Older coals, higher in "rank," contain more fixed carbon.

Analyses. Various tests and methods of analysis express coal qualities in figures instead of words. Principal characteristics are expressed in what is known as a *proximate analysis*, as distinguished from an *ultimate analysis*, which shows the exact chemical composition of a fuel, without paying any attention to the physical form in which the compounds appear. As we have seen, this gives data needed for combustion calculations.

For a better picture of coal's behavior in a furnace, the proximate analysis determines the percentage of (1) *moisture* (2) *ash* (3) *volatile matter* and (4) *fixed carbon*. These percentages add up to 100. In addition, it is customary to determine: (1) total amount of *sulphur*, as a separate percentage (2) *ash-fusion temperature*, and (3) heating value.

Reporting Analyses. There are five ways to report an analysis, although only the first three are likely to be met in power-plant work: (1) as received (2) air dried (3) moisture free (4) moisture and ash free, and (5) moisture and mineral free. As the name implies, the as-received analysis reports the condition of coal as delivered to the laboratory. This comes closest to giving the conditions as *shipped* or as *fired*, the values desired in practical work. Loss or gain of moisture between time of sampling and analysis depends on the kind of coal, size, weather conditions, and method of handling sample.

Following paragraphs discuss the various characteristics of coal (those reported in proximate analyses and others) and how they affect the value of coal in power-plant operation. For details on equipment and procedures for testing coal, consult *ASTM Standards on Coal and Coke* (1948).

Moisture. All coal contains some natural moisture (1 to 5% in Eastern coals and up to 40% in some lignites). This *inherent* moisture lies in the pores and forms a true part of the coal, being retained when it is air dried. *Surface* moisture depends on conditions in the mine, and during transit.

Moisture must be transported, handled and stored; its presence in large amounts increases cost and difficulty of these operations. Looked at another way, moisture replaces an equal amount of combustible material and thus decreases the heat content per lb. In addition, some heat liberated in the furnace goes to evaporating moisture in the fuel and superheating the vapor; this *moisture* loss can be figured from the chart on page 117.

MINERAL IMPURITIES

Ash. This incombustible mineral matter, left behind when coal burns completely, differs from "ashes," as the power-plant man knows them, because ashes taken from a furnace always contain some unburned coal.

Like moisture, ash is an impurity that increases shipping and handling costs. It must be removed from the furnace and the plant, usually requiring additional equipment and expense. Recent research shows that amount and character of ash constitutes the biggest single factor in fuel-bed and furnace problems like clinkering and slagging. An increase in ash content usually means an increase in carbon carried to the ashpit.

Volatile Matter. In a way not yet clearly known, coal holds combustible gases such as methane and other hydrocarbons, hydrogen and carbon monoxide, and incombustible gases like carbon dioxide and nitrogen. Heat releases these gases.

Percentage of volatile matter indicates the amount of gaseous fuel present and thus bears a direct relationship to firing mechanics. It affects furnace volume and arrangement of heating surfaces.

Fixed Carbon. When the volatile matter distills off, a solid fuel is left, consisting, in the main, of carbon, but containing some hydrogen, oxygen, sulphur and nitrogen not driven off with the gases. Subtracting percentage of moisture, ash and volatile matter from 100% yields a percentage called fixed carbon.

Sulphur. Although it burns, sulphur in coal is an undesirable element for power-plant use. It plays a part in clinkering and slagging, in corrosion of air heaters, economizers, breeching and stacks, and in spontaneous combustion of stored coal. It occurs mainly as iron sulphide (commonly known as pyrites), as organic sulphur, and in small amounts as sulphates. Only total sulphur is measured, although it is known that iron combined with the sulphur shares the blame for troubles laid to sulphur.

Ash Fusion. Temperature at which ash fuses is measured by heating cones of ash in a furnace arranged to produce a reducing atmosphere. Temperature at which the cone fuses down to a round lump is called *softening* or *ash-fusion temperature*. Other temperatures sometimes observed include that at which (1) cone tip starts to bend (*initial deformation temperature*) and (2) cone spreads out in a flat layer (*fluid*).

Ash-fusion temperature (and sometimes the spread between initial and softening, or softening and fluid temperatures) serves as the best single indicator of clinkering and slagging tendencies under given fuel-bed and furnace conditions.

Heating Value. If a coal sample is burned in a "bomb" calorimeter filled with oxygen under pressure, the higher heating value is measured. The consumer buys energy units when he buys fuel, and so the heating value plays a basic part in judging fuel values. Sometimes heating value of fuel may affect maximum capacity of a plant.

PULVERIZING QUALITIES

Grindability. Wide use of pulverized-fuel firing brought a need for tests to show the relative ease or difficulty of grinding different kinds of coal. ASTM tentatively approves two methods, *ball-mill* and *Hardgrove*. The first measures relative amounts of energy needed to pulverize different coals by finding the number of ball-mill revolutions needed to grind a sample so 80% passes a 200-mesh sieve (74 microns). The *ball-mill grindability index*, in percent, is found by dividing number of revolutions into 50,000.

In the Hardgrove test, a prepared sample receives a definite amount of grinding energy in a miniature pulverizer; results are measured by weighing amount passing a 200-mesh sieve. Multiplying weight passing the sieve by 6.93 and adding 13 to the product gives *Hardgrove grindability*.

Grindability values do not give a direct comparison of pulverizer capac-