THE MENTOR

THE STORY OF COAL

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DEPARTMENT OF SCIENCE

VOLUME 6
NUMBER 6

TWENTY CENTS A COPY
THE MINER
By BERTON BRALEY

Grimy, and caked with dust of coal he stands,
Grasping his pick within his mighty hands;
The arbiter of destiny and fate,
Greater by far than king or potentate.

Shops may not run except at his behest,
At forge and blast his strength is manifest.
The rolls that rumble and the shears that scream
And all the million miracles of steam
Depend on him for fuel that will turn
The wheels that urge them and the belts that churn.
Guns that will shatter fortresses of steel,
Ships that will plow the waves on steady keel.

Bearing munitions for an army’s need
Must wait the miner’s orders and take heed
That he who toils within the coal mine’s murk
Gives them the coal with which they do their work.

Behind the men who battle in the trench
There stand the workmen at the lathe and bench,
But back of them and master of them all
The miner stands and holds the world in thrall.

Not soon again shall any man forget
How much the world is in the miner’s debt,
For we shall read upon fame’s honor roll
“He won the war—his labor gave us coal!”

Reprinted by courtesy of Publishers of “Coal Age.”
HERE it possible for the lump of coal that we burn in our stove, grate or furnace to tell its story, it would take us back millions of years to a time when vast areas of the earth’s surface were covered with swamps, supporting a luxuriant vegetation. No human being, mammal or bird yet existed. Animal life included fish, shellfish and other aquatic species, besides reptiles and insects. The vegetal forms resembled our modern ferns, horse-tails, club-mosses and evergreens. The atmosphere was heavily charged with moisture, and a mild climate prevailed even in the polar regions. Such were the conditions under which, during the great Carboniferous Age, most of the existing coal-beds were deposited in the earth.

Coal is the litter of primeval swamps and forests. Year after year the débris of the humid jungles accumulated in shallow water or in the soggy soil, where it underwent partial decay, and was thus converted,
first of all, into the slimy or spongy material known as "peat." Similar deposits are in process of formation in the swamps of the present day, and the peat obtained from them is dried and used as fuel on an extensive scale in some parts of the world; especially Ireland, Holland, Germany and Scandinavia.

Gradual changes in the elevation of the land led to the submergence of the prehistoric peat bogs, during successive intervals of time, by lakes or shallow seas. Thus their vegetation was killed, and they were overspread with layers of mud or sand, above which, during a subsequent period of elevation, a new peat bog would form; and this process was repeated several times. The conversion of the peat into coal appears to have resulted from the pressure of the overlying strata, probably aided by the internal heat of the earth. Much of its moisture was squeezed and evaporated out; the proportions of its component gases were reduced; and the result was a hard mineral, which has earned the popular name of "black diamond" because consisting chiefly of carbon—the same chemical element which, in a pure and crystalline form, constitutes the true diamond. Chemically, coal consists of carbon; the gases hydrogen, nitrogen and oxygen; sulphur; and ash (the mineral matter that remains after combustion).

The record of these long-ago events is found when we sink a shaft through typical coal-bearing strata. We pass through not one, but several, layers of coal, which may vary in thickness from a fraction of an inch to a hundred feet or more, and are separated by generally much thicker layers of sandstone or shale (solidified clay). The layers of coal are known as "coal-beds." Unless a coal-bed is at least two feet thick it is hardly worth working, and, ordinarily, the thickness of a bed does not exceed eight or ten feet. The shale or sandstone above a bed is very commonly found to contain the remains or the impressions of the ancient plants from which the coal was formed. A study of these remains and casts has made it possible to classify hundreds of species of plants now extinct. Fragments of plants are also sometimes found in the coal itself, and thin slices of coal frequently show a
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vegetable structure under the microscope. Finally, to furnish conclusive proof of the vegetable origin of coal, we find under the coal-bed a layer known as the "underclay," which is a fossil soil filled with the roots and rootlets of the coal-producing plants. Different conditions of formation, and also, probably, differences in the character of the original vegetation, have resulted in the production of different kinds of coal. The most important heat-producing constituent in coal is the elementary substance called "carbon," and the simplest classification of solid fuels depends upon the percentages of fixed (non-volatile) carbon they contain, the average percentages running as follows: Wood, 50%; peat, 55%; lignite, 73%; bituminous coal, 84%; anthracite coal, 93%. When fuel is burned the greater part of it unites chemically with the oxygen of the air to form certain invisible gases—especially carbon dioxide and water-vapor—and only the ash remains.

In the popular mind coal is classified as hard or soft, while hard coal is further classified according to the size of the lumps. For both scientific and industrial purposes more elaborate classifications are necessary, and several have been used or proposed.

Kinds of Coal

The United States Geological Survey classifies coals, first of all, according to "rank," depending upon both chemical and physical characteristics. Anthracite,
which contains the largest percentage of carbon, ranks highest, and lignite, with the smallest percentage of carbon, lowest. Coals of the same rank are said to be of high or low "grade," according to whether they contain a relatively small or large percentage, respectively, of ash and sulphur. The ranks recognized by the Survey are: Anthracite, semi-anthracite, semi-bituminous, bituminous, sub-bituminous, and lignite.

"Anthracite" is the hardest of coals. It was formed from bituminous coal under the crushing pressure due to the upheaval of mountains or by the intense heat of adjacent molten rocks. Most American anthracite is mined in eastern Pennsylvania. The largest deposits in the world are found in China. Anthracite burns slowly, with little smoke. It is well adapted for domestic use on account of its cleanliness, but is not an economical fuel for steam-raising or general manufacturing.

"Semi-anthracite" also ranks as a hard coal, though it is less hard than anthracite. Very little is mined in this country, and it is generally sold as anthracite.

"Semi-bituminous" coal is a softer coal, which, when properly burned, gives off but little smoke. The best semi-bituminous coal ranks highest among the coals in heating value. It is the most valuable fuel for manufacturing purposes; also for steamships, as it requires less bunker space per unit of heat than any other coal.

"Bituminous" coal, or ordinary "soft coal," burns readily, with a smoky flame, and is the coal most commonly used for manufacturing purposes; in fact, the bulk of the coal mined throughout the world belongs to this rank. It includes a good many varieties, some of which are extensively used in making coke, while others, such as "cannel" coal,
have been in great demand for use in gas works. Nowadays, however, the widespread introduction of "water-gas,"* which does not require any particular kind of coal, has diminished the demand for "gas coals."

"Sub-bituminous" coal, or "black lignite," is common in some of our western coal fields. It is a clean and useful domestic fuel when used near the mines, but is not very satisfactory for shipment, as it shrinks and crumbles under the effects of "weathering" and is liable to spontaneous combustion.

"Lignite" is the least valuable of coals, and is the form of coal which is the least altered from the original peat. The Geological Survey applies this name only to those coals which are distinctly brown and either markedly woody or claylike in appearance. Lignite, as it comes from the mine, contains from thirty to forty per cent. of moisture, and it "slacks" or falls to pieces much more rapidly than sub-bituminous coal when exposed to the air. It is hardly suitable for transportation.

For commercial purposes coal is also classified according to size. The coal as it comes out of the mine, without any sorting into sizes, is known as "run of mine," and the semi-bituminous coals are commonly shipped in this form. Most coals, however, are passed over bars or gratings, which constitute screens of different degrees of fineness; each screen permits all the lumps below a certain size to fall through, and thus the coal is divided into the different standard sizes. The sizes of anthracite, from the smallest to the largest, are: rice, buckwheat, pea, chestnut (or nut), stove, egg, broken (or grate), steamboat, and lump. Bituminous coal is divided into slack, nut and lump (the largest size). A mixture of lump and nut is called three-quarter coal.

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*Made by forcing steam over glowing coal or coke. See Monograph No. 4.
The Modern History of Coal

The age of the steam-engine is also the age in which the use of coal has become widespread, and the output of coal is a faithful index of industrial progress. Although the Greek writer Theophrastus (about 300 B.C.) mentions the use of coal as a fuel, and its use was also known to the ancient Britons and the Chinese, it was virtually unknown throughout the Middle Ages. The first record of coal mining in England is of the year 1180 A.D., and coal was first shipped to London in the year 1240. It was long known as stone-coal, pit-coal, etc., to distinguish it from charcoal; also as sea-coal, on account of being carried to London by sea. Bituminous coal was first mined in America in 1750, near Richmond, Virginia. Anthracite was discovered in Rhode Island in 1760, and in Pennsylvania in 1766, but for many years its value was not recognized. As late as the year 1812 Colonel George Shoemaker, of Pottsville, was treated as an impostor and threatened with arrest for attempting to sell a few wagon-loads of anthracite in Philadelphia; methods of burning it were not understood, and it was declared to be merely “black stone.” In the year 1820 only 365 tons of anthracite were sold in this country, as compared with the present annual output of about 90,000,000 tons.

Before the days of the railway coal was shipped mostly by water in rough boats called “arks,” which floated down the rivers to the seaboard towns. As it was impossible to return against the current, the ark was sold with the coal at its destination. A great many arks were wrecked in transit, and the whole process of transportation

The coal passing over screens is graded according to size.
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was a costly one. Only with the introduction of steamboats, canals and railways, did the coal industry assume serious proportions.

The production of coal in America has grown at an amazing rate. In the year 1868 Great Britain produced 3.6 times as much coal as the United States, and the output was also exceeded by that of Germany. In 1899, the United States took the lead. At the present time, with an estimated production for the year 1917 of 643,600,000 tons, the United States is producing nearly half of all the coal mined in the world. Great Britain ranks second, closely followed by Germany.

How Coal is Mined

A relatively small amount of coal is quarried near the surface of the ground from open pits. The overlying soil is removed by steam-shovels, and the coal is then blasted out and shoveled into cars.

Most coal is mined underground. Access to the coal-beds is obtained either by sinking a vertical "shaft" or by driving a tunnel, according to the location of the beds. A tunnel driven at a steep angle is called a "slope." A horizontal tunnel leading into a coal-seam is called a "drift." In this country few coal mines are more than 300 or 400 feet below the surface, and the deepest is about 1,600 feet. Much deeper mines are found in Europe, especially in Belgium.

American mine shafts are generally rectangular and are divided into two or more compartments. Where a shaft passes through water-bearing strata it must be provided with a tight lining, or "tubbing," to prevent the mine from being
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flooded. All water that enters the mine collects in an excavation, or "sump," at the bottom of the shaft, and must be pumped to the surface.

The method of working coal-seams most commonly practiced in this country is known as the "room-and-column" system. One or more tunnels, or "entries," are first driven from the bottom of the shaft or the mouth of the drift. These are the main thoroughfares of the mine, and are usually provided with tracks, over which the mine cars are hauled by mules or by some other method of traction—locomotives, endless chains, etc. Secondary entries ("headings," "butt entries," etc.) branch off from the main entries. Finally, the work of extracting the coal consists of excavating open spaces, or "rooms," adjoining the entries.

The actual mining is done in the rooms, and different methods are in use. Anthracite is generally "shot from the solid"; that is, blasted out from the face of the coal without any preliminary cutting. This method is objectionable, especially in bituminous mines (where it is, however, much practiced), because the large charges of powder it requires produce a great deal of coal-dust and weaken the roof and pillars, often leading to falls of coal and fatal accidents. A better plan consists of "undercutting" the coal before it is blasted out. A long groove is made at the level of the floor, either with a pick or with a coal-cutting machine. Holes are then drilled some distance above the groove for the insertion of the blasting charges, and the coal is blasted down. A single shot will sometimes dislodge a ton or two of coal.

The next step is to shovel the coal from the floor into a mine car, which is then pushed
into the adjacent entry. The miner attaches a numbered tag to the car, so that he will be duly credited for his work, which is paid for by the ton. The loaded cars are eventually hoisted or hauled out of the mine, to be weighed and discharged above ground.

The final step in working a coal-seam by the room-and-pillar method is to mine out the thick walls or pillars of coal, which are originally left between adjacent rooms to support the roof. As this work proceeds the worked-out sections are filled with waste rock, or the roof is allowed to fall. The object is to leave as little coal in the mine as possible, but practically it is rare that more than 60 or 70 per cent. is recovered.

One feature of a coal mine that must be carefully planned is the system of ventilation. This is provided not merely for the comfort of the miners, but to prevent, as far as possible, the accumulation of poisonous and explosive gases. There are always at least two airways leading into the mine (one or both of which may also be used for hoisting or other purposes), known as the "upcast" and the "downcast," according to the direction in which the air passes through them. A current of air is maintained either by keeping a fire burning at the bottom of the upcast or by the use of powerful fans or blowers. A system of tight trap-doors prevents the air from taking a short cut between the downcast and the upcast, and thus leaving the greater part of the mine unventilated.

The coal in the mine constantly gives off various gases, one of which, the notorious "fire-damp" (methane or marsh-gas), is responsible for many
explosions. In recent years it has been discovered that coal-dust itself, when mixed with the right proportion of air, is violently explosive. Mine explosions may be minimized by requiring the use of "safety-lamps" (oil, gasoline, or electric); by providing devices to prevent sparking in electrical apparatus; and by using for blasting operations only so-called "permissible" explosives, which give a shorter and cooler flame than black powder. Coal-dust explosions can be largely prevented by wetting the walls of the mine, or by the new process of "rock-dusting," which consists of applying dry incombustible powdered rock to all surfaces. Unfortunately, none of these precautions are employed as generally as they should be.

The elevator used for hoisting in the mine shaft is called a "cage." After the mine cars reach the surface they pass upon an elevated structure called the "tipple." This is generally the most conspicuous feature of a mining property above ground, and provides facilities for screening and otherwise "preparing" the coal as it passes down chutes to the railway cars underneath. The more elaborate structure used for anthracite is called a "breaker"; it includes machinery for crushing the coal and arrangements for removing "slate" and other waste rock by hand picking or otherwise.

Coal mining in this country gives employment to an army of 765,000 men. The word "army" has a sinister appropriateness in this connection, since out of every thousand men employed in the industry three are killed and one hundred and eighty injured annually.

The World's Coal Resources

In order of output, the leading coal-producing countries of the world are: United States, Great Britain, Germany, Austria-Hungary, France, Russia, Belgium,
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Japan, China, India, and Canada. The total production during the latest year for which data are available was about 1,346,000,000 tons.

How long will the world's coal supply last? This is a question to which various answers have been given. Geologists are able to furnish a rough estimate of the amount of coal now in the ground and near enough to the surface to be mined; but with the growth of the world's industries the demand for coal is increasing by leaps and bounds, and nobody can safely predict how much will be needed at any future time.

The world's "coal reserves"—that is, the amount of coal remaining unmined—are estimated at 8,154,322,500,000 tons. In the United States it is estimated that we have used only four-tenths of one per cent. of our available coal supply. At the present rate of consumption the coal in this country would last about 4,000 years; but if the present rate of increase in consumption should be maintained, it would last only 100 years!

Fortunately for posterity there are sources of heat, light and power which are not, like the fuels, exhaustible. Water-power, for example, is a permanent asset, and there are other inexhaustible sources of energy, such as solar heat and the internal heat of the earth, which Man's ingenuity will someday turn to good account.

SUPPLEMENTARY READING

COAL CATECHISM  By W. J. Nicholls
THE STORY OF AMERICAN COALS  By W. J. Nicholls
A YEAR IN A COAL MINE  By Joseph Husband
YEAR BOOK OF THE U. S. BUREAU OF MINES

* * Information concerning these books may be had on application to the Editor of The Mentor.
Coal is "a burning question," that has to be met and answered every day. It supplies heat, light and power—and a thousand and one useful by-products—and it is an ever-present, ever-fruitful subject of public and private discussion. We average folk know something of the varied uses of coal in the big affairs of the world, but we know it more intimately and vitally in the forms in which it ministers to our own personal welfare. Coal, in our everyday—and night—life, means heat and light. It means home comfort—and if this "coal comfort" is denied us, or even curtailed, we raise an immediate and mighty outcry. And why not? The health of a community can be fatally affected by a few heatless days. The experience of the past winter has shown us how dependent we are on fuel, not only for luxury and comfort, but for life itself.

Why do we need so much heat? Many of the peoples of the earth get along comfortably with much less heat than we consider necessary. Europeans and South Americans call us a "steam-heated nation." Why do we have to surrender so completely and abjectly to the domination of Old King Coal? It is true, as Owen Meredith said: "Civilized man cannot live without cooks"; and light is all important in turning night hours to advantage; but why must we be so warm? Humanity was not created in a warm room, nor was the human race nurtured, in its infancy, by a coal fire or a gas stove. Primitive man was his own heater. He had to discover fire, and then exploit its uses. He was originally supplied by nature with a warm body, and he now finds artificial ways of making it warmer. Has not civilization pampered us to a point that has impaired our original heat-giving resources and substituted a forced warmth that has enervated us? The doctors tell us that many diseases come out of artificial heat—indoor diseases, they might be called—the diseases that are treated, and sometimes cured today, by foregoing artificial heat and going back to nature.

Does this mean that I suggest reverting to primitive conditions and giving up heat? No, indeed. I do not advocate giving up heat—suddenly. But letting up gradually on artificial heat, I do most earnestly advocate. Most of us live an over-heated existence—to the depletion of our health. The steam pipe, like a huge python, is closing its coils about us, and gradually stifling our native vital resources.

On the coldest days of winter a white-haired man, nearly seventy years of age, may be seen walking New York streets, without a hat, clad only in light "Palm Beach" trousers, and a silk negligée shirt, open at the throat. "He is crazy," you say: "Perhaps," I answer, "but at any rate he is healthy—and immune from cold." Heatless days mean nothing to him. On a raw, drizzling day in November last a slender man was playing golf in a light woolen suit. A companion player, weighing over 200 pounds, full blooded and hearty in appearance, and bundled up in two heavy sweaters, asked the lightly clad player if he was not afraid of catching a fatal cold. "No," he answered, "you are the one that gives me concern. If I had your clothing on I would be a sick man. I am not healthy enough to wear all those things.

Which means that we would be better off in health if we could accustom ourselves to less heat; if we could live as the people of some other nations do—comfortable and content with heat enough to take the chill off the air, and not demanding that we shall be "kept going" by means of artificial heat outside of our own natural heat-giving apparatus. We make caloric cripples of ourselves by giving crutches to nature in the form of roaring furnaces and hissing steam pipes. Fresh cold air is better for us than hot air—in winter as well as in summer. Would it not be worth while to form a national Fresh Air Fraternity, based on the principle of foregoing artificial heat and developing the original body caloric? We would then leave artificial heat largely to infants, weaklings and invalids; we would abolish several diseases altogether, improve the mortality rate, and be healthy, happy and vigorous. Incidentally, too, we would have more coal for cooking and other really necessary purposes.
IN THE HIGH SCHOOL

THE MENTOR is a part of our High School. Each day 192 pupils and 11 teachers have opportunity to partake of its splendid contents. Think of a big family of 200 enjoying it daily. I say daily because I have all the back numbers, and each day a new Mentor with all its gravures is displayed on a specially constructed rack in my recitation room. The important features to be found in it are enumerated on the blackboard, and after having pursued this method for a year I am anxious to tell you something about it.

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J. B. SHEETZ, Principal, McClellandtown, Penn.

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THE MENTOR IS PUBLISHED TWICE A MONTH
BY THE MENTOR ASSOCIATION, INC., AT 114-116 EAST 16TH STREET, NEW YORK, N. Y.
SUBSCRIPTION, FOUR DOLLARS A YEAR. FOREIGN POSTAGE 75 CENTS EXTRA. CANADIAN POSTAGE 50 CENTS EXTRA. SINGLE COPIES TWENTY CBNTS.

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I, Thomas H. Beck, Publisher, do hereby certify that the statements required by the Act of Congress have been made and filed by me. And it is hereby certified that the first publication of the issues containing such statements was at New York, N. Y., on April 1, 1918.

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MAKE THE SPARE MOMENT COUNT
WHILE the vegetable origin of coal is beyond question, two rival views are current among geologists to account for the deposit of ancient plant material in the form of coal-beds, such as we now find in the earth. One school of geologists holds that the coal plants grew in great lagoons and swamps, like the mangrove swamps of today, and that the modern coal-beds mark the locations of these swamps. From time to time these areas subsided and were flooded with water to such a depth that the plants were killed. Eventually the decayed vegetation of the former swamps was covered with a layer of mud or sand. Later a slow upheaval of the ground brought these regions again to the surface; a new swamp formed, only to be submerged again at a later period; and the same process was repeated several times in the course of hundreds of thousands of years.

The bulk of evidence seems to favor this view, but there is another. Perhaps the coal-beds are not the sites of former swamps, but of estuaries and ocean shores where the plant material settled down, in still water, after a long drift down the ancient rivers from its place of origin. It is not impossible that both explanations are correct; some coal-beds having been formed in one way, and some in the other. With the progress of time the deposits of sand were compacted into sandstone, and the mud and clay into shale; while the layers of vegetation were solidified by pressure, some of their constituents were vaporized and expelled by heat, and the final product was coal.

The coal-measures abound in fossil plants of species long ago extinct, and we also find the molds or casts of plants that have themselves disappeared, leaving only their impressions in the mud by which they were once enveloped. These records of ancient vegetation are mostly found in the rocks just above and below the coal-beds, and not in the coal itself.

The plants of the Carboniferous Period, during which most but not all of the coal-beds were formed, bore a family likeness to certain kinds of plants that flourish today. Many of them were ferns, ranging in size from the smallest species up to great tree-ferns. Others resembled our modern horsetails or scouring-rushes, with their fluted and jointed stems, but these *calamites*, as the geologists call them, grew to the size of trees, sometimes eighty or ninety feet in height. Some plants of the coal age were like the modern cycads (intermediate in appearance between tree-ferns and palms); some were like the ginkgo, a tree with leaves like those of maidenhair fern, widely introduced into this country from China and Japan. One of the commonest and largest trees was the *lepidodendron*, closely resembling, except in its vastly greater size, the club-moss or ground pine which we know so well as a Christmas decoration.

The animal life of the period, of which, also, abundant fossil remains are found, included mollusks, fishes, crustaceans, insects, spiders, thousand-legs, snails, reptiles and lizards. Some of the insects were a foot or more in length. Of cockroaches, alone, more than five hundred species have been found in the coal-measures.
WHEN a coal famine is upon us there is a grain of comfort in the reflection that beneath the soil of this country, and within 3,000 feet of the surface, there still lies 3,538,554,000,000 tons of coal. This is the estimate of the United States Geological Survey. We have mined coal wastefully and used it prodigally, yet we have taken from the ground, up to the present time, only a fraction of one per cent. of the total amount at our disposal. The whole of our “coal reserves,” if they could be extracted and placed in a great cubical pile, would form a mass 8.4 miles long, 8.4 miles wide and 8.4 miles high. If the coal thus far mined were piled up in the same way, the cube would be 7,200 feet long, 7,200 feet wide, and 7,200 feet high.*

The coal-producing areas of the country are divided into six great divisions, known as the Eastern Province, the Interior Province, The Gulf Province, the Northern Great Plains Province, the Rocky Mountain Province, and the Pacific Coast Province. The Eastern Province contains probably nine-tenths of the high-rank coal of the country. It is made up of the anthracite regions of Pennsylvania and Rhode Island, the Atlantic coast region of Virginia and North Carolina, and the great Appalachian region, which embraces all the bituminous and semi-bituminous coal of what is called the “Appalachian trough.” The state of Pennsylvania produces 47 per cent. of all the coal mined in the country, and nearly all of the anthracite.

The Appalachian region is the greatest storehouse of high-rank coal in the United States, if not in the world. “This nearby and almost inexhaustible supply of high-grade fuel,” says the Geological Survey, “has been the foundation of the development of the blast furnaces, the great iron and steel mills, and the countless manufacturing enterprises of the Eastern states.”

The Interior Province includes all the bituminous coal fields and regions near the Great Lakes, in the Mississippi Valley, and in Texas, and is made up of four distinct sections—the northern (Michigan), eastern (Illinois, Indiana and western Kentucky), western (Iowa, Missouri, Kansas, Oklahoma and Arkansas), and southwestern (Texas). The coal of this province is not, in general, of as high a quality as that of the Eastern Province, but it is very extensively mined, and is used for heating and for generating power in the many cities and towns of the Mississippi valley and the Great Lakes region. Indeed, extensive coal fields in proximity to rich agricultural lands have made possible the existence of such manufacturing centers as Chicago, St. Louis and Kansas City, and have been a leading factor in the development of the vast railway systems of the Middle West.

The Gulf Province is at present of little commercial importance. Its coal is mined only at a few places in Texas, and is mostly lignite.

The Northern Great Plains Province includes all the coal fields in the Great Plains east of the Front Range of the Rocky Mountains. The coals are of low rank, being either lignite or sub-bituminous, except in a few of the basins near the mountains. The largest coal region in this province is the Fort Union region, lying in the Dakotas, Montana and Wyoming. The amount of unmined coal in this region is estimated to be twice as great as that lying in the rich Appalachian region, but it has been little worked, as it is generally of poor quality.

The Rocky Mountain Province contains a greater variety of coal than any other province in the United States. It includes all ranks, from lignite to anthracite, but the prevailing ranks are sub-bituminous and low-grade bituminous.

The coal of the Pacific Coast Province is mined chiefly in the state of Washington, where it has aided in developing the industries of the Puget Sound region. Oregon and California have small fields, but the coal is of poor quality, and little mining has been attempted.

*These figures were furnished by Mr. M. R. Campbell, of the U. S. Geological Survey. They differ materially from figures previously published by the Survey.
THE STORY OF COAL

THREE

In times gone by coal was carried out of the mines on the shoulders of men and women, and then transferred in wheelbarrows to the sailing-vessels or wagons in which it was taken to market. In progressive mines of today the coal is loaded in the mine into small mine cars, which are hauled and hoisted to the surface by electricity or steam. The mine cars are dumped on an elevated platform called the "tipple," and the coal passes through chutes or conveyors to the railway cars waiting underneath to receive it. On its way downward it undergoes a more or less elaborate process of screening, breaking, picking, washing, etc., according to the kind of coal and the purpose for which it is to be used.

The coal reaches the market by three general methods of transportation: (1) All-rail; (2) rail to the seaports, where it is used for bunkering steamers or carried by vessels to other ports, foreign and domestic; (3) rail to the Great Lakes, especially Lake Erie ports, from which it is carried to ports on the upper lakes, and from the latter again by rail to markets in the interior. The railroads themselves use about one-fourth of all the coal mined in this country. The coastwise coal-carrying trade is mainly by wooden barges towed by steamers, though much coal is also carried by schooners, some of which can carry a cargo of 5,000 tons or more. About four per cent. of the bituminous coal output goes to foreign countries.

"The consumption of coal," says the United States Geological Survey, "is a measure of the industrial activity of a people, for as yet coal is the main source of mechanical energy. In this respect the United States is the foremost nation, its average annual consumption of coal for all purposes being about five tons per capita. Prior to the present war in Europe the consumption of coal per capita in England, Belgium and Germany was about four tons, in Russia a quarter of a ton, and in France about 1.6 tons."

Marvelous forms of labor-saving machinery have been introduced to facilitate the loading and unloading of coal. The principal form of apparatus for transferring coal either to or from a vessel is the "bridge tramway plant," which consists of long steel bridges mounted side by side on suitable rails so that they can be moved into place over the hatchway of a vessel. Huge buckets, which load and unload themselves, are carried on a "trolley," suspended from the bridge, and transfer coal at high speed from the vessel to the stock pile or railway cars, or vice versa. The cost of loading coal by this method is only a cent or two a ton.

Another ingenious device is the "caramp." This powerful machine picks up bodily from the railway track a car loaded with a hundred tons of coal, overturns it, and discharges its contents into the hold of a vessel; after which it returns the car to the track. It is capable of handling fifty cars an hour. It is equipped with special apparatus to prevent the coal from being discharged too violently, and thus being badly broken up.
THE STORY OF COAL

Coal Products

The story of the coal products forms one of the most romantic chapters in the history of applied science. The marvels of fairyland are surpassed by the achievements of the modern manufacturer in obtaining from mere black rocks dug out of the ground not only heat and light, but a bewildering variety of useful gases, liquids and solids—drugs, chemicals, dyestuffs, and so forth.

For hundreds of years it has been known that when coal is covered or enclosed, to keep out the air, and then heated for a certain length of time, instead of burning to ash it is converted into a porous gray-black substance called "coke." This material, which burns without smoke or flame, is a valuable fuel for many purposes: especially for use in blast-furnaces for the smelting of ore. Nowadays coke is made on a vast scale from certain grades of bituminous and semi-bituminous coal. The coal is heated in "coking-ovens," of which there are several kinds. The most common form of oven in this country is the "bee-hive oven," which produces coke only. Another type of coking-oven, more generally used in Europe than in America, is the "flue-oven," which produces, besides coke, a number of valuable by-products.

When coal is converted into coke it gives off combustible gases. The idea of saving these gases and using them for illuminating purposes was first practically applied in the latter part of the eighteenth century. "Coal-gas" is made by heating coal in a closed vessel, called a "retort." It is a mixture of hydrogen and methane (a compound of hydrogen and carbon), with small amounts of several other gases. Most of the carbon in the coal remains in the retort as coke, which is, therefore, a by-product in the process of making coal-gas. After the gas is given off from the coal it passes through a series of vessels, where, by chemical and other methods, it is freed from ingredients which would impair its value as an illuminant, but which are saved and used for other purposes; the most important of these are "coal-tar" and "ammoniacal liquor." The purified coal-gas is finally conveyed to a gas-holder or "gasometer," from which it is distributed to the consumers.

In recent times other methods of gas-making have come into use. In one of these nearly all the carbon in the fuel is turned into a combustible gas by passing air through the hot coal. The product is known as "producer-gas," and is very valuable for use as fuel and as a motive power in gas-engines, but it is not an illuminant. A modification of this process, in which steam is passed over the heated fuel, gives a mixture of hydrogen and carbon monoxide, known as "water-gas." This is also a valuable source of heat and power; but for use as an illuminant it must be mixed with a gas made from oil. It is then known as "carburized water-gas," and is very extensively used for lighting purposes; either by itself or mixed with ordinary coal-gas.

Of the by-products of gas-making, ammoniacal liquor was, until recently, the only commercial source of ammonia. Coal-tar, formerly thrown away as worthless, is today the source of innumerable substances of immense value to science and the industries. From coal-tar are obtained benzine, toluene, xylene, phenol (carbolic acid), naphthalene, anthracene, etc., and these more direct products are combined with one another or with other chemicals to produce coloring matters, explosives, perfumes, flavoring materials, sweetening substances, disinfectants, medicines, photographic developers—in short, a little of everything. The total number of coal-tar products runs into the thousands, and is constantly being increased by fresh discoveries.

In Germany, just before the war, the industries engaged in making these products (no longer by-products, but far more important than coke and gas) were capitalized at $750,000,000. One firm made no less than 1,800 coal-tar dyes, besides 120 pharmaceutical and photographic preparations.
SMOKING is a costly and injurious habit. This is not the beginning of an appeal on behalf of the anti-cigarette crusade, but the introduction to a few facts in regard to the far-reaching effects of smoky chimneys. The smoke nuisance is as old as the use of coal. In the fourteenth century a man was executed in London for befouling the air of that city with the fumes of “sea-coal,” as ordinary mineral coal was once called in England, because it was brought to London by sea. Under Queen Elizabeth a law was passed forbidding the burning of coal while Parliament was in session, as the legislators believed their health was likely to be impaired by the smoky air of the city. What would these bygone gentlemen say if they could see modern London enveloped in one of its famous “pea-soup” fogs—the color and denseness of which are entirely due to coal-smoke?

Smoke is injurious to health, destructive to vegetation, and fatal to architectural beauty; and, along with all this, it is enormously expensive. In the first place, a smoky chimney means imperfect combustion, and a waste of part of the heating value of fuel. Then a smoky atmosphere entails big laundry and dry-cleaning bills; frequent repainting of houses; injury to metal work; damage to goods in shops; excessive artificial lighting in the daytime. Pittsburgh was once the most famous American example of all these evils, but, it has recently reformed. Before the Mellon Institute of Industrial Research carried out its elaborate smoke investigation in that city, and, in consequence, stringent smoke-abatement ordinances were adopted, the annual smoke bill of Pittsburgh was estimated at nearly ten million dollars. The city was the paradise of the laundryman, and light-colored clothing was so little worn by the inhabitants that it was known as “the mourning town.”

Throughout the United States it is said that smoke causes an annual waste and damage amounting to half a billion dollars. No wonder numerous societies have been formed to mitigate this evil, and a great many laws have been enacted on the subject. With a gradual increase in the use of gas, coke and other smokeless fuels, and improved methods of stoking furnaces, the smoke nuisance is now happily abating.

The pollution of the air by smoke is the subject of systematic investigation and measurement at certain places in this country and abroad. Measurements of the “soot-fall” made in Pittsburgh a few years ago indicated an annual average deposit of soot in that city amounting to 1,031 tons per square mile. London’s average is 248 tons per square mile for the whole city and 426 tons in the central districts. In the heart of Glasgow the annual soot-fall is 820 tons per square mile.

In Great Britain there is a Committee for the Investigation of Atmospheric Pollution, which has installed standard measuring apparatus in sixteen English and Scotch towns. The soot is collected in a “pollution gauge,” consisting of a large cast-iron funnel, enameled on the inside. Projecting above the gauge is a wire screen, open at the top, to prevent birds from settling on the edge of the vessel. The gauge communicates at the bottom with one or more bottles for collecting rain-water, with its solid contents. The bottles are emptied once a month, when their contents are weighed and analyzed.

Smoke is injurious to the respiratory organs, conducive to eye-strain and responsible for a lowering of human vitality. The gloominess of a smoke-laden atmosphere also has a depressing effect upon the minds of many people.
SINCE the year 1870, some 60,000 men have lost their lives as a result of coal mining accidents in this country. This is approximately one fatality for every 180,000 tons of coal mined. Gradually this bad record is being improved, thanks to the combined efforts of the United States Bureau of Mines, the mining departments of the various states, the operators and the miners themselves; but coal mining remains a hazardous pursuit.

Falls of the roof are responsible for more accidents than any other single cause. These are likely to occur wherever the roof is not fully timbered; especially in the “rooms,” where the coal is being blasted out. Many accidents also occur in mine shafts, notwithstanding the various safety devices with which the “cage” or elevator is nowadays provided.

Fires and explosions attract a greater amount of public attention than other mining disasters on account of the large number of victims so often involved in a single occurrence of this kind. In the explosion at the Courrières colliery, in France, March 10, 1906, more than 1,100 miners perished. This mine had previously been renowned for its freedom from accidents.

Coal mine explosions are due to two principal causes, which may act either separately or in combination—fire-damp and coal-dust. Accumulations of fire-damp, or methane, locked up in the coal seams, are liberated by the removal of the coal. Frequently streams of this gas gush forth with a hissing noise, and are known as “blowers.” Fire-damp is explosive when combined with certain proportions of air. Apart from ventilation, which dilutes the gas below the danger limit, the principal precaution against explosives is the use of safety-lamps, so constructed that the gas cannot come in contact with a naked flame. An excessive amount of coal-dust in the air of the mine may also give rise to explosions. Such explosions may be prevented by wetting the dust, moistening the air, or powdering the walls, roof and floor with a non-explosive “rock-dust.”

After an explosion the air of a mine contains a large amount of the deadly gas carbon monoxide, and this “after-damp,” as it is called, makes rescue work extremely dangerous. Wherever suitable apparatus is available, the rescuers carry with them a supply of oxygen, by breathing which they are able to live for some hours in a poisonous atmosphere. The Bureau of Mines has established a number of rescue stations in the coal-mining districts and maintains several mine safety cars for hurrying rescue crews to the scene of a disaster. The Bureau also instructs the miners in first-aid and rescue work, and is directing a national campaign in behalf of “safety first” in mines.

Of the many methods that have been devised for testing the air of mines for noxious gases none is more interesting than the use of caged canaries. These birds are much more susceptible than human beings to the effects of carbon monoxide, and show signs of distress before a man begins to feel any discomfort from the gas. In many mines they are carried in routine inspections. After an explosion the number of rescuers equipped with oxygen apparatus is always limited. These form the advance guard, and are followed by men without apparatus, who carry canaries, by observing the behavior of which they can tell how far they may safely penetrate into the mine. The Bureau of Mines has devised a special form of cage in which the canary may be revived with oxygen after being overcome with gas. Experiments show that the bird may be asphyxiated and revived again and again without suffering any ill-effects; neither does he acquire an immunity to poisoning which would make him a less reliable indicator.