cable for hoisting in the deeper mines at Virginia City. The Comstock became the showplace of Western mining by utilizing the most advanced mining techniques available.

The Comstock Lode produced gold and silver valued at more than $105 million in 1873-82; moreover, in 1874-81, $74,250,000 was paid in dividends. Besides Hearst, others who reaped these rewards included the four bonanza kings, John W. Mackay, James G. Fair, James C. Flood, and William S. O'Brian (all from penniless Irish backgrounds); William C. Ralston, founder of the Bank of California; and a San Francisco financier, Alvinya Hayward.

Although relatively short-lived, the Comstock Lode generated important ramifications. Politically, the huge output of silver was a major factor in the movement to establish parity with gold in the Nation's currency. Technologically, the increased geological understanding of veins and the development of large-scale deep mining contributed to the revival of quartz mining in California and the beginning of underground mining in Utah and Nevada. These factors also inspired a boom in underground mining in Montana, Idaho, and the Southwest.

In 1866, as one of Nevada's first U.S. Senators, William M. Stewart maneuvered through Congress a lode-claims law that established three major points: First, it gave both retroactive and future sanction to the miners' exploitation of minerals in the public domain; second, it established a procedure for obtaining U.S. patents to mining claims; and third, it specified that existing local arrangements were to be respected and continued. (Similar laws applying to placer claims were passed in 1870.) In 1872, a revision listed the information required for local records, described how claims should be marked, and specified the minimum amount of work on a claim to avoid forfeiture. The revision also ruled that a lode claimant must locate his surface boundaries so as to embrace the apex of the vein. If he succeeded, he could follow the vein through the side limits of his rectangular claim (but not through the end limits) as they extended downward from the surface. This "Apex Law" led to millions of dollars of litigation regarding the geologically uncertain questions of whether the apex of a claim was within the boundaries and what parts of a deposit could be considered a downward extension of the apex. When replacement deposits became economically important, the words of the statute had to be bent to include a type of deposit not foreseen by Congress.

Near the end of the 1870's, Congress created a Public Lands Commission to investigate the public lands and land laws of the West. Although the local laws had been sufficient when mineral lands were not crowded and no alternative existed, the commission concluded that these laws had outrun their usefulness and should be abolished. Evidence revealed an extraordinary contrast in the cost and frequency of litigation in the mineral lands east and west of the Missouri River, and the commission blamed this on imperfections of local laws and the apex provision. Congress did not enact the major changes proposed by the commission, but the way was opened for a gradual displacement of these codes by a growing body of State and territorial legislation.

Colorado

Stories about Arapahoe Indians who shot golden bullets, an old mountain man who stumbled on a fabulous mine, and a trapper who returned to Missouri with gold nuggets kept alive rumors of a very rich mine in Colorado. The first recorded strike was made in the spring of 1850 when a party of miners bound for California stopped to try their luck on Ralston Creek on the South Fork of the Platte River. They found some gold, but not enough to detain them. A Cherokee Indian named John Beck who was with the group returned there with a Georgian, William Green Russell, in June 1858. Beck, Russell, and 70 other Indians and Georgians struck gold about 8 miles above the mouth of Cherry Creek. Later, they were joined by a group from Lawrence, Kans., led by J. H. Tierney, who formed the St. Charles Town Association and laid out a town east of the junction of Cherry Creek and the South Platte. Shortly afterward, another group from Missouri and eastern Kansas organized the Auroria Town Co. Interest then switched from gold mining to real estate speculation. In November, another party arrived from Leavenworth, Kans., under the leadership of William Larimer. Realizing that the two best townsites had already been claimed, Larimer appropriated the lands of the St. Charles Co. (since most of that party had returned to the East) and organized the Denver City Co. All this was in expectation of an influx of prospectors to the Pike's Peak country.

The speculators had guessed right. The Panic of 1857 provided the proper setting to promote the famous Pike's Peak gold rush. A barrage of propaganda spread through the Mississippi Valley when a trader who had visited the Russell party on the South Platte arrived in Kansas City with a sackful of gold dust. Disappointment and tragedy followed. The hopeful youths, needy farmers, and unemployed shopkeepers who responded were inexperienced as prospectors and miners and lacked the necessary financial backing. Many did not survive the trip to the Rockies. Most of those who did regretted their own gullibility and returned home cursing guidebook writers and Denver land speculators.

In January 1859, as the first "Pike's Peak or Bust" movement subsided, a Missourian, George A. Jackson, discovered placer gold on Chicago Creek, a small tributary of Clear Creek near the future site of Idaho Springs. He kept his secret until late April, when he returned to his strike with a few companions to operate a cradle. Shortly after, gold was found at Gold Hill in Boulder Canyon also. Neither Chicago Creek nor Gold Hill proved very rich, but they revived general optimism.

John S. Gregory found a rich outcrop of gold-bearing quartz on the North Branch of Clear Creek, at a place later named Gregory Gulch and presently the site of Black Hawk, Colo. Soon after, the hillsides along Clear Creek were covered with miners. Gregory sold his claim for $21,000 and accepted a fee of $100 per day to prospect for others.

Early mining concentrated where Gregory and Jackson had made their discoveries in Gilpin County, which became as well-known to miners as Nevada County in California and Storey County in Nevada. Located at an altitude of

8,000 feet and 35 miles from Denver, these mines could be reached only by rough, steep mountain roads (fig. 16).

During the remainder of 1859 and throughout 1860, most of the central Rockies was prospected. Gold was discovered at Russell Gulch and Spanish Diggings along the South Fork of Clear Creek near Idaho Springs, at Jefferson Diggings and Twelve Mile Gulch of the Boulder River, and in the waters of Tarryall and Fairplay Creeks of the South Park region. Later strikes were made in California Gulch of the Arkansas River, near the present site of Leadville, and across the Continental Divide on Blue Creek, a tributary of the Colorado River. Denver doubled its population by 1860 and other towns sprang up nearer the mines: Boulder at the mouth of Boulder Creek, Golden on Clear Creek, Canon City and Colorado Springs along the road to South Park, and Pueblo at the gateway to the Arkansas River mines.

Both placer and vein mining developed quickly. At this stage, the severely eroded vein deposits were not readily distinguishable from true placers until they were mined deeper. The gold was separated by rockers, long toms, and sluices, methods similar to those used in the early days of California. Mining districts and codes were patterned after California prototypes although, unlike California, lode gold was important from the very beginning. From 1858 to 1867, about 40 percent of Colorado gold came from lodes. The gold produced during this decade has been estimated at only $25 million, however, much smaller than the production in California and Nevada.

Colorado's surface gold ores were rich and free of sulfides; yields were good and the gold amalgamated readily. At depths below 100 feet, the enriched, weathered ores gave way to leaner ores containing sulfides. These ores were not only more expensive to mine, but also were difficult to treat metallurgically; only 50 percent or less of the potential value of the ore could be recovered by amalgamation. The only way to recover more was by smelting. This problem was tackled by Nathaniel P. Hill, a teacher of applied

FIGURE 16. - Mining in Gilpin County, Colo.

chemistry at Brown University in Providence, R.I. Financially backed by some New England industrialists, he traveled to Colorado to observe the metallurgical difficulties, and to Great Britain and Europe to study smelting techniques. He shipped several tons of Gilpin County ores for testing at the Welsh smelting center at Swansea. Finally, he built a modified version of the Swansea smelter at Black Hawk. Although it was technologically successful, the operating cost was so high that only the richest ores could be smelted at a profit.

Another boon to the Colorado mining industry was the coming of the railroad. The Union Pacific extended to Cheyenne, Wyo., 110 miles north of Denver. The Denver and Pacific Railroad was built in 1870, and the Kansas Pacific, from Kansas City to Denver, was completed later the same year. The Colorado Central ran first to the foot of the mountains at Golden and later up Clear Creek Canyon, reaching Black Hawk in 1872.

In 1878, the Boston and Colorado Co. moved their smelter from Black Hawk to Denver, a more central location for fuel and ore. By that time, coal and coke were replacing charcoal as metallurgical fuel and the ores could be obtained from other districts as well as Gilpin County. Other mining firms followed Boston and Colorado's move to Denver, and the city soon became a major smelting center.

At California Gulch, a placer mine at the head of the Arkansas Valley, 10,000 feet above sea level, gold-washing operations were hindered by heavy sands and rocks. After nearly 10 years, two miners correctly guessed that these deposits were rich in silver. Fortunately, the St. Louis Smelting and Refining Co. hired August R. Meyer, a metallurgist educated in Freiburg, Germany. Meyer identified the ores as lead carbonates; in 1877, he built a smelter at a place that became the town of Leadville. By 1880, Leadville, with a population of 14,820, was the second-largest city in Colorado. During Leadville's boom period, its annual silver output exceeded that of any foreign nation except Mexico, and lead output was nearly equal to that of England. The area ranked next to the Comstock in silver production. As the Comstock Lode declined in 1878-1880, Leadville ascended; its first big year was 1878. Annual silver production climbed to \$11.5 million by 1880. Lead produced during the boom was valued in excess of \$2 million per year. Copper production began in 1884 and zinc in 1885 (fig. 17).

In 1872, Clarence King, a geologist who became the first Director of the U.S. Geological Survey, directed a geological survey of the mountainous region of the West along the 40th parallel (69). The survey was sanctioned by the Federal Government under the auspices of the Army Engineers. After its inception in 1879, the Geological Survey examined questions of direct and immediate interest to the mining industry. The first Far Western mining districts studied in detail were the Comstock Lode, Eureka, Nev., and Leadville, Colo. The resulting monograph on the Leadville District, prepared by Samuel F. Emmons, head of the Rocky Mountain Division of the Survey is a classic in geology and mining technology (23). Emmons concluded that the Leadville ores occurred as replacement deposits in limestone. These ores are typical of the lead-silver deposits of the Rocky Mountains and Great Basin.

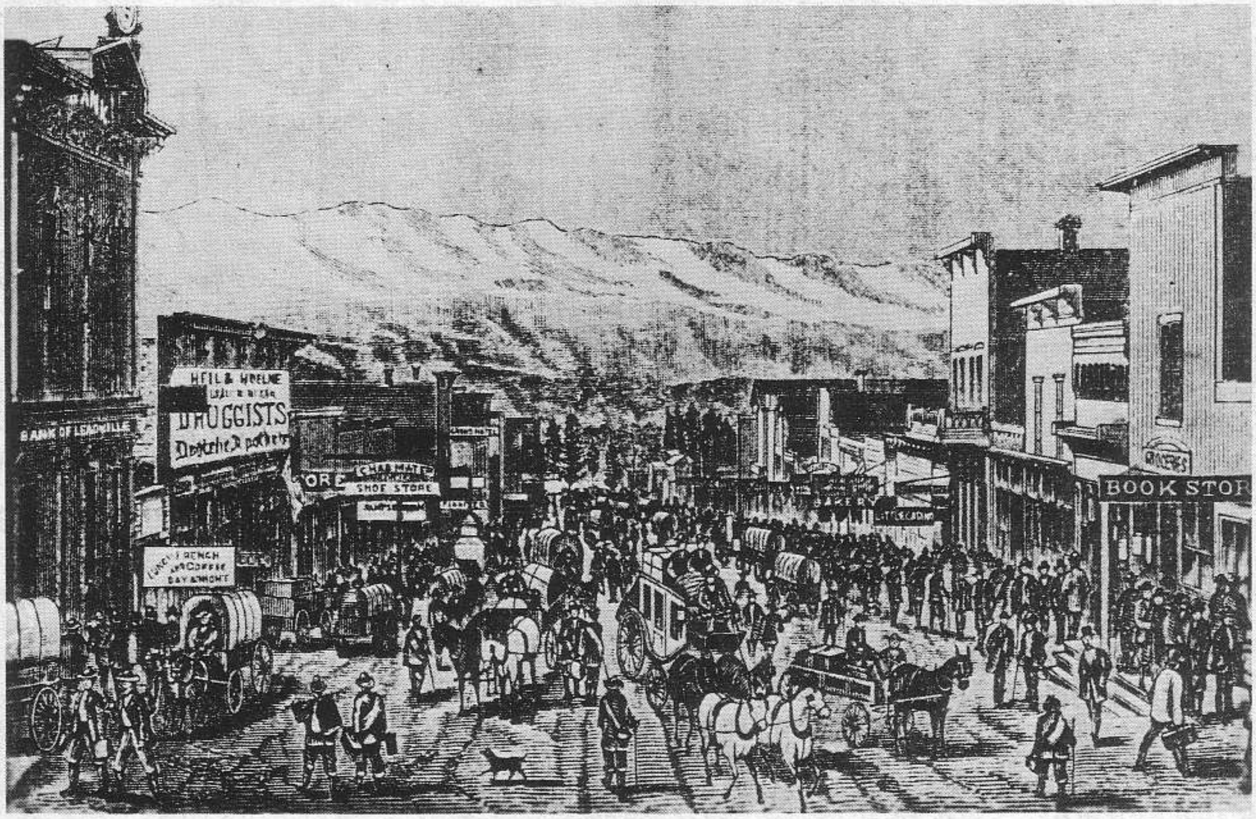

FIGURE 17. - Leadville, Colo.

Another Geological Survey team found that the Eureka, Nev., deposits were similar to those of Leadville. The monographs on Leadville and Eureka provided a scientific basis for understanding the most important types of Western ore deposits. With their appearance, geology, mining, and metallurgical engineering were recognized as essential disciplines for developing the mining industry.

In 1890-91, another gold strike at Cripple Creek, near Pike's Peak, was treated with skepticism for several years, thereby retarding the onset of the usual rush. By 1894, however, Cripple Creek was a thriving town of 10,000 people. The Cripple Creek ores occurred as sylvanite or gold and silver tellurides.

Modern methods of mining came of age in Colorado. The Burleigh compressed air drill was first used in Colorado in the late 1860's; it was widely employed there for driving tunnels in the early 1870's before it was used in California and Nevada. Electrical power was introduced in mines at Aspen, Colo., when a streetcar motor was used for hauling and hoisting. For three decades following the initial discovery of gold in California, the centers of mining were California and Nevada. Early in the 1880's, Colorado took the lead, California was second, and Nevada, third. Although Colorado dominated throughout the remainder of the 19th century, the importance of Utah, Idaho, Montana, Arizona, and New Mexico rose steadily.

The Great Basin

Much of the silver in the Great Basin occurred as complex ores combined with lead, zinc, and copper; also, much of it was found in large irregular replacement deposits instead of veins. The silver and base metals could not be recovered from these deposits by simple amalgamation, but required smelting.

Few miners of the early West had the theoretical understanding and practical knowledge to attempt to build and operate a smelter. Moreover, the Great Basin ores presented smelting problems no one had encountered before. In 1871, 20 smelters operated in Nevada; few of them were profitable, even though they treated only the richest ores in their respective localities. In part, the trouble arose from building too many small local smelters that were dependent upon uncertain ore supplies and insufficient timber for charcoal.

Thomas H. Selby's San Francisco smelter was the exception. Selby, a forty-niner originally from New York, founded the San Francisco firm of Thomas H. Selby and Co., importers of metal and merchandise. His business interests included a shot tower and lead-pipe manufactory for which he had to transport pig lead from the East. After the discovery of silver-lead ores in the West, he built a smelter at North Beach, San Francisco, in 1867. Selby was able to hire skilled supervisors and labor and his location was ideal for obtaining ores from many sources. In 1869-70, he bought ores from 20 mines in California, Nevada, and Arizona, and transported most of them to San Francisco by the newly constructed Central Pacific Railroad. Even before constructing his plant, Selby established an ore-buying office on the Colorado River to ship to San Francisco by water.

The first successful silver smelter within the Great Basin was on the Humboldt River in northwestern Nevada. A. W. Nason built it at the settlement of Oreana, located on the line of the prospective Central Railroad. To assure a steady supply of ore, he bought the Montezuma mine, 3 miles away. Nason used European smelting methods that were technologically successful, but only marginally profitable. When the railroad arrived, the smelter had a short period of prosperity because the base-metal byproducts, lead and antimony, could then be shipped to the Selby plant in San Francisco. Eventually, Nason suspended operations when he became involved in litigation.

Silver-lead ores were discovered in 1864 in Eureka, Nev., the first important center of silver-lead smelting in the United States. Attempts in 1866 and 1868 to operate small smelters subsequently failed. In 1869, a local mining man hired two experienced Welshmen to operate a smelter that consequently proved successful. This led to the organization of the Eureka Consolidated Mining Co., which hired W. S. Keyes, a Freiburg-educated engineer and metallurgist, to be general manager. Keyes had operated a smelter in Argenta, Mont., from 1866 until he realized the economic impracticality of this remote region. Keyes and Albert Arents, his principal associate, erected several European-style furnaces which they improved and modified over the next 15 years. The U.S. Geological Survey Monograph published in 1884 credited Eureka with the production of $60 million worth of precious metals plus 225,000 tons of lead.

Silver was found in southeastern Nevada in 1863, but very little happened in the area until a San Francisco financier, F. L. A. Pioche, bought a group of claims and erected the mining town of Pioche. Early smelting experiments failed because the ores contained too little lead. Subsequently, the promoters realized the suitability of the Washoe pan process for these ores. The town experienced a brief boom from 1870 to 1873, and reached peak production of $5,364,000 in 1872. By 1875, the richest ore from the upper levels was nearly exhausted and flooding was encountered at a depth of 1,200 feet. Thereafter, the camp slowly declined. It was almost deserted by 1885, but had a renaissance in the 20th century.

One of the most remarkable silver ores occurred in eastern Nevada in the White Pine Mining District. An outcrop of silver chloride, mineralogically known as cerargyrite or horn silver, was found by an Indian directing a prospecting party to the summit of Treasure Hill, a mountain 9,000 feet high. After a brief period of skepticism, people hurried eastward from California and westward from Salt Lake City. Capital arrived from San Francisco and Great Britain. A total of 13,000 small mining claims were filed in 2 years. The chloride ores were so rich that the slope of Chloride Flat on Treasure Hill looked like the early California placer goldfields. Stamp mills and smelters were hastily and expensively built in much greater numbers than necessary. The boom was short lived. Born in 1868, it peaked in 1872 when silver production was valued at slightly more than $2 million, and died by 1875. When a Great Basin mining camp failed, its decline was likely to be sudden and complete. Lumber was so scarce and costly that the buildings were torn down; the boards and beams were reused in other towns, sometimes many miles away. Likewise, stamp mills were carted off to be erected at other sites.

Utah

Mining in Utah followed a course different from other parts of the West. Utah was settled by the Mormons who migrated west for religious reasons rather than for gold. Moreover, Brigham Young and other leaders of the Mormon Church viewed mining with cautious reserve. They feared a mining boom might disrupt the peaceful, ordered society they were trying to establish, despite the fact that the California gold rush was largely responsible for the early survival of the Salt Lake Valley settlement. A Utah historian (4, p. 64) concluded:

> "The effect of the Gold Rush upon the Mormon economy of 1849 and succeeding years is clear and unmistakable. Faced with hunger, inadequate clothing, poor housing, and a gross insufficiency of tools and equipment, the Mormon colonists would most likely have had to give up--or at least postpone their dreams of a Great Basin empire had not the Argonauts passed through, strewing their many

> and varied benefits. As a result of the discovery of gold in California, the Mormons were able to provide themselves with a convenient circulating medium, and, in addition, they were able to acquire the wherewithal with which to launch giant immigration, colonization, and other programs essential to the growth and development of their projected Kingdom."

The initial development of mining in Utah resulted from the decision to garrison Utah with the Third California Volunteers during the Civil War. As might have been expected, the California Volunteers were more interested in prospecting than soldiering. Moreover, their commanding officer, Col. Patrick Conner (later a general), encouraged prospecting because he realized that a mining boom not only would be profitable personally, but also would attract a large Gentile population to counter the dominant influence of the Mormons. Conner's men discovered a placer in Bingham Canyon, just south of the southern tip of Great Salt Lake. Reportedly, it produced $1 million from 1865 to 1872. Even more significant was their discovery of veins of gold, silver, and base metals in the Wasatch Mountains and in minor ranges along the eastern edge of the Great Basin.

The Mormon Colony also profited from gold discoveries in Colorado. Wagon trains loaded with grains and other produce from Utah made the 500-mile trip across the Continental Divide to supply the Colorado goldfields. Similarly, the Utah territory supplied the mines of Idaho, Montana, and Nevada. As a result of this trading, merchants and bankers, not all of them Mormons, grew wealthy in Salt Lake City. These men welcomed the opportunities to invest in mining developments that evolved with the arrival of the railroad in Utah in 1869. The Mormon Church built branch lines to connect Salt Lake City and other parts of Utah with the main line of the Union Pacific at Ogden, Utah, thereby enabling Salt Lake City to become a center of smelting and ore processing. While many small smelters were built near the mines in the districts south and southeast of Great Salt Lake, the more important and prosperous ones were located near Salt Lake City.

In 1870, the Mormon Church sponsored a cooperative association to develop the iron deposits of southwestern Utah; the Union Iron Works produced up to 2,500 pounds per day of pig iron and supplied the local silver and lead stamp mills with its products. In 1873, the association's capital resources expanded into the Great Western Iron Mining and Manufacturing Co., which increased production to 5 tons per day of iron and manufactured iron products such as stoves, sheet iron, and mining machinery. The Utah Iron Manufacturing Co. acquired these facilities in 1881 to experiment with iron manufacture, but litigation with a wealthy non-Mormon over the ownership of mining claims delayed progress. In 1884, the church leadership and the Board of Trade organized the Iron Manufacturing Co. of Utah. One-fourth of the $250,000 capital stock was subscribed by the church. The company hired an experienced iron monger, built a furnace, foundry, and storehouse, and bought the small Pioche and Bullionville Railroad. The rails, cars, and equipment were used to transport coal to the furnace. About this time, the church encountered difficulties with the antipolygamy movement, and further efforts to develop Utah's iron and coal resources were forestalled.

Perhaps the most important mining development was the evolution of the Utah Copper Co. This was the forerunner of the large low-grade porphyry copper mines of today. The story begins with Col. Enos A. Wall, who had mined in Colorado and Montana previous to his arrival in Utah in 1868. In 1887, he was attracted to a discoloration on the hillside of Bingham Canyon. Upon close examination, he identified the outcrop of igneous rock as monzonite. It was impregnated with copper that assayed an average of 3 percent over a distance of 300 feet. Analysis of specimens from an abandoned tunnel identified copper sulfide minerals, chalcocite, and bornite, and numerous panning tests indicated that a 30- to 40-percent-copper concentrate could be produced. Since this ground had been abandoned, Wall began locating claims in anticipation of exploiting the deposit on a large scale.

In 1895, a mining entrepreneur, Capt. Joseph R. DeLemar, examined Wall's prospects at Bingham. His test on 76 tons of the ore in a small stamp mill recovered 60 to 62 percent of the copper in a concentrate assaying 28 to 33 percent copper. DeLemar was not encouraged, for the price of copper had fallen from 12 to 9-3/4 cents per pound. The ores were sampled and tested again 3 years later by Robert C. Gemmell and Daniel C. Jackling, engineers who had joined DeLemar's staff. Jackling's report estimated the ore reserves to be more than 12 million tons averaging 2 percent copper, plus another 25 million tons of probable ore. Samples tested with stamps, Wilfley tables, and a Frue vanner showed a potential recovery of 71.7 percent of the copper as a concentrate containing 22 percent copper.

Soon after his examination, Jackling left DeLemar's employ. In 1901, he became a consulting engineer in Colorado Springs. With the financial backing of his Colorado associates, Jackling worked out a deal to purchase DeLemar's interest in the property in Bingham for $125,000. Wall received $420,000 for a 55-percent interest. In June 1903, Utah Copper Co. was organized under the laws of Colorado and 500,000 shares were issued at $1 each. In 1904, it was reorganized and registered in New Jersey with capital assets of $4.5 million at $10 per share. In 1936, Kennecott Copper Co. acquired the assets.

By 1942, the Utah Copper mine had become the most productive in the world. At that time, nearly 300 million tons of ore containing more than 2 million tons of copper already had been mined. An estimated 640 million tons of ore reserves containing 1.07 percent copper remained. Stripping operations that removed 80,000 to 120,000 tons of waste preceded the mining. Using open pit methods, the ore was extracted from a series of benches extending up the mountain, loaded onto trains by electric shovels, and transported to concentrating mills with a capacity of 90,000 tons per day (fig. 18).

The advent of the flotation process contributed to the success of the low-grade copper mines in Utah, Montana, and Arizona. Flotation became the universal method of concentrating base metal ores, copper, lead, and zinc, as well as many precious metal ores. The process separates finely ground minerals, particularly sulfides, from gangue minerals and from each other. Small amounts of surface-acting chemicals introduced into an aqueous pulp cause the mineral particles to adhere to finely divided bubbles generated in

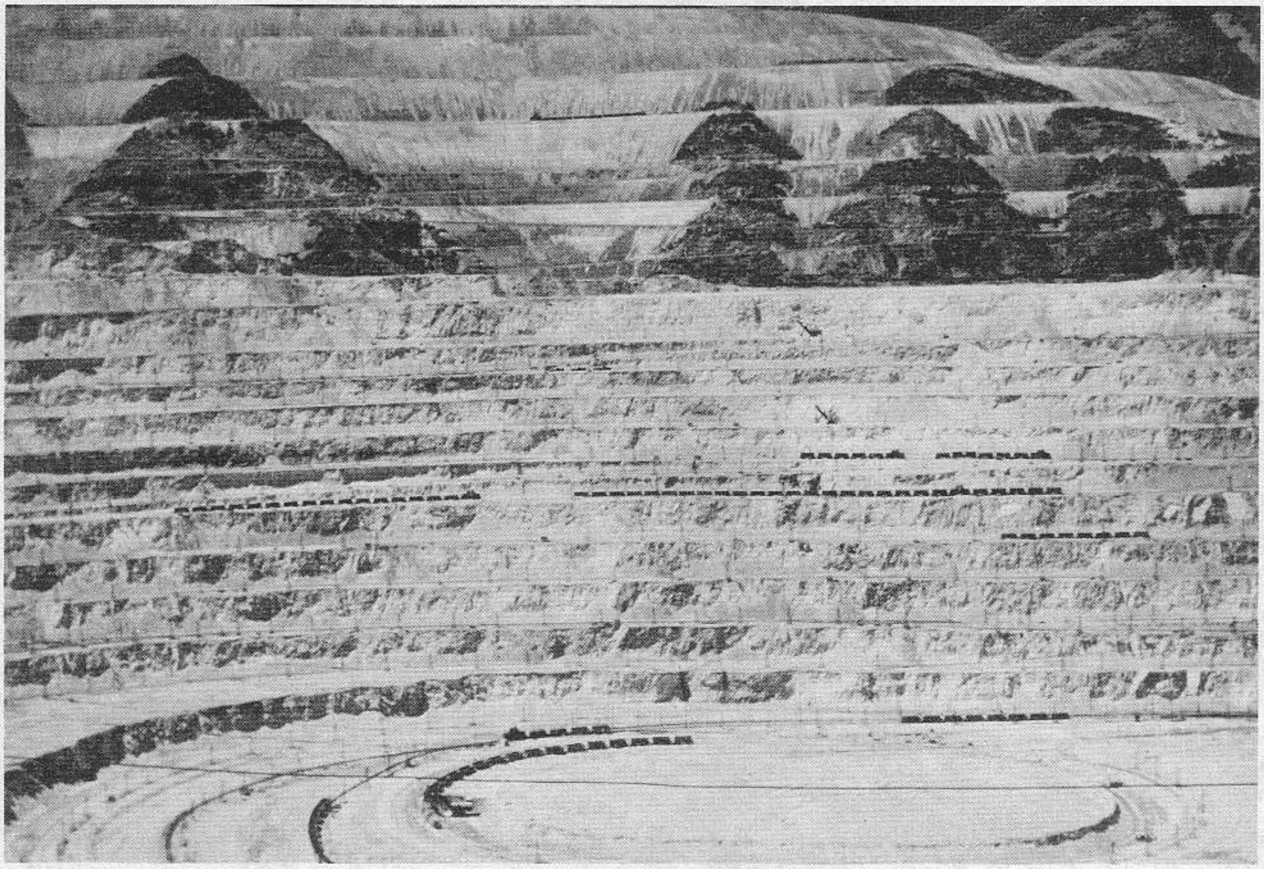

FIGURE 18. - The Utah copper mine, Bingham, Utah.

the pulp; then, they float to the surface. The concentrated mineral froth is skimmed off the surface; the tailings, or rejected minerals, are discharged with the underflow. Consequently, it is possible to recover more than 90 percent of the valuable minerals as one or more concentrates.

Idaho and Montana

Of all the regions opened to mining in the 1860's, Idaho and Montana offered prospectors the greatest opportunity since California. The area contained rich, extensive placer deposits, which could be worked with simple equipment, and promising lodes of gold and silver. Gold was discovered in northern Idaho in 1860 at Orofino Creek, a tributary of the Clearwater River. The great placers of the Boise Basin, discovered in 1862, were the most productive in Idaho during the early 1860's. Waldemar Lindgren of the Geological Survey estimated that the Basin produced $3 million in 1863, $4 million in 1864, and $5 million in both 1865 and 1866. This was more than Colorado's entire production in the same years.

Active mining in Montana followed that in Idaho by a few years. Discoveries were made at Bannock in the summer of 1862, at Alder Gulch

(Virginia City) in 1863, and at Butte and Last Chance Gulch (Helena) in 1864. The ore deposits occurred mostly in gulches and high mountain valleys. The mining camps were difficult to get to and to live in. Transportation within the territory was arduous and expensive, and transportation to the outside world was even worse. The water route via the Missouri River was described by Rossiter Raymond as "tedious and precarious." The 450-mile land route via the basaltic plains of the Snake River was no better.

Eventually, Montana mining centered around Butte, near the spot where G. O. Humphrey and William Allison had found placer deposits in Silver Bow Creek in 1864. By 1867, the town had grown to between 400 and 500 inhabitants, but a water shortage caused many to leave. The census of 1870 listed only 241 people.

Mining the veins and constructing processing plants proved too expensive and complex for local miners to attempt. In the 1870's, William A. Clark, Samuel T. Hauser, Andrew J. Davis, and Marcus Daley began to invest in Montana. Initially, silver was of primary interest, but eventually it became evident that copper ores were more important. High-grade silver and copper ores were first transported 400 miles by ox and mule wagons to the nearest railroad in Utah, then shipped by rail to smelters in Utah and Colorado and to Omaha, Nebr., Baltimore, Md., and Newark, N.J., for shipment to Germany.

Ore shipped by William A. Clark to the Boston and Colorado Smelting Co. smelter at Black Hawk, Colo., produced such good results that the company joined Clark to create the Colorado and Montana Smelting Co., which built a profitable copper smelter at Butte in 1879. Meanwhile, a shipment of Butte silver ore proved so rich that the Walker brothers of Salt Lake City sent Marcus Daley to the area to examine and purchase mining claims. Daley's long mining experience extended to California, Nevada, and Utah, and included a stint as a mine foreman on the Comstock Lode. After developing a mine and mill for his Utah employers, he took an option on another silver mine, the Anaconda, for himself. To finance his venture, he appealed to George Hearst and two of Hearst's associates, James B. Huggin and Lloyd Tevis. Realizing that his mine was very rich in copper, Daley proposed a huge investment to mass-produce the copper. After some hesitation over such a venture, his associates agreed to back him.

Initial smelting operations at Butte did not attempt to produce metallic copper; the final product was matte containing 60 to 70 percent copper, which was later refined in Swansea, Wales. The first complete smelter in Montana was built in 1883 at Anaconda.

For many years, copper ores were smelted in blast furnaces, which had a larger capacity and operated more economically than the small reverberatories then in use. Although the blast furnace was excellent for coarse ores, the reverberatory was more suited to smelting fines and concentrates. As the richer ores were depleted and mining of the lower grades increased, concentrates composed a larger proportion of the feed to the smelters. Consequently, emphasis shifted to reverberatory smelting and long, continuous reverberatory furnaces were developed. The flotation process developed in 1910 made it possible to concentrate nearly all copper ores and, as a result, reverberatory furnaces completely replaced blast furnaces for copper smelting. The copper sulfide matte from the reverberatory furnaces was converted to metallic copper by blowing it with air in a copper converter that operated much like a Bessemer steel furnace.

Idaho's rich silver-lead ores were developed more slowly than Montana's mineral deposits because access to rail transportation came later. Eventually, two railroads built to connect to the Pacific coast crossed through Idaho: One was a branch of the Union Pacific that followed the route of the Oregon Trail; the other, the Northern Pacific, crossed the narrow panhandle north of Lake Pend Oreille. The railroads first advertised the rich Coeur d'Alene District as a gold region and caused a rush there in 1884; but soon it became evident that the real wealth was in the silver-lead ores. Capital arrived from San Francisco, Portland, and Montana, and the Coeur d'Alene District became a major source of lead, silver, and zinc.

New Mexico and Arizona

New Mexico and Arizona developed their mineral deposits more slowly than the other Western States because of problems with hostile Indians, poor transportation, and the desert climate. The Apaches and Navajos were among the most militarily competent Indians in North America. Although western Arizona was accessible to ships traveling up the Colorado River from the Gulf of California, the rest of Arizona and all of New Mexico was landlocked. Access to the outside world did not occur until the railroads arrived in 1878 to 1883, when the Southern Pacific and Santa Fe finally built parallel lines across Arizona and New Mexico; a line was also run down the Rio Grande Valley to El Paso, Tex. Kit Carson's conquest of the Navajos in 1863-64 led to a permanent treaty in 1868. Some of the Apache bands were defeated and forced into reservations in the 1870's, but others remained hostile until the 1880's.

Actually, minerals were discovered very early in New Mexico, long before it was part of the United States. Cabeza de Vaca, who was probably the first European to enter the Southwest, reported "many signs of gold, antimony, iron, copper, and other metals." The first recorded mining claim was filed there in 1685. It was not until 1801, however, that significant mining began at the copper deposits of Santa Rita in the southwestern part of the State. Long before that, the Indians fashioned crude utensils from copper they had mined from this mountain. Each year after 1804, about 4 million pounds of copper were mined, crudely smelted into 150-pound ingots, and carried by muleback to Mexico City. Although lead and zinc were also important, copper became New Mexico's principal metal product.

The Ortiz Mountains between Albuquerque and Santa Fe became the oldest gold-mining district within the present boundaries of the United States when gold was discovered there in 1828.

In 1863, Magdalena and Socorro were the centers of silver mining, but Silver City ultimately became the leader. By 1916, annual silver production peaked at a value of more than $1 million.

Some disappointed California forty-niners first struck gold in Arizona in 1853. The strike was made where the Gila River joins the Colorado, about 20 miles from Yuma City. Gila City, the mining camp established at that isolated spot, became the most wide-open town in the West. Even though the mines were exhausted by 1864, they yielded $2 million in gold during their brief existence.

The gold and silver mines of the Tucson area in southern Arizona were more enduring. Acquired by the United States in the Gadsden Purchase of 1853, this area was occupied 3 years later when Fort Buchanan was built 20 miles east of the border village of Tubac as a protection against the Apaches. Charles D. Poston, a Kentuckian, and Herman Ehrenberg, a German, joined forces in San Francisco to form the Sonora Exploring and Mining Co., which opened eight mines in the Santa Rita and Cerro Colorado Mountains. Shortly after, mines in the Santa Cruz Mountains were opened by Sylvester Mowry, a West Point graduate. Both operations stopped completely during the Civil War when troops were no longer available for protection from Apache attacks.

In 1877, Arizona experienced one of the last big rushes when a prospector named Ed Schieffelin discovered rich silver mines. According to the legend, when Schieffelin set out to prospect Apache-infested southeastern Arizona, he was asked his destination. Upon hearing his reply, "To look for stones," a soldier warned him, "The stone you find will be your tombstone." Hence, he named his first claim the Tombstone, which became the name of the district.

Arizona copper mining began at Ajo in 1854, about a year after the Gadsden Purchase from Mexico, when a group of entrepreneurs organized the Arizona Mining and Trading Co. to mine outcrops of copper ore. Initial operations were frequently interrupted by Mexicans, who were uncertain about the exact position of the new international boundary. The first ore was shipped from an area that later became the western end of the New Cornelia Workings; it was hauled in oxcarts 100 miles across the desert to San Diego. Later, shipments were hauled to Yuma, floated on barges down the Colorado to the Gulf of California, and then shipped to Swansea, South Wales, for smelting. Ajo imported Arabian camels to carry water from the Gila River.

The Ajo mine, first called the Cornelia and later the New Cornelia, experienced the usual vicissitudes until improvements in mining, metallurgy, and transportation brought about conditions favorable for mining low-grade ores. In 1913, the property was acquired by the Calumet and Arizona Mining Co. The company's experiments on a leaching process led to a 40-ton pilot plant that operated for a year and then, in 1917, to a large plant with a daily capacity of 5,000 tons. Following further experiments on concentration by sulfide flotation, a 6,000-ton flotation mill was built in 1924. Water was supplied by tapping the water table of the region with a shaft 650 feet deep about 6 miles away. Four pumps delivered 4,550 gallons per minute to Ajo for drinking and cooking, and also supplied the mill.

In 1865, a regiment of soldiers in pursuit of Indians began prospecting and discovered copper ore in Graham County, later known as the Clifton District. Mining in earnest began in 1870 in Gold Gulch, 2 miles west of

Morenci, and in 1871 at the Longfellow mine. Copper ore was first smelted in Arizona in 1875; the ore was from the Longfellow mine. In 1882, a Scottish company, the Arizona Copper Co. took possession of the property in this district. During the same year, a narrow-gage railroad was built 70 miles to Lordsburg, N. Mex., where it connected with the Southern Pacific. Extending the railroad into Arizona not only facilitated transport of the copper to markets on the east coast, but also made it possible for smelters at Clifton and Globe to obtain a variety of ores, thereby making smelting operations profitable.

The copper deposits of Bisbee were originally discovered in 1877 by Jack Dunn, an Indian scout. The Copper Queen deposit was discovered in the same year and registered, or "relocated," as the Copper Queen in 1879. A small smelting furnace, a water-jacketed cupola, was built in 1880 to smelt high-grade ore containing 23 percent copper. In 1881, James Douglas came to Bisbee as the agent for the Phelps-Dodge Co. and took an option on the Atlanta claim, which was next to the Copper Queen. Unsuccessful at first, he eventually found an ore body that became the basis for a great copper enterprise. In 1885, the Phelps-Dodge Co. acquired the Copper Queen. Only oxidized ores were mined until 1893, when converters were added to the smelting plant to recover copper from the increasing amounts of matte produced. In 1906, 35,855 tons of copper, 332,300 ounces of silver, and 7,500 ounces of gold were extracted. From 1885 to 1930, the Copper Queen yielded more than 29 million tons of ore. Metals extracted from this ore amounted to 1.37 million tons of copper, 49,580 tons of lead, 20.45 million ounces of silver, and 486,690 ounces of gold.

The blue and green copper carbonates in the outcrop of the United Verde ore body were used as pigments by the Indians before Europeans arrived. The first mining claim in the future Jerome District was located by Alfred Sieber, a well-known scout, in 1877; he named it the Verde. In 1883, the United Verde Copper Co. was organized, with James A. MacDonald as president and Eugene Jerome, after whom the town was named, as secretary-treasurer. During the last 5 months of 1883, 2 million pounds of matte and black copper were produced at an operating cost of 7 cents per pound. The black copper contained 94 percent copper and the matte, 60 percent. These products were hauled to Ash Fork, the most accessible point on the Atlantic and Pacific Railroad, which had been extended into Arizona in 1882. After a few years, the ores that could be worked at a profit were depleted and by 1887 operations ceased.

In 1888, W. A. Clark of Montana bought the property and reopened the United Verde the next year. He built a narrow-gage railroad in 1894 to connect with the newly built Santa Fe at Jerome Junction and also a smelter with a capacity of 3.5 million pounds per month of copper. Unfortunately, it was placed over the mine workings and had to be moved when settling ground endangered it. A new smelter was built at Clarkdale in 1915, at the same time the Santa Fe Railroad built a standard-gage branch to this point. From the date of Clark's purchase to 1930, the mine yielded more than 20 million tons of ore that produced about 980 thousand tons of copper, 1 million ounces of gold, and 34.6 million ounces of silver.

The birth of Globe as a mining center occurred when the Silver King mine was discovered in 1874. Globe had a good supply of water from Pinal Creek and became a distributing point for mining in the surrounding area. For a decade, the mine produced silver and gold rather than copper. Copper operations began when the Old Dominion smelter was constructed at Globe. By 1886, Globe had six furnaces, but at the end of the year a drop in the price of copper to 11 cents per pound forced all of them to shut down. In 1892, Phelps-Dodge Co. purchased the United Globe mines and acquired many claims in the Miami area. In 1903, the company gained control of the Old Dominion.

During the remainder of the 19th and into the 20th century, Arizona mining was characterized by the development of large, low-grade deposits that had awaited the development of metallurgical techniques and adequate railroad transportation to make them economically successful. Although the rich ores of Bisbee and Jerome had attracted the original capital and engineering skill, the evolution of mining immense masses of copper-bearing rock and the flotation process made Arizona the most productive copper region in the world. In 1960, nearly 90 percent of Arizona's copper came from large, low-grade mines such as Morenci, New Cornelia, Lavender Pit of the Phelps-Dodge Corp., Ray of Kennecott, Inspiration, Miami, Silver Bell, and most recently, the San Manuel, which opened in 1956.

Black Hills, S. Dak.

The last gold stampede took place in the Black Hills in the southwest corner of South Dakota. This area was a part of a large reservation guaranteed to the Sioux Indians by treaty in 1868. Repeated rumors of the occurrence of gold were confirmed in the summer of 1871 by a military reconnaissance under the command of Gen. George A. Custer. These reports were publicized widely; an editorial in the Mining and Scientific Press of September 19, 1874, stated, "the glowing reports from Custer's expedition to the Black Hills have had the effect of exciting a lot of prospectors who want some new country to work in." Victims of the Depression of 1873 saw an opportunity to reestablish themselves. The Army's policy of ejecting trespassing miners from the reservation proved increasingly futile as 1875 closed. The first gold had been washed in Whitewood and Deadwood Gulches in August. New treaties negotiated in 1876 legally opened the Black Hills by the following spring. By then, thousands of gold seekers had already invaded the forbidden territory. Camps were established at Bear Rock, Whitewood, Deadwood, Gold Run, and Palmer Gulch.

Moses Manuel, a prospector, located the most important discovery, the Homestake mine, in April 1876. While sinking the discovery shaft, Manuel and his partners removed a rich lump of quartz that weighed about 200 pounds. They extracted gold worth $5,000 during the winter of 1876-77. The following year, the Homestake was sold to George Hearst, James Huggin, and Lloyd Tevis of San Francisco. They completed an 80-stamp mill in July 1878, and a 120-stamp mill 6 months later. The gold was coarse and well-suited to stamp-milling and amalgamation. In 1888, the Homestake Co. milled 243,355 tons of ore that yielded, on a per ton basis, $3.71 at a cost of $2.52, a profit of $1.19. In 1895, the company was operating two mills, one of 100 and another of 160 stamps. Each stamp weighed 880 pounds and dropped 9-1/2 inches about 85 times per minute. By 1912, more than 90 percent of the gold was recovered by milling. Around the turn of the century, the cyanide process was introduced to treat the sand; in 1906, a filter press was installed to treat slimes. By 1912, the Homestake Co. had processed gold worth more than $115 million and had paid dividends of nearly $28 million.

AMERICAN MINING COMES OF AGE

The foregoing account of the early American mining industry has been more or less humanistic, based on persons and places. As the 20th century approached, the action centered around institutions rather than individuals. Specific places lost their significance also as the industry gradually was absorbed into the national industrial complex, thereby losing much of its separate identity. In this final episode of the industry's maturation, we will confine our attention to the commodities that form the base of a modern industrial society, iron and steel, and the mineral fuels. Coal and petroleum are the preponderant energy sources for the machines of production; iron and steel provide the means for utilizing this energy.

The Iron and Steel Industry

In the 17th and 18th centuries, the American iron industry comprised a large number of widely dispersed furnaces and forges that worked on local ores. The fuel was charcoal; the products were cast and wrought iron. During the 19th century, both the industry and the technology changed profoundly. The industry eventually concentrated around a few great centers near the Great Lakes and pig iron was converted largely to steel instead of wrought iron. The discoveries and events that influenced this evolution will be described briefly and chronologically.

Crucible steel was manufactured for the first time in the United States in Cincinnati in 1832.

In 1834, the Oxford furnaces in New Jersey operated the first hot blast for making pig iron. Raising the temperature of the blast to 250° F increased the output of iron about 10 percent. Coke was first used successfully as a blast furnace fuel at the Mary Anne furnace in Huntingdon County, Pa., in 1835. In 1839, Benjamin Perry, at the Pioneer furnace in Pottsville, Pa., and David Thomas, at Catasauqua, Pa., used anthracite for the same purpose.

The manufacture of heavy iron rails for the Nation's rapidly growing railway systems began at the Mount Savage Rolling Mill in Allegheny County, Md., and at the Montour Rolling Mill, at Danville, Pa. Iron rail production was 22,000 tons in 1849 and 809,000 tons in 1872.

The pneumatic process for converting pig iron into steel was developed independently by William Kelly of Eddyville, Ky., and by Henry Bessemer of England. In the Bessemer-Kelly process, the carbon in molten pig iron is oxidized within minutes after air is injected into the converter, a specially designed furnace. No fuel is required to keep the metal hot; heat is generated by oxidation of the carbon, silicon, and phosphorus in the metal. Bessemer's patent was issued in 1856. Although Kelly proved that his work began as early as 1847, he did not apply for a patent until 10 years later. Kelly had been unable to perfect his invention earlier because he lacked financial support. After many difficulties, Bessemer built a converter at a steelworks in Sheffield, England, that began operating in 1860. The first Bessemer plant was erected in the United States in 1864 at the Wyandotte Iron Works, Wyandotte, Mich. Kelly was operating an experimental converter at the Columbia Steel Works, Johnstown, Pa., by 1861.

The first Bessemer converters had silica refractory linings to withstand siliceous slag. As a result, ores containing phosphorus could not be refined. In the early 1870's, Sidney Thomas and a cousin developed the Basic Bessemer or Thomas-Gilchrist process to treat phosphatic ores by lining the converter with lime or dolomite and adding lime to the slag.

The next advance in steel metallurgy was the open-hearth process. It was based on the regenerative furnace invented by Karl Wilhelm Siemens, a naturalized British citizen from Germany. The regenerative principle involves preheating the air used for combustion with the heat from the combusted gases. As a result, fuel is conserved and the furnace attains a higher temperature. At first Siemens could not adapt his invention to steelmaking on the furnace hearth. The process was not successful until the Martin brothers, using Siemen's principle, built a furnace in which the fuel was gasified first. Hence, in Europe it is known as the Siemen-Martin process; in America, it is the open-hearth process.

The first small open-hearth furnace installed at Trenton, N.J., did not produce satisfactory steel at a reasonable cost, but an economically productive furnace was operating in Boston by 1870. The hearth of Siemen's first furnace was made of silica brick, but he later switched to basic magnesite refractories so he could use a slag high in lime to permit the removal of phosphorus from the metal. Basic open-hearth steel production began in 1888 at the Homestead Works of Carnegie-Phipps Co. at Homestead, Pa. Total steel production in 1871 amounted to 84,000 tons: 2,000 tons converted by the open-hearth process, 45,000 tons by the Bessemer process, and 37,000 tons by crucible, puddling, and other processes. As time passed, the open-hearth steel industry grew steadily and produced 3.8 million tons in 1900, 30 million tons in 1920, and 61.5 million tons in 1940.

Electric steel furnaces resulted from the development of dynamos during the decade 1860-70. The Heroult furnace, commercially operating in France by 1899, was not installed in this country until 1906, in Syracuse, N.Y. Before World War I, furnaces with capacities of more than 6 tons were exceptional, but afterward capacities increased drastically; a 125-ton unit was built in 1927. By 1940, there were 430 electric steel furnaces with a total capacity of 1.88 million tons.

The year of completion of the Sault Sainte Marie Shipping Canal, 1845, also marked the discovery of iron ore in the Lake Superior District. This ore was first processed in a blast furnace at Sharpsville Furnace, Mercer

County, Pa., in 1852. For 30 years, all the ore came from the Marquette Range; in 1887, the Menominee Range was first mined, and soon after, the Gogebic and Vermillion Ranges. The Mesabi Range, largest and most important, was opened in 1892. During the mid-1960's, the 76 mines of the Lake Superior District produced 141 million tons of iron ore, of which 133 million tons were mined by open pit methods. From 1845 to 1973, the district provided a total of 3.7 billion long tons; 2.5 billion tons came from the Mesabi Range.

In the 1950's, just as the rich ores of the region seemed nearly depleted, a concentrating technique that had taken 35 years to develop was finally ready for commercial use. By this technology, taconite, a low-grade but plentiful ore, could be processed into high-grade pellets that make an excellent feed for the blast furnace.

During the progressive period in the art of steelmaking, the size and design of the blast furnace also underwent steady improvement. The typical modern blast furnace is now about 100 feet high and 28 feet in diameter. The hot blast reaches about 700° C and enters the furnace at a rate of 100,000 cubic feet per minute. The production rate of 2,000 tons per day equals the maximum the old Saugus works could produce in 5 years.

Before the 19th century closed, the United States had become the world's foremost producer of iron and steel. The great steelmaking complex comprising the iron ores of the Lake Superior District, the transportation system of the Great Lakes, and the steel mills of Illinois, Indiana, Ohio, and Pennsylvania was considered a wonder of the world. With a great deal of pride, Andrew Carnegie described the operation (6, p. 175):

> "Two pounds of ironstone mined upon the Superior and transported nine hundred miles to Pittsburgh; one pound and one-half of coal, mined and manufactured into coke, and transported to Pittsburgh; one-half pound of lime, mined and transported to Pittsburgh; a small amount of manganese ore mined in Virginia and brought to Pittsburgh, and these four pounds of materials manufactured into one pound of steel, for which the consumer pays one cent."

The business of steelmaking had begun as widely dispersed operations consisting of a multitude of small riverside mills, each turned by a water wheel and owned by a single master or a partnership. It grew by stages into a vast industrial complex of mines, ships, railroads, and steel plants. As the 20th century began, the industry was typified by the billion dollar United States Steel Corp.

Coal Mining

Although good coal was available in Virginia and Pennsylvania in the early part of the 18th century, it was not burned because wood was so plentiful. When the Revolution interrupted shipment of coal to eastern ports from England and Nova Scotia, some coal was mined along the James River in Virginia and shipped via water to Philadelphia and other ports. By 1800, the great seams of bituminous coal near Pittsburgh were being mined, but Pittsburgh housewives still preferred wood as cooking fuel. The anthracite of eastern Pennsylvania became acceptable fuel even more slowly than bituminous coal; many refused to believe that it would burn. Only after the War of 1812 shut off the supply of Virginia bituminous coal was anthracite burned in Philadelphia.

It was not until the advent of the steam engine that coal became an important commodity. By the 1840's, steamboats of Long Island Sound, the Hudson River, and the Great Lakes were burning both bituminous and anthracite coal. During the Civil War, the Pennsylvania Railroad adapted its locomotive fireboxes to bituminous coal. Meanwhile, even before the Civil War, charcoal was being replaced by coal as fuel for the manufacture of iron and steel. These developments marked the ascent of coal production as the principal mining industry of the United States. The per capita consumption of coal rose rapidly from 0.01 ton in 1800 to 0.1 ton in 1845, 1.0 ton in 1880, 2.5 tons in 1900, and more than 5 tons in 1918.

In 1870, all coal was mined by hand. The first cutting machine, operated by compressed air, became available in 1877, and thereby inaugurated mechanized coal mining that eventually culminated in the nearly exclusive use of machinery for underground and large-scale strip mining. Mechanization generated a remarkable decrease in the cost of coal and a corresponding increase in its use as a source of energy. In 1932, 1 pound of coal cost less than one-tenth of a cent at the mine, and 2 pounds of coal provided energy about equal to that provided by the work of one man in 1 day. At that time, about two-thirds of the energy consumed in the United States was supplied by coal.

The Oil Industry

The oil industry, like the metal-mining industry, had a small beginning followed by a period of romance, which finally matured into consolidation and routine production. Before the middle of the 19th century, "rock oil" occasionally appeared on the surface of streams or in drilled salt wells in Pennsylvania, Kentucky, Ohio, and the region that became West Virginia. At first, it was sold as medicine. By chance or experiment, Samuel Kier, a medicine vendor, realized its potential as a lubricant and luminant and, in 1849, with the help of a chemist, began to refine crude oil by distillation. On the basis of Kier's experience, G. H. Bissell interested some investors in a speculative venture in oil. In 1854, he organized a company and sent its representative, Edwin Drake, to sink a well near Titusville in northwestern Pennsylvania. In August 1859, Drake struck oil at a depth of 70 feet and thereby demonstrated that the black liquid could be extracted by drilling into underground oil structures. Thus began the world's petroleum industry.

The oil boom that followed was a romantic episode that rivaled the California gold rush. Hundreds of wells were started within the next few months to supply the growing demand for kerosene (or coal oil) and lubricants. Oil produced in 1860, the first full year after Drake's discovery, totaled more than one-half million barrels.

The young oil industry was very unstable. The supply fluctuated widely, for it cost only a few thousand dollars to drill a well that might yield a million dollars worth of oil--or nothing. Gushers that were delivering thousands of barrels daily would suddenly dwindle or dry up altogether. The same uncertainty prevailed in oil refining; the refining processes of the time were simple and required relatively small capital investments. Hence, competition was keen, keeping the whole industry in a flush of speculation. The Price of oil was $20 per barrel in 1859, $0.52 in 1861, $8 in 1863, and less than $3 in 1865.

John D. Rockefeller, the guiding genius of the new industry, was only 20 years old when Drake brought in the first oil well. With capital he accumulated during his early career as a clerk and bookkeeper, he began to speculate in commodities. By 1862, he was investing in oil and in 1865 he organized his own oil concern in Cleveland. After several successful years in this venture, he joined H. M. Flagler and S. V. Harkness to establish the Standard Oil Co., an Ohio corporation. A thrifty, tireless worker, Rockefeller involved himself in every part of the business to eliminate waste and inefficiency, effect economies, improve processes, and enlarge the scope of operation.

Rockefeller entered the industry during one of its periodic depressions. The price of kerosene was falling, the number of refineries was increasing, and the weaker companies were desperate. A corporation of uncertain origin, the South Improvement Co., was set up in Pennsylvania to stabilize the industry. The company united refineries in Cleveland, Pittsburgh, Philadelphia, and New York and secretly arranged rebates on oil shipments with the Erie, Pennsylvania, and New York Central Railroads. Of the $2.56 per barrel charged by the carrier to haul crude oil to New York, $1.06 was kicked back to the corporation. Similar arrangements were made for other shipping points. Rockefeller's involvement in this arrangement is uncertain. In any case, other oil producers protested vociferously, a congressional committee characterized the scheme as a "gigantic and daring conspiracy," and the Pennsylvania Legislature annulled the company's charter.

Within a few months after the South Improvement Co. lost its charter, Rockefeller allegedly made a compact with the New York Central Railroad and other lines for secret rebates. Once special privileges with the railroads were established, the Standard Oil Co. consolidated the industry by buying out competitors and thereby stabilized the production and price of oil products.

In 1878, the Tidewater Co. began to pump oil over the Alleghenies by pipeline and announced that the price per barrel to deliver oil to the seaboard by this method was only about 16 cents, whereas the cost of rail transport was $1.25 to $1.40. The Standard Oil Co. organized a large pumping subsidiary, the National Transit Co., and eliminated its dependence upon the railways for oil transportation.

Having secured control over transportation and refining, the Standard Oil Co. proceeded to perfect its marketing system. The company divided the country into districts and subdistricts and set up a network of distributors and agencies to market petroleum products in all the towns, villages, and hamlets. In 1887, the company entered the drilling and pumping phase of the business on a large scale and steadily extended its authority over leases and oil lands. Ten years later it was master of the oil business from the well to the lamp. The Standard Oil system became a loose federation grouped around the original company, which owned the controlling interest in all affiliated plants. The direction of this economic empire was under the authority of nine men, among whom Rockefeller acted as first consul.

The pattern of development of the steel and oil industries was followed by most of the rest of the mining industry. By the middle of the 20th century, independently operated mines had virtually disappeared. Production of metals and fuels became the province of large corporations with widespread mining and metallurgical operations.

STATISTICAL HISTORY OF MINERAL AND METAL PRODUCTION

The Federal Government did not collect statistics on the national production of mineral commodities until 1866 when J. Ross Browne and James W. Taylor were appointed special commissioners of the Treasury Department to compile facts and figures on mineral resources. Taylor was assigned to cover the Rockies and the Eastern States; Browne published reports on the rest of the Far West. In 1868, Browne was succeeded by Rossiter W. Raymond, a mining engineer of excellent reputation. He continued to gather statistics on the Far West, including the Rockies, until the U.S. Geological Survey assumed the task in 1882. The Geological Survey annually published statistics on U.S. production of metals, minerals, and fuels in volumes of Minerals Resources of the U.S. until 1940. Since 1940, the U.S. Bureau of Mines has been responsible for publishing this information in annual volumes of the Minerals Yearbook.

The statistical history of mineral commodities produced during the 19th and 20th centuries is illustrated by the following line graphs. Figure 19 shows U.S. population and mineral production, calculated by the Bureau of Mines for the years 1800 through 1975. It represents the composite value of all commodities evaluated at the mean price in current dollars of each commodity at the time it became a marketable product. Note that the most remarkable rise in mineral production has been in the past 35 years, or since the beginning of World War II.

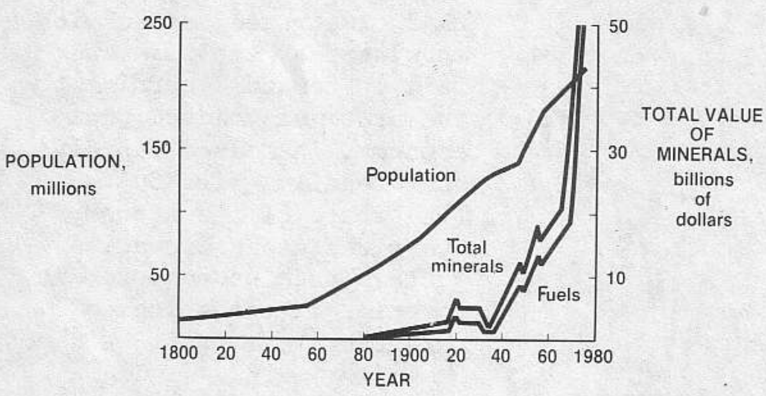

FIGURE 19. - Value of minerals compared to population, 1800-1975.

The increasing importance of mineral products to modern society is expressed even more dramatically as production per capita in table 1. Because most of the minerals produced are consumed domestically, table 1 also indicates the rising importance of these products to the average American. During the first 60 years of this century, the value of mineral products per capita increased about five times, but in the last 35 years the increase has been ninefold. Since these values are expressed in current rather than constant dollars, part of this increase was caused by inflation. As might be expected, most of the increase is due to fuels.

TABLE 1. - Production of mineral products, dollars per capita

Year	Metals	Nonmetals	Fuels	Total
1880..............	2.48	1.11	2.39	5.98
1890..............	2.96	1.28	3.66	7.91
1900..............	4.19	2.47	5.34	12.01
1910..............	5.09	4.44	8.96	18.47
1920..............	8.17	9.67	39.55	57.40
1930..............	4.12	7.91	20.33	32.36
1940..............	5.70	5.94	20.17	31.80
1950..............	8.95	12.07	57.54	78.56
1960..............	11.23	21.49	67.46	100.18
1970..............	19.25	28.00	98.78	146.03
1975..............	22.67	40.34	224.93	287.94

Source: Minerals Yearbook.

A statistical history of the metal mining industry is given in the appendix, which shows annual production of pig iron, gold, silver, copper, lead, zinc, and aluminum.

The iron and steel industry is represented by pig iron production. Even if statistics were available for iron produced during the 17th and 18th centuries, the values would be too small to register on the graph. The modern steel industry began after the Civil War when the railroads were built. After that time, steel production, modulated by the rise and fall in demand according to the state of the national economy, increased rapidly and steadily (fig. 20). (The state of the economy overrides other causative factors such as new ore discoveries or technological advances.)

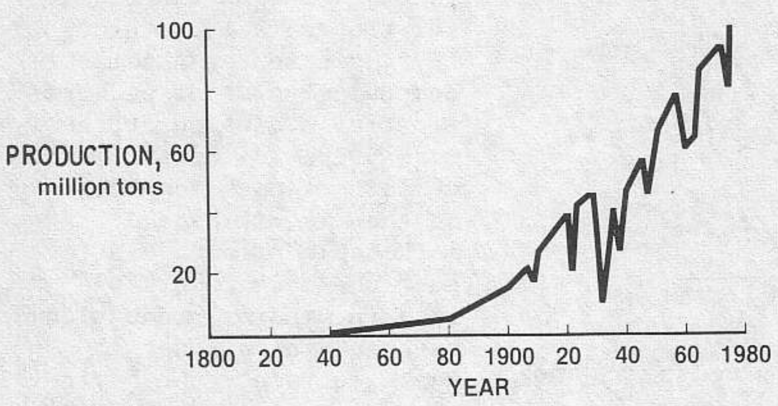

FIGURE 20. - Production of pig iron, 1800-1975.

The production curve for gold is unique. It rises spectacularly from the date of the California discovery, then gradually declines, although spikes indicate the booms in the Comstock Lode, Colorado, and other areas. The railroad system generated a general increase in all mining activity throughout the Far West, causing a corresponding rise in production of byproduct gold. Another remarkable feature is the sharp spike that occurs during the Great Depression in contradistinction to the corresponding crevasse in the curves for all other commodities. During the recent decades, the trend in gold production has declined despite a sharp rise in price (fig. 21).

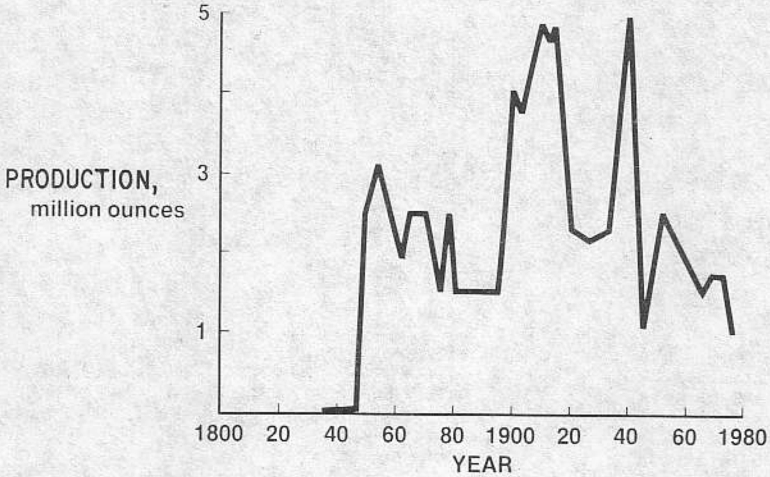

FIGURE 21. - Gold production, 1800-1975.

With the discovery of the Comstock Lode around 1860, silver production rose sharply, but less spectacularly than gold, and continued with successive discoveries of silver-lead deposits in the Great Basin and Colorado. Similar rises in lead and copper production follow in respective order. The spectacular rise in aluminum was caused by the approach of World War II and the rapid increase in aircraft manufacture (figs. 22-25).

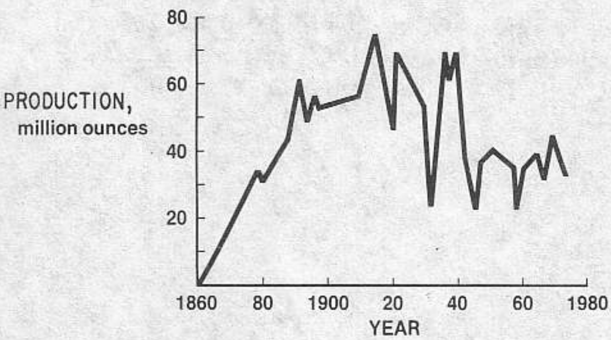

FIGURE 22. - Silver production, 1860-1975.

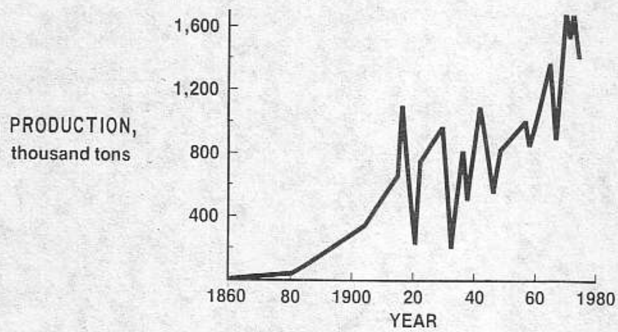

FIGURE 23. - Copper production, 1860-1975.

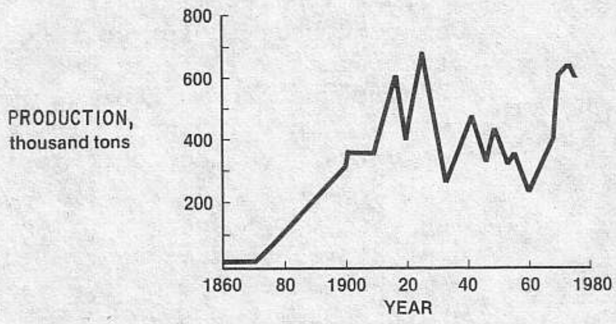

FIGURE 24. - Lead production, 1860-1975.

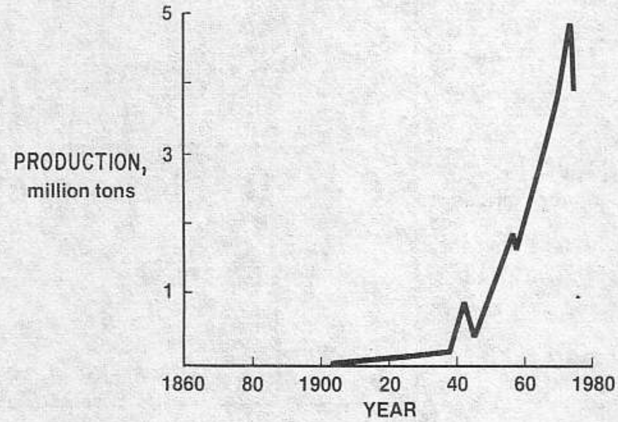

FIGURE 25. - Aluminum production, 1860-1975.

CONCLUSION

The fluctuations in mineral products in response to the political and economic fortunes of the Nation manifest the fundamental importance of mineral industry. The average citizen seems to be more conscious of the importance of agriculture, the other mammoth industry, to his livelihood because he associates food and fiber products directly with the farm. He appears less aware of his dependence on the mining industry because he buys steel and other metals as end products, such as automobiles, refrigerators, and washing machines, that seem remote from their sources in the earth. During the recent energy crisis, we gained national consciousness of our dependence on oil and coal. Let us remember that these fuels cannot be used by themselves; steel, copper, aluminum, concrete, to name a few essential minerals, provide the sinew, muscle, bone, and nerve to convert the fuel energy into useful work and goods.

BIBLIOGRAPHY

1. Adams, J. M. The Treatment of Gold and Silver Ores by Wet Crushing and Pan Amalgamation Without Roasting. Trans. AIME, v. 2, 1874, pp. 159-171.

2. American Institute of Mining, Metallurgical, and Petroleum Engineers. Centennial Volume, 1871-1970. New York, 1971, 215 pp.

3. American Philosophical Society. Observation on the Geology of the United States--Explanatory of a Geological Map. Trans. Am. Phil. Soc., v. 6, 1809, pp. 411-428.

4. Arrington, L. J. Great Basin Kingdom: Economic History of the Latter Day Saints, 1830-1900. University of Nebraska Press, Lincoln, Nebr., 1958, 534 pp.

5. _____. From Wilderness to Empire: The Role of Utah in Western Economic History, Monograph 1. Institute of American Studies, Salt Lake City, Utah, 1961, 20 pp.

6. Beard, C., and M. Beard. History of the United States: A Study in American Civilization. The Macmillan Co., New York, 1941, 706 pp.

7. Beck, W. A. New Mexico--A History of Four Centuries. University of Oklahoma Press, Norman, Okla., 1962, 363 pp.

8. Becker, G. F. Geology of the Comstock Lode and the Washoe District. U.S. Geol. Survey Monograph 3, 1882, 422 pp.

9. Bell, I. L. On the Hot Blast, With an Explanation of the Mode of Action in Iron Furnaces of Different Capacities. Trans. AIME, v. 5, 1876, pp. 56-81.

10. Bennett, E. Old Deadwood Days. J. H. Sears & Co., New York, 1928, 300 pp.

11. Billington, R. A. The Far Western Frontier, 1830-1860. Harper & Row, New York, 1956, 324 pp.

12. Bishop, J. L. A History of American Manufactures From 1608 to 1860. Edward Young & Co., Philadelphia, Pa., 1868, 3 v.

13. Blair, T. S. The Direct Process in Iron Manufacture. Trans. AIME, v. 2, 1874, pp. 175-199.

14. Blake, W. P. The Mass Copper of the Lake Superior Mines and the Method of Mining It. Trans. AIME, v. 4, 1875, pp. 110-112.

15. Bold, F. C. Michigan in Four Centuries. Harper & Row, New York, 1954, 528 pp.

16. Bowie, A. J., Jr. Hydraulic Mining in California. Trans. AIME, v. 6, 1877, pp. 27-100.

17. Butler, B. S., G. F. Loughlin, V. Heikes, and others. The Ore Deposits of Utah. U.S. Geol. Survey Prof. Paper 111, 1920, 672 pp.

18. Daggett, E. Economical Results of Smelting in Utah. Trans. AIME, v. 2, 1873, pp. 17-28.

19. de Quill, D. (W. Wright). History of the Big Bonanza. American Pub. Co., Hartford, Conn., 1877, 569 pp.

20. Eggleston, T. The American Bloomery Process for Making Iron Direct From the Ore. Trans. AIME, v. 8, 1880, pp. 515-530.

21. _____. Copper Mining in Lake Superior. Trans. AIME, v. 6, 1877, pp. 275-312.

22. Eilers, A. Progress of the Silver-Lead Metallurgy of the West During 1874. Trans. AIME, v. 3, 1875, pp. 307-314.

23. Emmons, S. G. Geology and Mining Industry of Leadville, Colorado. U.S. Geol. Survey Monograph 12, 1886, 770 pp.

24. Falkner, H. U. American Economic History. Harper & Row, New York, 1960, 816 pp.

25. Furnas, J. C. The Americans--A Social History of the United States, 1587-1914. G. P. Putnam & Sons, New York, 1969, 1015 pp.

26. Hafen, L. R. Colorado Gold Rush: Contemporary Letters and Reports, 1858-1859. The Arthur H. Clark Co., Glendale, Calif., 1941, 386 pp.

27. Hague, A. Geology of the Eureka District, Nevada. U.S. Geol. Survey Monograph 20, 1892, 419 pp.

28. Hahn, O. H., A. Eilers, and R. W. Raymond. The Smelting of Argentiferous Ores in Nevada, Utah, and Montana. Trans. AIME, v. 1, 1871, pp. 91-130.

29. Hartley, E. N. The Ironworks on the Saugus, The Lynn and Braintree Ventures of the Company of Undertakers of the Ironworks in New England. University of Oklahoma Press, Norman, Okla., 1957, 328 pp.

30. Hawkes, D. The Colonial Experience. The Bobbs-Merrill Co., New York, 1966, 774 pp.

31. Henderson, C. W. Mining in Colorado: A History of Discovery, Development, and Production. U.S. Geol. Survey Prof. Paper 138, 1926, 263 pp.

32. Hewitt, A. S. A Century of Mining and Metallurgy in the United States. Trans. AIME, v. 5, 1876, pp. 164-196.

33. Hill, J. M. The Mining Districts of the Western United States. U.S. Geol. Survey Bull. 507, 1912, 309 pp.

34. Hunt, R. W. A History of Bessemer Manufacture in America. Trans. AIME, v. 5, 1876, pp. 201-216.

35. Hunt, T. S. The Origin of Metalliferous Deposits. Trans. AIME, v. 1, 1872, pp. 413-426.

36. _____. The Cornwall Iron Mine and Some Related Deposits in Pennsylvania. Trans. AIME, v. 4, 1876, pp. 319-325.

37. Jefferson, T. Notes on the State of Virginia. Harper & Row, New York, 1964, 228 pp.

38. Jernegan, J. L. Lead and Silver Smelting in Chicago. Trans. AIME, v. 2, 1874, pp. 279-295.

39. _____. The Swansea Silver Smelting and Refining Works of Chicago. Trans. AIME, v. 4, 1875, pp. 35-53.

40. Johnston, W. D., Jr. The Gold Quartz Veins of Grass Valley, California. U.S. Geol. Survey Prof. Paper 194, 1940, 101 pp.

41. Keyes, C. William Maclure: Father of Modern Geology. Pan-American Geol., v. 43, September 1925, pp. 81-94.

42. Keyes, W. S. The Eureka Lode of Eureka, Eastern Nevada. Trans. AIME, v. 6, 1877, pp. 344-371.

43. Lindgren, W. The Mining Districts of the Idaho Basin and Boise Ridge, Idaho. Ch. in U.S. Geological Survey 18th Annual Report, 1896-1897. Pp. 617-744.

44. Morison, S. E. The Oxford History of the American People. Oxford University Press, New York, 1965, 1150 pp.

45. Morris, R. B. (ed.). Encyclopedia of American History. Harper & Row, New York, 1953, 776 pp.

46. Morton, S. G. A Memoir of the Late William Maclure, Esq., Late President of the Academy of Natural Sciences of Philadelphia, July 1, 1841. Am. J. Sci., v. 47, 1844, pp. 1-17.

47. North, D. C., and R. P. Thomas. The Growth of the American Economy to 1860. Harper & Row, New York, 1968, pp. 80-82, 112-113, 238-289.

48. Overman, F. The Manufacture of Iron. H. C. Baird, Philadelphia, Pa., 1850, 492 pp.

49. Parson, A. B. (ed.). Seventy-Five Years of Progress in the Mineral Industry, 1871-1946. American Institute of Mining, Metallurgical, and Petroleum Engineers, New York, 1948, 817 pp.

50. Paul, R. W. Mining Frontiers of the Far West, 1848-1880. Holt, Rinehart and Winston, New York, 1963, 236 pp.

51. Peckin, E. C. The Position of American Pig-Iron Manufacture. Trans. AIME, v. 1, 1872, pp. 277-286.

52. Phillips, J. A. Elements of Metallurgy. Charles Griffin & Co., London, 1874, 764 pp.

53. Pitkin, T. Statistical View of the Commerce of the United States. Durrie & Peck, New Haven, Conn., 1835, 600 pp.

54. Raymond, R. W. Production of Gold and Silver in the United States. Trans. AIME, v. 3, 1874, pp. 202-207.

55. Read, T. T. Our Mineral Civilization. The Williams & Wilkins Co., Baltimore, Md., 1932, 165 pp.

56. Rickard, T. A. A History of American Mining. McGraw-Hill, New York, 1932, 419 pp.

57. Roberts, P., Jr. The Puddling Process, Past and Present. Trans. AIME, v. 8, 1880, pp. 355-362.

58. Rolker, C. M. The Silver Sandstone District of Utah. Trans. AIME, v. 9, 1881, pp. 21-33.

59. Shinn, W. P. The Advance of Mining and Metallurgical Art, Science, and Industry Since 1875. Trans. AIME, v. 9, 1881, pp. 293-299.

60. Singer, C. J., E. J. Holmyard, A. R. Hall, and T. I. Williams (ed.). A History of Technology. V. 3, 1500-1750; v. 4, 1750-1850. Clarendon Press, Oxford, 1957.

61. Smith, G. H. The History of the Comstock Lode, 1850-1920. Univ. of Nevada Bull. 37, No. 3, Geology and Mining Series, Reno, Nev., 1943, 297 pp.

62. Spencer, V. E. Production, Employment, and Productivity in the Mineral Extractive Industries, 1880-1938. Works Progress Administration Nat. Res. Proj., Philadelphia, Pa., 1940, 168 pp.

63. Swank, J. M. History of the Manufacture of Iron in All Ages--and in Particular in the United States From Colonial Times to 1891. American Iron and Steel Institute, Philadelphia, Pa., 1892, 554 pp.

64. Tryon, F. G., T. T. Read, K. C. Heald, and others. Technology and the Mineral Industries. Prepared for National Resources Committee, Philadelphia, Pa., 1937, 63 pp.; available for examination at the Central Library, U.S. Department of the Interior, Washington, D.C.

65. Turner, F. J. The Frontier in American History. Holt, Rinehart & Winston, New York, 1920, 375 pp.

66. U.S. Bureau of the Census. Historical Statistics of the United States, Colonial Times to 1970. 1972, 2 v.

67. U.S. Bureau of Mines. Minerals Yearbook, 1940-1975.

68. _____. Mining and Mineral Operations in the Pacific States. A Visitor Guide. BuMines SP 4-76, 1976, 76 pp.

69. U.S. Exploration of the Fortieth Parallel. Report of the Geological Exploration of the Fortieth Parallel Made by Order of the Secretary of War According to Acts of Congress of March 2, 1867, and March 3, 1869, Under the Direction of ... A. A. Humphreys, Chief of Engineers, by Clarence King, U.S. Geologist, 1870-1880, 7 v. plus atlas; available for examination at the U.S. Geological Survey Library, Reston, Va.

70. U.S. Geological Survey. Mineral Resources of the United States, 1882 through 1939.

71. Weed, W. H. Geology and the Ore Deposits of the Butte District. Montana. U.S. Geol. Survey Prof. Paper 74, 1912, 262 pp.

72. Whitney, J. D. Metallic Wealth of the United States. Lippincott, Grambo, & Co., Philadelphia, Pa., 1854, 510 pp.

73. Williams, W. M. The Chemistry of Iron and Steel Making. Chatto & Windus, London, 1890, 420 pp.

74. Wright, E. (ed.). Causes and Consequences of the American Revolution. Quadrangle Books, Chicago, Ill., 1966, 316 pp.

75. Works Progress Administration. Colorado--A Guide to the Highest State. Hastings House, New York, 1941, 511 pp.

APPENDIX.--ANNUAL PRODUCTION OF PRINCIPAL MINERAL COMMODITIES, 1810-1975

	Thousand ounces		Thousand tons					Millions				
Year	Gold	Silver	Aluminum	Copper	Lead	Pig iron	Zinc	Total metals	Nonmetals	Fuels	Total mineral	Population[1]
1810	-	-	-	-	1.0	60	-	-	-	-	-	7.2
1820	-	-	-	-	1.5	22	-	-	-	-	-	9.6
1828	-	-	-	-	7.5	146	-	-	-	-	-	12.2
1829	-	-	-	-	8.6	159	-	-	-	-	-	12.6
1830	-	-	-	-	8.0	185	-	-	-	-	-	12.8
1831	-	-	-	-	7.5	214	-	-	-	-	-	13.3
1832	-	-	-	-	10.0	224	-	-	-	-	-	13.7
1833	-	-	-	-	11.0	-	-	-	-	-	-	14.2
1834	-	-	-	-	12.0	-	-	-	-	-	-	14.6
1835	39	-	-	-	13.0	-	-	-	-	-	-	15.0
1836	26	-	-	-	15.0	-	-	-	-	-	-	15.4
1837	16	-	-	-	13.5	-	-	-	-	-	-	15.8
1838	24	-	-	-	15.0	-	-	-	-	-	-	16.3
1839	23	-	-	-	17.5	-	-	-	-	-	-	16.7
1840	24	-	-	-	17.0	321	-	-	-	-	-	17.1
1841	30	-	-	-	20.5	-	-	-	-	-	-	17.7
1842	43	-	-	-	24.0	241	-	-	-	-	-	18.3
1843	58	-	-	-	25.0	-	-	-	-	-	-	19.0
1844	55	-	-	-	26.0	-	-	-	-	-	-	19.6
1845	49	-	-	0.1	30.0	-	-	-	-	-	-	20.2
1846	55	-	-	.2	28.0	857	-	-	-	-	-	20.8
1847	43	-	-	.3	28.0	896	-	-	-	-	-	21.4
1848	484	-	-	.6	25.0	896	-	-	-	-	-	22.0
1849	1,935	-	-	.8	23.5	728	-	-	-	-	-	22.6
1850	2,419	39	-	.7	22.0	631	-	-	-	-	-	23.3
1851	2,661	39	-	1.0	18.5	-	-	-	-	-	-	24.1
1852	2,902	39	-	1.2	15.7	560	-	-	-	-	-	24.9
1853	3,144	39	-	2.2	16.8	-	-	-	-	-	-	25.7
1854	2,902	39	-	2.5	16.5	736	-	-	-	-	-	26.6
1855	2,661	39	-	3.4	15.8	784	-	-	-	-	-	27.4
1856	2,661	39	-	4.5	16.0	883	-	-	-	-	-	28.2
1857	2,661	39	-	5.4	15.8	798	-	-	-	-	-	29.0
1858	2,419	39	-	6.2	15.3	705	-	-	-	-	-	29.9
1859	2,419	77	-	7.1	16.4	841	-	-	-	-	-	30.7
1860	2,225	116	-	8.1	15.6	920	0.8	-	-	-	-	31.5
1861	2,080	1,547	-	8.4	14.1	732	1.5	-	-	-	-	32.4
1862	1,896	3,480	-	10.6	14.2	788	1.5	-	-	-	-	33.2
1863	1,935	6,574	-	9.6	14.8	948	1.7	-	-	-	-	34.0
1864	2,230	8,508	-	9.0	15.3	1,136	1.8	-	-	-	-	34.9
1865	2,575	8,701	-	9.5	14.7	932	2.1	-	-	-	-	35.7
1866	2,588	7,734	-	10.0	16.1	1,350	2.0	-	-	-	-	36.5
1867	2,502	10,441	-	11.2	15.2	1,462	3.2	-	-	-	-	37.4
1868	2,322	9,281	-	13.0	16.4	1,603	3.7	-	-	-	-	38.2
1869	2,395	9,281	-	14.0	17.5	1,917	4.3	-	-	-	-	39.1
1870	2,419	12,375	-	14.1	17.8	1,865	5.4	-	-	-	-	39.9
1871	2,104	17,789	-	14.6	20.0	1,912	6.9	-	-	-	-	40.9
1872	1,742	22,236	-	14.0	25.7	2,855	7.8	-	-	-	-	42.0
1873	1,742	27,650	-	17.4	41.9	2,868	9.6	-	-	-	-	43.0
1874	1,620	28,868	-	19.6	51.2	2,689	13.1	-	-	-	-	44.0
1875	1,619	24,530	-	20.2	58.6	2,267	16.7	-	-	-	-	45.1
1876	1,932	29,996	-	21.3	62.9	2,093	17.0	-	-	-	-	46.1
1877	2,269	30,126	-	23.5	80.4	2,315	15.6	-	-	-	-	47.1
1878	2,477	36,141	-	24.1	89.1	2,577	19.6	-	-	-	-	48.2
1879	1,882	31,566	-	25.8	90.8	3,071	21.3	-	-	-	-	49.2

See footnotes at end of table.

	Thousand ounces		Thousand tons					Millions				
Year	Gold	Silver	Alu-minum	Copper	Lead	Pig iron	Zinc	Total metals	Non-metals	Fuels	Total mineral	Population[1]
1880	1,742	30,319	-	30.2	95.7	4,295	25.1	$125	$56	$120	$301	50.3
1881	1,679	33,259	-	35.8	114.5	4,642	30.3	130	61	150	340	51.5
1882	1,572	36,198	-	45.3	129.8	5,178	33.8	144	64	170	378	52.8
1883	1,451	35,734	-	57.8	140.3	5,147	36.9	136	61	186	383	54.1
1884	1,490	37,745	-	72.5	136.3	4,590	38.5	130	58	166	355	55.4
1885	1,538	39,910	-	92.9	126.2	4,530	40.7	129	62	183	374	56.7
1886	1,687	39,694	-	78.9	132.2	6,365	42.6	138	67	185	389	57.9
1887	1,603	41,722	-	90.7	156.6	7,187	50.3	153	77	217	448	59.2
1888	1,604	45,793	-	113.2	156.0	7,269	55.9	164	80	231	476	60.5
1889	1,595	51,356	-	113.4	178.4	8,516	58.9	164	83	208	456	61.8
1890	1,589	54,516	-	129.9	157.8	10,307	63.7	187	81	231	499	63.1
1891	1,605	58,330	-	142.1	198.4	9,273	80.9	184	83	237	504	64.4
1892	1,597	63,538	-	172.5	208.2	10,256	87.3	186	90	248	524	65.7
1893	1,738	60,000	-	164.7	224.3	7,979	78.8	158	70	252	480	67.0
1894	1,911	49,500	-	177.1	213.6	7,452	75.3	136	127	236	498	68.2
1895	2,255	55,727	-	190.3	235.8	10,580	89.7	161	126	268	555	69.6
1896	2,568	58,835	1	230.0	257.5	9,658	81.5	185	120	268	573	70.9
1897	2,775	53,860	1	247.0	282.2	10,811	100.0	193	128	254	574	72.2
1898	3,118	54,438	1	263.3	302.1	13,187	115.4	213	151	268	631	73.5
1899	3,437	54,764	2	284.3	298.0	15,255	129.1	272	185	341	798	74.8
1900	3,830	57,647	3	303.1	367.8	15,444	123.9	319	188	406	914	76.1
1901	3,806	55,214	3	301.0	371.0	17,784	140.8	299	219	442	960	77.6
1902	3,870	55,500	3	329.8	367.9	19,960	156.9	295	254	469	1,018	79.2
1903	3,560	54,300	3	349.0	368.9	20,170	159.2	309	272	634	1,215	80.6
1904	3,911	56,000	4	406.3	393.5	18,477	186.7	309	274	584	1,167	82.2
1905	4,266	56,102	5	444.4	388.3	25,751	203.8	392	319	602	1,313	83.8
1906	4,565	56,518	7	458.5	-	28,344	-	477	362	652	1,492	85.4
1907	4,372	56,515	8	423.6	364.7	28,875	253.0	501	376	789	1,667	87.0
1908	4,561	52,441	5	478.4	330.2	17,848	234.1	376	325	716	1,417	88.7
1909	4,810	54,722	15	563.3	385.1	28,891	302.4	439	386	746	1,517	90.5
1910	4,650	57,138	18	544.1	382.7	30,580	324.4	470	410	828	1,707	92.4
1911	4,686	61,109	19	557.4	426.6	26,487	331.5	432	407	836	1,675	93.9
1912	4,466	66,034	21	624.5	442.1	33,294	385.6	537	430	946	1,912	95.3
1913	4,311	71,187	24	617.8	483.1	34,682	413.8	538	467	1,088	2,092	97.2
1914	4,418	69,623	29	574.2	504.8	26,132	415.8	446	431	993	1,870	99.1
1915	4,754	72,354	45	744.0	542.1	33,506	588.1	677	429	973	2,078	100.5
1916	4,417	78,857	58	1,002.9	601.4	44,167	703.2	1,107	554	1,333	2,993	102
1917	3,900	70,662	65	947.7	628.5	43,256	713.6	1,228	666	2,238	4,131	103
1918	3,213	68,059	62	955.0	562.4	43,741	636.1	1,179	648	2,736	4,563	103
1919	2,753	51,897	64	606.2	429.6	34,737	548.8	744	752	2,511	4,007	105
1920	2,383	56,539	69	612.3	496.8	41,357	587.5	866	1,025	4,193	6,084	106
1921	2,345	46,333	27	233.1	414.5	18,691	256.6	344	780	2,703	3,828	109
1922	2,293	61,208	37	482.3	477.6	30,486	472.0	524	921	2,738	4,183	110
1923	2,405	70,356	64	738.9	547.2	45,204	610.7	778	1,157	3,317	5,252	112
1924	2,444	64,071	75	803.1	596.1	35,174	638.0	682	1,174	2,899	4,754	114
1925	2,307	66,710	70	839.1	684.4	41,105	710.8	715	1,187	2,910	4,812	116
1926	2,233	62,487	74	862.6	683.9	44,097	774.6	721	1,219	3,371	5,311	117
1927	2,107	59,626	82	825.0	665.5	40,954	718.5	622	1,201	2,875	4,698	119
1928	2,148	57,872	105	904.9	627.2	42,734	695.2	655	1,163	2,666	4,484	121
1929	2,059	60,860	114	997.6	648.0	47,728	724.5	802	1,166	2,940	4,908	122

See footnotes at end of table.

	Thousand ounces		Thousand tons					Millions				
Year	Gold	Silver	Alu-minum	Copper	Lead	Pig iron	Zinc	Total metals	Non-metals	Fuels	Total mineral	Population[1]
1930	2,139	47,725	115	705.1	558.3	35,562	595.4	$507	$973	$2,500	$3,980	123
1931	2,225	29,857	89	528.9	404.6	20,107	410.3	287	671	1,620	2,578	124
1932	2,330	22,740	52	238.1	293.0	9,576	238.1	128	412	1,460	2,000	125
1933	2,304	23,131	43	190.6	272.7	14,591	384.3	205	432	1,413	2,050	126
1934	2,779	32,782	37	237.4	287.3	17,569	438.7	277	520	1,947	2,744	126
1935	3,237	48,519	60	380.5	331.1	23,326	517.9	365	564	2,013	2,942	127
1936	3,783	61,153	112	614.5	372.9	33,885	575.6	516	685	2,405	3,606	128
1937	4,117	71,409	146	842.0	364.9	40,483	626.4	756	711	2,798	4,265	129
1938	4,267	61,706	143	557.8	369.7	20,812	516.7	460	622	2,436	3,518	130
1939	4,673	64,373	164	728.3	414.0	34,805	583.9	631	754	2,423	3,808	131
1940	4,870	70,436	206	878.1	457.4	46,204	665.1	752	784	2,662	4,198	132
1941	4,751	67,048	309	958.1	461.4	55,085	749.1	890	989	3,228	5,107	133
1942	3,457	54,091	521	1,080.1	496.2	59,078	768.0	999	1,056	3,568	5,623	134
1943	1,364	41,461	920	1,090.8	453.3	60,765	744.2	987	916	4,028	5,931	134
1944	998	34,474	776	972.5	416.9	61,004	718.6	900	836	4,574	6,310	133
1945	955	29,024	495	772.6	390.8	53,224	614.4	774	888	4,569	6,221	132
1946	1,575	22,915	410	608.7	335.5	44,842	574.8	729	1,243	5,090	7,062	140
1947	2,109	35,824	572	847.6	384.2	58,327	637.6	1,084	1,338	7,188	9,610	143
1948	2,014	38,096	623	834.8	390.5	60,073	630.0	1,219	1,552	9,502	12,273	146
1949	1,992	34,675	603	752.8	409.9	53,323	593.2	1,101	1,559	7,920	10,580	149
1950	2,394	42,459	719	909.3	430.8	64,500	623.4	1,351	1,822	8,689	11,862	151
1951	1,981	39,765	837	928.3	388.2	70,278	681.2	1,671	2,079	9,779	13,529	153
1952	1,893	39,452	937	925.4	390.2	61,308	666.0	1,617	2,163	9,616	13,396	156
1953	1,958	37,571	1,252	926.4	342.6	74,853	547.4	1,811	2,350	10,257	14,418	158
1954	1,837	36,941	1,461	835.5	325.4	57,948	473.5	1,518	2,630	9,919	14,067	161
1955	1,880	37,198	1,566	998.6	338.0	76,849	514.7	2,055	3,076	10,780	15,911	164
1956	1,827	38,948	1,679	1,104.2	352.8	75,031	542.3	2,358	3,391	11,741	17,490	167
1957	1,794	38,720	1,648	1,086.9	338.2	78,404	531.7	2,137	3,387	12,709	18,233	170
1958	1,739	36,800	1,566	979.3	267.4	57,155	412.0	1,594	3,466	11,589	16,649	174
1959	1,603	23,000	1,954	824.8	255.6	60,210	425.3	1,570	3,861	11,950	17,381	177
1960	1,667	36,800	2,014	1,080.2	246.7	66,501	435.4	2,022	3,868	12,142	18,032	180
1961	1,548	34,794	1,904	1,165.2	261.9	64,853	464.4	1,927	3,946	12,357	18,230	183
1962	1,543	36,799	2,118	1,228.4	237.0	65,638	505.5	1,937	4,117	12,784	18,838	186
1963	1,454	35,242	2,313	1,313.2	253.4	71,840	529.3	2,002	4,316	13,317	19,635	188
1964	1,456	36,334	2,553	1,246.8	286.0	85,458	574.9	2,366	4,623	13,623	20,612	191
1965	1,705	39,806	2,754	1,351.7	301.1	88,207	611.2	2,544	4,933	14,047	21,524	194
1966	1,803	43,669	2,968	1,429.2	327.4	91,287	572.6	2,703	5,176	15,088	22,968	196
1967	1,584	32,119	3,269	954.1	316.9	86,799	549.4	2,333	5,206	16,195	23,729	197
1968	1,478	32,729	3,255	1,204.6	359.2	88,767	529.4	2,703	5,448	16,820	24,971	199
1969	1,733	41,906	3,793	1,544.6	509.0	95,003	553.1	3,332	5,624	17,965	26,921	201
1970	1,743	45,006	3,976	1,719.7	571.8	91,293	534.1	3,928	5,712	20,152	29,790	204
1971	1,495	41,564	3,925	1,522.2	578.6	81,382	502.5	3,403	6,058	21,247	30,708	206
1972	1,450	37,233	4,122	1,664.8	618.9	88,876	478.3	3,642	6,482	22,061	32,185	208
1973	1,176	37,484	4,529	1,717.9	603.0	100,929	478.8	4,362	7,413	25,012	36,788	210
1974	1,127	33,762	4,903	1,597.0	664.0	95,477	500.0	5,552	8,681	40,921	55,155	212
1975	1,026	34,100	3,900	1,397.0	614.0	80,000	474.0	4,852	8,633	48,135	61,620	214

[1]Residing in the United States.

Source: U.S. Bureau of Mines, U.S. Geological Survey, and U.S. Treasury Department data.

☆ U.S. GOVERNMENT PRINTING OFFICE: 1977 O—227-340