Violent death has been a part of coal mining for more than a century and a half. But in recent decades the long struggle to eliminate it has finally started to succeed.

SAFETY FIRST, AT LAST

by Mary Blye Howe

▲ **Rescue workers carry out a victim of the December 21, 1951, mine explosion at West Frankfort, Illinois, in which 119 men died. The author's father was in the mine at the time.**

It was the last shift before the 1951 Christmas holiday, and the coal miners at the Orient No. 2 mine in West Frankfort, Illinois, were in a festive mood as they boarded the cage (the mine elevator) to go to work underground. My dad, a foreman, rode the cage down too. His job this evening was to assign tasks to a group affectionately nicknamed the peanut gang, men with no specific job descriptions who worked wherever they were needed.

As my dad, Joe Burnett, made his way to the main north tunnel, however, he received a call from the mine manager. "Joe, a car derailed in nineteenth east," the manager said, referring to one of the underground "rooms" where mining was taking place. "Send Oak Cantrell to take care of the peanut gang, and you bring a crew to take care of the accident."

An hour and twenty minutes later, not long after my dad and his crew arrived at the scene of the accident, the power went off. Immediately, as mine procedures dictate, he checked his watch, then went to a phone to find out what had happened.

"There's been an explosion," the voice at the other end of the receiver said. "Main north and new main north."

"What's it look like?" Dad asked.

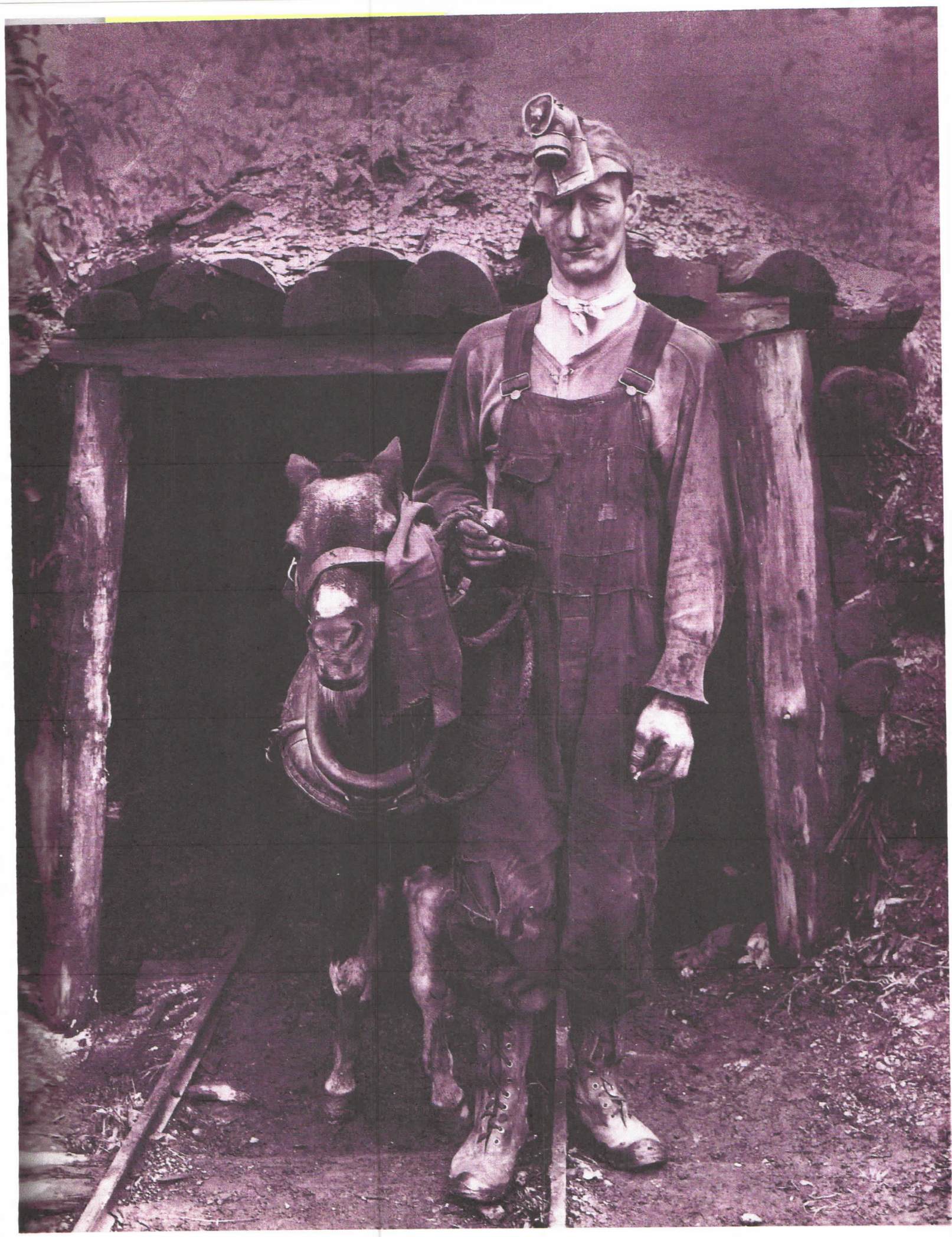
"Looks bad," the manager said. "Looks bad."

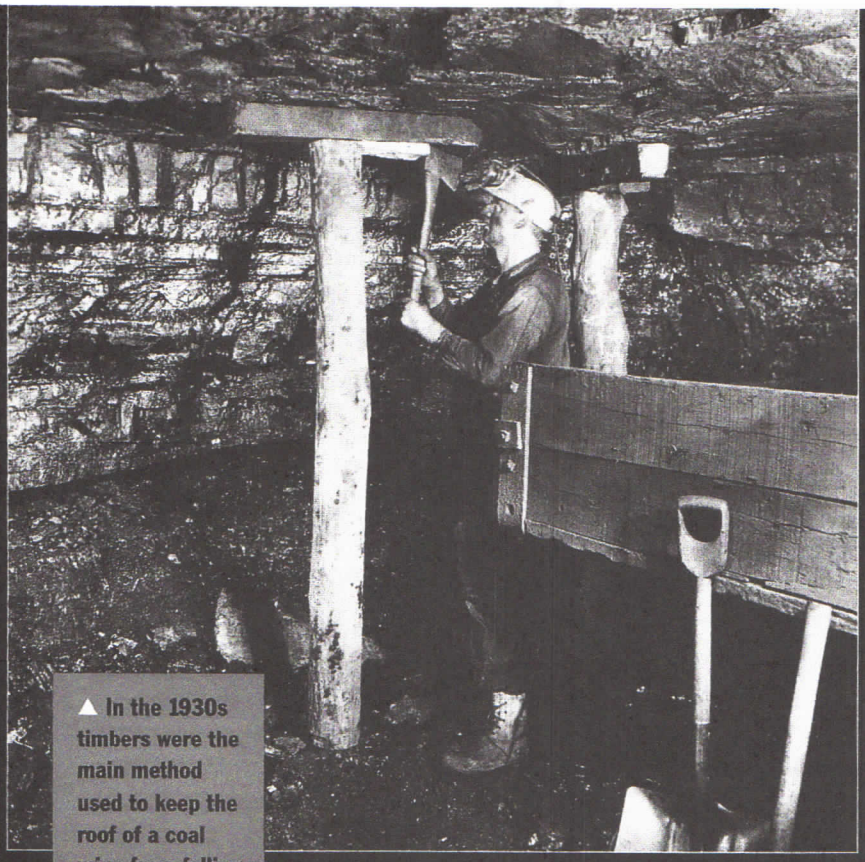
All stations that could be reached were notified, and all men were told to come immediately to the surface. Only a few responded.

At the Central Junior High gymnasium the announcer interrupted the basketball game with a request for all doctors to go immediately to Orient No. 2. As the doctors hurried from the gymnasium, so did

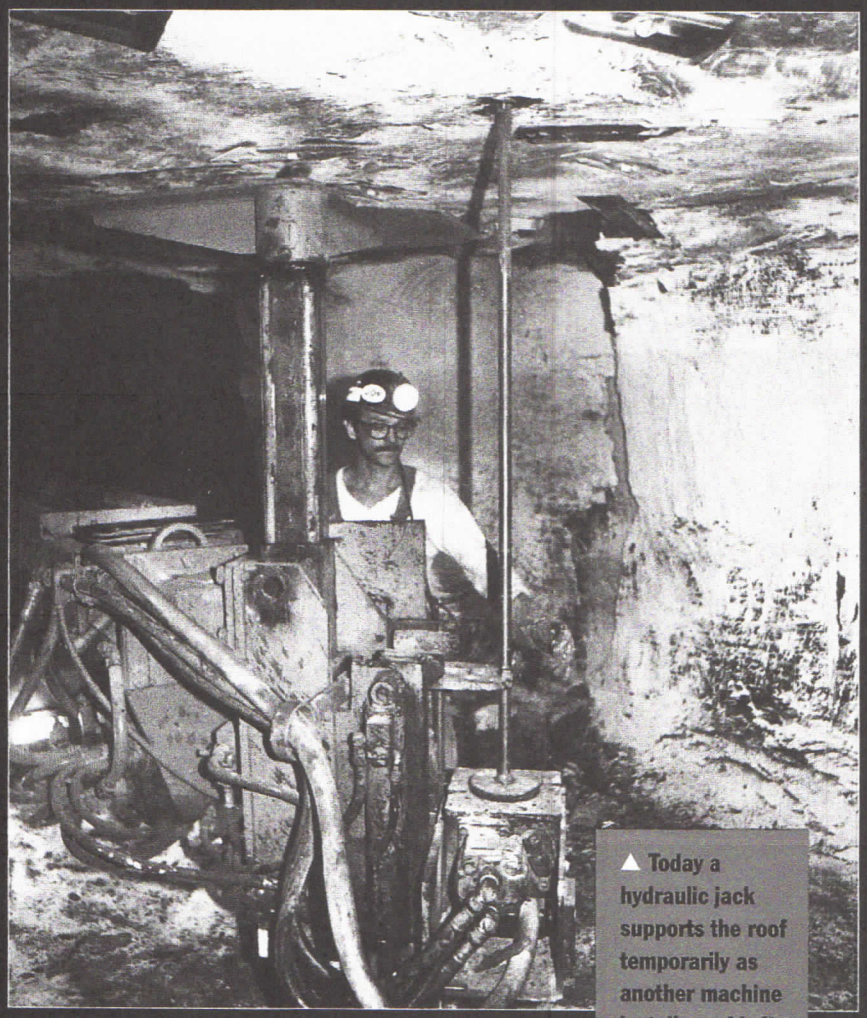
▶ **A 1930s miner stands with his mule near the mouth of his small private mine in Penfield, Pennsylvania. He holds a lit cigarette and wears an open-flame head lamp.**

ABOVE: AP/WIDE WORLD PHOTOS. RIGHT: LIBRARY OF CONGRESS





▲ In the 1930s timbers were the main method used to keep the roof of a coal mine from falling.



▲ Today a hydraulic jack supports the roof temporarily as another machine installs roof bolts.

almost everyone else, many of them panicked wives and family members of Orient miners. In a few minutes the gym was nearly empty. In a few hours it would be full again—lined with body bags.

Not far away, unaware of the disaster, my mother waited for a neighbor to come over for coffee. At 10:00 P.M. Hester knocked on the door, but not for coffee. "Mig, I don't know how to tell you this," she said, "but I just heard on the radio that there's been an explosion at Orient. Three men are dead, and Joe's one of them."

In a state of shock my mother drove to the mine. By the time she got near, cars lined the highway bumper to bumper, and the police had set up blockades. One report stated that "hundreds pushed past police roadblocks, and some who couldn't lined the highways for miles." Obviously the explosion was far worse than had originally been reported.

Once inside the mine grounds, my mother found her way to the washhouse, where the wives, some sobbing, some stunned into silence, waited for word. Miners rushed around everywhere, dazed and oblivious to everything except the urgent work in front of them. All of them looked nearly alike, with blackened faces and clothes, and my mother searched through the mass of faces, hoping to find her husband.

It wasn't until 11:30 P.M., four hours after the explosion, that official word was received: two hundred or more men were underground. Occasionally a voice would boom over the speaker with news of a man who had escaped safely: "John Elliott is out, and he's O.K." Family members would burst into tears of relief. But as the first of the charred and dismembered bodies were brought to the surface, sobs echoed across Orient.

For hours my mother sat with no word. Finally someone touched her shoulder. It was her brother, his face black and his voice choked. "I just saw Joe," he said. "He's O.K." She wept. Both her husband and her brother had survived the explosion.

TOP: EASTERN REGIONAL COAL ARCHIVES;
BOTTOM: AMERICAN IRON AND STEEL INSTITUTE

Most of those who kept the vigil were not so lucky. "I'm sorry," one woman was told. "Both of your sons were killed." A family of twelve screamed their grief as they found out that they were orphaned. Soon my mom would carry to her friend Hester the news that it was not my father but Hester's husband who had been killed in the explosion. Oak Cantrell died in place of my dad because the blast had occurred in the part of the mine to which he had been sent while my father checked on the derailment.

My mother left the mine about 4:00 A.M., and an hour later my father stumbled through the door and into her arms. "They're all gone," he sobbed. "Oak Cantrell, Zoggie, Reach, Southern—they're all gone." Most of my parents' close friends and three of their relatives had died. It was one of only two times anyone has ever seen my dad cry.

After a brief rest my father returned to Orient to assist in rescue operations. Before they could begin, it was necessary to restore ventilation and locate the men trapped inside. Walls known as stoppings are erected throughout coal mines to regulate air flow, and when an explosion occurs, many of the stoppings are blown out. Deadly carbon monoxide and other gases from the explosion accumulate and have to be cleared out before anyone can enter. In this case, even after ventilation was restored, rescue teams found it impossible to work more than two hours at a time because of the dust, smoke, and impenetrable darkness.

Some of the men below found aircourse entries—ventilation tunnels—and made their way to the surface on their own. Others, unable to escape, devised plans to survive for as long as they could. In one instance three men met seven others, all looking in vain for a way out. In an open air course they built a brattice (curtain) out of burlap in order to reroute carbon monoxide and preserve ventilation until they were rescued. The brattice kept the gas away from them for about two hours.

The men then found their way to another entry and built another brattice. One man set his dinner bucket in a haulage road, wrote his name on a cap board (a wedge of wood used to tighten supports against the roof), and drew arrows pointing to the area where they would be entombing themselves. Along their route they wrote "Men Here" on big chunks of coal.

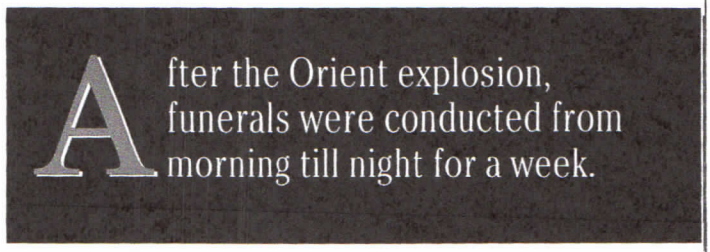
As the gas again began to enclose them, they sang hymns and shared the one pencil they had to write notes to their families. "May the Good Lord bless and keep you, Dear Wife and Kids," one man, the only one of the ten who survived, wrote. "Meet me in Heaven." One by one they began to lose consciousness, and by the time rescue workers arrived nine were dead.

For three days my dad and other miners assisted federal, state, and union inspectors in rescue operations. The explosion occurred on Friday, December 21, and all but one body was recovered by the following Monday morning, Christmas Eve. The last of the 119 bodies was finally found on Wednesday by federal inspectors.

Funerals were conducted from morning until night for a week. Christmas came and went, but few in West Frankfort or the surrounding towns noticed.

The St. Louis *Post-Dispatch* called the explosion at Orient No. 2 "the worst [mine disaster] in the United States in 23 years." My grandfather Roy Groves, at that time a miner for fifty-one years and an examiner for twelve years, a former president of the union local who was described by the *Post-Dispatch* as "the dean and unofficial spokesman for the company's 25 full-time examiners," criticized the Orient company in a headline-making report. The newspaper said that he had examined Orient No. 2 shortly before the explosion and found a number of safety hazards. "The way things are going," he was quoted as having said to a main-line motorman the day of his inspection, "there's going to be the worst explosion here we've ever seen."

The Orient No. 2 mine was believed to be the largest in the world, with the main hoisting shaft located at the northern edge of West Frankfort and the working area of the mine (about twelve square miles) extending to the southern edge of Benton, a town seven miles away. Official reports regarding the explosion conflicted somewhat, but in the end it was more or less agreed that methane accumulation ignited by an electrical arc or a cigarette had caused the initial blast, which was then spread by coal dust.



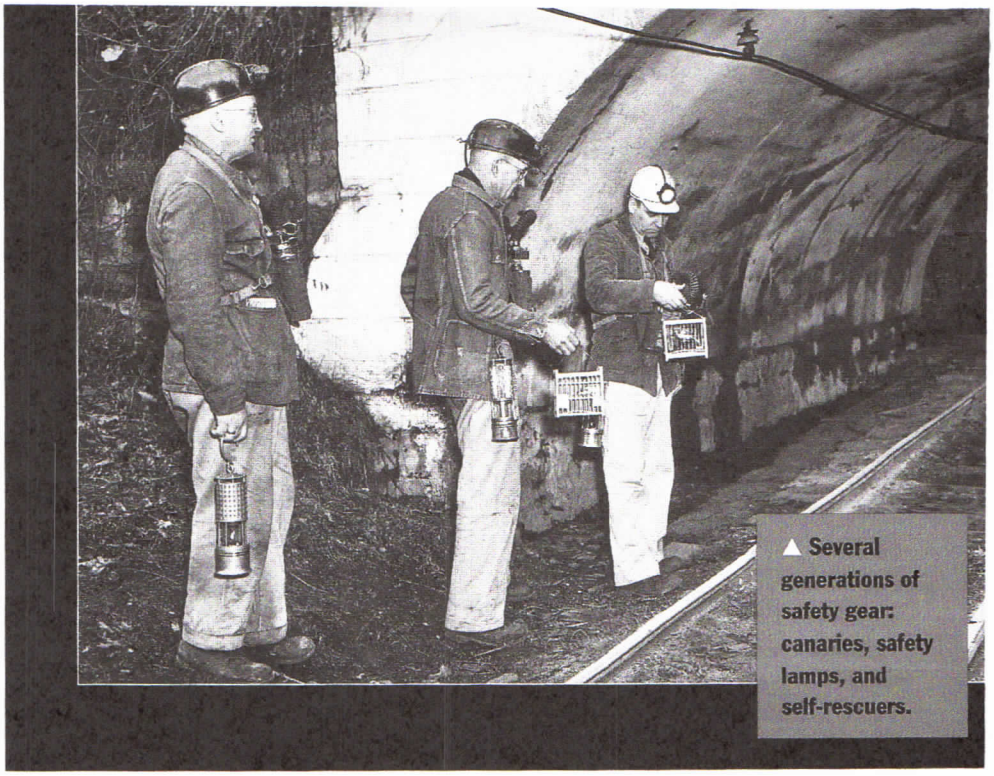
Opinions over the cause of the explosion varied, but one thing was certain: Men had been killed, once again, in an unnecessarily hazardous profession. More than a hundred children were left fatherless. The reverberations penetrated the hearts of Americans, and technological advances in the area of safety became a priority.

This explosion finally spurred the first effective federal mine-safety legislation. President Harry S. Truman asked Congress to give the Interior Department the power to enforce safety in coal mines "since most states failed to protect miners' lives." John L. Lewis, president of the United Mine Workers of America (UMWA), made an impassioned plea before the House of Representatives on February 21, 1952, that helped bring the legislation into effect.

"I just watched 119 funerals . . . ," Lewis said. "They went to work, the last shift before Christmas. And many of them were brought home to their loved ones in rubber sacks . . . because they were mangled, and shattered, and blown apart, and cooked with gas, until they no longer resembled human beings. And the best the morticians could do was to put them

in long rubber sacks with a zipper. And for a Christmas present in Franklin County, 119 families could look at rubber sacks in lieu of their loved ones. . . . The mining industry continues to be a mortician's paradise."

That year the Federal Coal Mine Safety Act took effect. It did not meet President Truman's stated goal of putting mining under federal control, but it did give the Bureau of Mines "limited power to issue notices of violation and withdrawal orders when imminent danger exists." There was still a long way to go, but it was a good beginning.



▲ Several generations of safety gear: canaries, safety lamps, and self-rescuers.

In the mid-1800s miners in Pennsylvania began to dig the first large amounts of coal in the United States. From that time through the first few decades of the twentieth century, mining was not mechanized and was extremely hazardous.

When he was twelve years old, in 1896, my grandfather George Burnett, like most miners, worked ten hours a day, six days a week, for twenty-five cents a day. Women, and children as young as ten, hauled coal from the mines. Thousands died from explosions, roof falls, floods, fires, collapses, and other accidents, and thousands more from lung diseases.

The federal Bureau of Mines was created in 1910, but power stayed with the states.

In 1905 a record number of mining disasters occurred, with twenty separate incidents, but other years in this time period weren't far behind: there were eighteen in 1907, nineteen in 1909, and nineteen again in 1910. In Monongah, West Virginia, the worst mine disaster in U.S. history occurred on December 6, 1907. At least 361 men were killed, and that was only the official figure. It's believed that the deaths of many immigrants and children went unrecorded. In a single grim month that became known as Bloody December, 34 men had died just five days before Monongah in an explosion at the Naomi mine near Fayette City, Pennsylvania; then ten days after Monongah, 57 died in a blast at Yolande, Arkansas; and three days after that, 239 men died at the Darr mine in Jacobs Creek, Pennsylvania.

Clearly, explosions occurred often in coal mines. Coal is made up of moisture, fixed carbon, ash, and volatile matter. As it is mined, dust is stirred into the air, and the ventilation system then can carry it throughout the mine. One-twelfth of an ounce of dust per cubic foot of air is enough to do the job. Moreover, the finer the dust, the greater its explosiveness; any particle small enough to pass through a twenty-mesh screen (one with twenty holes per inch) can start an explosion.

Roof falls also contributed to early disasters. As they dug, coal miners erected wooden props to support the roof of the mine. These props repeatedly proved inadequate, and men were killed, either from the roof falling in on them or from "squeezes," where roof and floor gradually come together and force methane into the air courses.

Finally, ventilation was highly inadequate. In any mine air comes in through an entry and goes out through a "return" shaft. Stoppings are built to regulate the flow. Early stoppings were made of wood. If an explosion or fire occurred in the mine, they could burn, cutting off ventilation and hindering rescue work.

In those days the methods of actually extracting the coal were also extremely hazardous. A miner drilled a hole six to eight feet into a coal seam and placed black powder into the back. A narrow rod was then inserted. The man tamped dirt around the rod and carefully worked it back out, leaving a little tunnel from the outside wall to the black powder.

The miner would then place a squib (a fuse) into the hole, yell "Fire in the hole!" to warn the other workers, light it, and run. The squib would shoot through the little tunnel and ignite the powder, causing an explosion. Coal would fall, and men would break it into pieces with picks, hand-load it, and haul it to the surface.

One danger with this method was that if a miner didn't tamp the dirt tightly enough, the black powder could shoot back out the hole instead of blasting down the coal. A second, more obvious peril was that black powder and methane-laden coal don't interact for a safe working environment. As early as 1839 an explosion at

▲ A modern counterpart to the hardly reliable canary detects methane in minute concentrations.

a coal mine near Richmond, Virginia, killed forty men. The blast was so strong that it blew three men a hundred feet into the air.

Before the 1930s safety measures progressed slowly. In the very early years, miners took a canary underground to test for carbon monoxide immediately after an explosion. If the bird died, the men would increase the ventilation until the gas was blown out the return. The method was picturesque, and it lives on as a popular figure of speech, but it was not very reliable.

During the first half of the nineteenth century miners began to carry safety lamps. Three separate models were introduced within a few weeks in the fall of 1815. Their inventors were William Reid Clanny, George Stephenson, and Sir Humphry Davy, the famous English chemist.

To use the lamp, a miner lit the flame and took it into working areas to test for gas. If the flame increased, methane was present; if it went out, carbon monoxide was present; if it stayed steady, conditions were safe. A wire mesh encased the flame, and only if the wire became as hot as the flame could it cause an explosion.

Unfortunately, older safety lamps could be taken apart, and when they didn't seem to work properly, men often did so. At Orient No. 2 in 1926, and undoubtedly at other mines at other times, explosions were caused and lives were lost by miners taking apart a safety lamp when methane was present.

The late nineteenth century saw another safety improvement when ventilation fans replaced furnaces. In the early years furnaces were built underground, and the heat they generated caused air circulation. Large fans installed aboveground moved the air more efficiently, but small auxiliary fans, which were often used inside the mine, actually turned out to be safety hazards; they could incorrectly route toxic air or stir up coal dust.

During the first decade of the twentieth century, as mining employment and accidents mounted, several further safety measures came into force. Professional "shot-firers" began to perform the dangerous task of blasting the coal. Earlier anyone could use explosives, but now blasting was done before the shift began by men specifically trained for the job. Accidents from blasting became less frequent, and when they did occur, fewer men were present. Dynamite and other more stable explosives slowly replaced black powder, though the higher cost was an obstacle, and certification became a requirement for mine employment in some states. Prospective miners were tested (sometimes not very rigorously) to ensure that they could speak enough English to warn and instruct others in an emergency.

Communication became a priority. Amid the workers' rights movements of the Progressive era, and following the horrors of Bloody December and a 1909 mine fire in Cherry, Illinois, that killed 259 men, the federal Bureau of Mines was created in 1910 to investigate disasters and circulate information. The bureau had no enforcement power, since there were no federal regulations on mine safety and the bureau did not have any authority to create them. The best it could do was to recommend safety standards with which state governments were urged to comply. (Eventually, in the 1940s, the bureau would gain the authority to shut down mines in case of imminent danger, but its scope for action remained quite limited.)

Another major advance was rock dusting, in which miners spray finely crushed limestone onto the ribs and roof of the freshly mined coal. Rock dusting, which was put into use between 1915 and 1920, reduces the spread of explosions by reducing coal dust. Unfortunately, since it was a costly added step instead of a one-time investment, like safety lamps, rock dusting was harder to justify when economic conditions were tough, which was most of the time. Since miners were paid by the amount of coal they loaded, they sometimes cut corners on safety to make more money.

During the 1920s and 1930s mechanization began to take over many mining tasks. Dynamite still "shot down the coal" in what is known as the room-and-pillar system of mining, in which miners excavate "rooms" from a vein of coal, leaving some of it as "pillars" to support the roof. But cutting and loading machines replaced picks and shovels for the most part, locomotives replaced mules to haul the coal away, and electric drills and other equipment began to appear.

Around this time concrete stoppings were introduced. Not only did they

▲ In the longwall method, jacks support the roof as coal is cut to be carried off by a conveyor.

provide somewhat better roof support, they aided ventilation, since fire could not destroy them as it did wooden stoppings. During the 1940s roof bolting also greatly improved roof support. In this system a metal plate, about six inches square with a hole in the center, is placed against the spot where a hole has been drilled in the roof. A long bolt with an expansion shell is then inserted through the metal plate and into the roof. As the miner rotates the bolt, the shell expands, much like an umbrella opening, and binds the overhead layers of rock together.

With the passage of the Norris–La Guardia Act of 1932, which prevented injunctions against legal strikes (a favorite tactic of management and government in the 1920s), and the Wagner Act of 1935, which guaranteed the right to collective bargaining, the next couple of decades passed in a flurry of labor struggles and massive strikes. Mine labor had been plagued by factional struggles since first being organized in the 1840s; now, as the unions' position became stronger, violence continued, this time between UMWA members and "progressives," a dissident faction with its greatest strength in Illinois. In one episode early in this period in southern Illinois, my uncle Floyd Groves, a strong UMWA advocate, was shot in the back during an argument. He was laid to rest several years ago with the bullet still in his spine.

In 1920 John L. Lewis had taken over as president of the UMWA, a position he would hold for forty years. He was all but omnipresent and took full advantage of every law and opportunity to further the union cause. A drastic cut in coal consumption throughout the country following World War I resulted in the laying off of so many miners that one account of the era says they had "almost a ten-year head start on the Depression." Lewis pulled together what was left of them and began to organize massive strikes.

Lewis and seven other union leaders organized the Committee for Industrial Organizations (later the Congress of Industrial Organizations) in 1935, and he began to preach the gospel of mine safety to America via radio. These were decades of intensity, of demands and anger and frustration as the age of safe working conditions was born amid fierce labor pains. But even the idea of technological advances in safety was something of a paradox. At one point more accidents occurred from the use of machinery than from any other cause. Sparks from machinery in gassy areas caused most explosions. For the miners ushering in the new age of technology, these years were anything but the golden age of mining safety.

By the 1950s machines called continuous miners were beginning to appear in American coal mines. The continuous miner (which today accounts for about 65 percent of United States un-

NATIONAL COAL ASSOCIATION

derground coal extraction) did away with the separate tasks of mining: cutting, drilling, blasting, and leading, a series of jobs that used to require four different crews. It accomplishes everything with a stroke of its giant steel jaws. After cutting coal from the seam, the machine feeds the coal via its own conveyor to its tail, where it's loaded automatically into a shuttle car. Continuous miners decreased the need for explosives, but they created more coal dust and methane—as well as more noise—than earlier methods. At first operators tried to fit continuous miners into existing production schemes, but soon it became obvious that specially designed systems were necessary. Miners grew restless for safety technology to catch up with production technology.

Even though strikes and labor demands continued during the 1950s and 1960s, earlier unionized protests eased into a period of relative peace. This was partially due to the generally improving safety conditions and the resulting decrease in fatal accidents: deaths in U.S. coal mines declined from 1,463 in 1931 to 420 in 1955. (Mine employment decreased from 590,000 to 260,000 over the same period; the fatality rate fell from 1.66 to 1.00 per million man-hours.) The antiunion Taft-Hartley Act of 1947 made it hard for the UMWA to hold on to the gains it had achieved, and after Lewis's defiance of a 1948 federal court order to end a strike resulted in a heavy fine, the union moved toward less confrontational tactics. Lewis's retirement in 1960, which led to a bitter and bloody struggle for control of the union, also played a part in the lull.

It was not a strike but another disaster that brought on the next, and most powerful, piece of federal legislation. In 1968 one of the five worst disasters in half a century killed seventy-eight men in Mannington, West Virginia. Early in the morning of November 20, an explosion in the Consolidated Coal Company's No. 9 mine destroyed the electrical circuits that ran the ventilating equipment. Over the next nine days sporadic explosions, sixteen in all, continued as fire raged and thick black smoke poured from the shafts. Nobody trapped inside could be reached, and eventually the mine had to be sealed to cut off the air supply and put out the fire.

For the first time in history, most of America received the news of a major mine disaster via television. There had been worse accidents, but never before had the shocking images been so widely and instantly disseminated. What had been accepted before as a necessary evil suddenly became an outrage. The result was the Federal Coal Mine Health and Safety Act of 1969, a law that finally gave the federal government full power to enforce mine-safety regulations.

The new law forced coal-mine operators to have plans for ventilation, roof support, and emergency evacuation approved by the Mining Enforcement and Safety Administration, predecessor of today's Mine Safety and Health Administration (MSHA). It required federal inspections four times per year at every underground coal mine and gave the inspectors the authority to issue citations and stop mining operations if imminent danger existed. Samples of coal dust must now be provided to inspectors for lab analysis. (More than five hundred coal companies faced nearly five million dollars in fines last year for tampering with samples. Many companies are contesting the charges, but one recently pled guilty and was assessed the largest federal fine ever given for a case that did not involve a fatality.)

The law also mandated grants to states and universities for safety-related research. This opened the door to the greatest and fastest progress the mining industry has ever seen. The goal of zero coal-mining fatalities by the year 2000 set by U.S. Secretary of Labor Lynn Martin is starting to look achievable.

In the 1970s many mines began to monitor safety conditions with computers. I recently toured Sahara No. 21 at Harrisburg, Illinois, and saw strategically placed sensors designed to pick up signs of fire, gas, or malfunctioning equipment. If the sensor detects trouble, an alarm sounds in a central office, where a staff member reads the report on a computer screen—for example, "carbon monoxide is 15 parts per million on your number two belt" or "there's a decrease in air velocity" or "an increase in methane"—and takes the appropriate action. Sahara hasn't had a fatality in more than six years.

> At one point sparks from machinery caused more explosions than anything else.

With the enactment of the 1969 legislation, rescue teams became a requirement at all mines. (Many of these teams compete in annual contests.) Individual mines devise their own emergency procedures. At Kerr-McGee in Galatia, Illinois, sensors have lined the walls and ceiling in the fuel-storage room since 1985. Should a fire break out, the doors would automatically shut and the entire room fill with foam to smother the flames.

Fireproof ropes with cones attached run along the walls. In case of fire miners can slide their hands down the rope, following the contour of the point to safety. A twelve-hundred-foot slope set at a seventy-degree angle provides a last-resort exit in case a power failure shuts down the cages. An escape capsule installed in the early 1970s provides an alternate way out for miners at Sahara. If they can't escape any other way, the capsule, which is big enough to hold two men standing up and is hoisted like a cage, can bring them out through a shaft dug for the purpose.

In addition, the law requires every miner to be equipped with a device called a self-rescuer, which is similar to

a gas mask. A self-rescuer converts exhaled carbon monoxide to harmless carbon dioxide, allowing a miner to escape from a monoxide-rich area by breathing air he has exhaled. Similar devices called "self-contained" self-rescuers are stored in various places throughout the mine; instead of converting carbon monoxide, these provide a supply of oxygen. The first, or "conversion," self-rescuer is used for a short time only, to give the miner time to reach the second.

Although the 1969 legislation required the development of this latter type of self-rescuer, mines didn't begin using them until the early 1980s, when a Kentucky disaster that left miners unharmed by the direct effects of an explosion but dead from lack of oxygen prompted federal enforcement. During the last few years a smaller self-contained self-rescuer has been developed. Soon miners will be able to carry these on their belts and dispose of the conversion rescuers altogether.

The Secretary of Labor's goal is zero coal-mining fatalities by the turn of the century.

Because coal-mine operators focus on preventive technology, emergency procedures are rarely needed. Although Sahara's capsule is tested often, it has never been needed for an emergency. No miner has groped his way along the ropes and out of Kerr-McGee because of an explosion; none has occurred. Increasingly safe roof support is another modern precaution. Today roof bolts must be placed every five feet, and larger bolts must be used for less stable roofs. "You *don't* want a roof citation," says Terry Guest, a safety technician at Sahara.

One modern method of roof support involves an entirely different method of coal mining from the traditional room-and-pillar. Longwall mining, introduced in Europe in the late 1800s and still widely used there, became popular in our country in the 1970s. Now employed by about a hundred American mines, it provides mobile roof support that allows clean and solid roof falls. Unlike room-and-pillar mining, in which pillars of coal are left standing to help support the roof, longwall mining leaves little coal behind. However, longwall equipment is very expensive, and many mines can't afford to make the switch. In Europe, where coal is less plentiful, there is more of a need to extract as much as possible from a mine.

In the longwall method two tunnels spaced 250 to 750 feet apart are driven in the coal seam from the main haulage tunnel and are linked by a fourth tunnel. A shearing or plowing device removes the coal from this fourth tunnel in slices running parallel to the haulage tunnel. Hydraulic jacks supporting a long, flat canopy hold up the roof and advance with the miners. The roof then falls in behind the men as they advance or retreat. Because of the clean roof falls, there's no danger of a squeeze or an accidental fall. Although longwall mines produce only about 5 percent of American coal (the rest is divided between room-and-pillar and surface, or strip, mining), more and more mines are converting to this method.

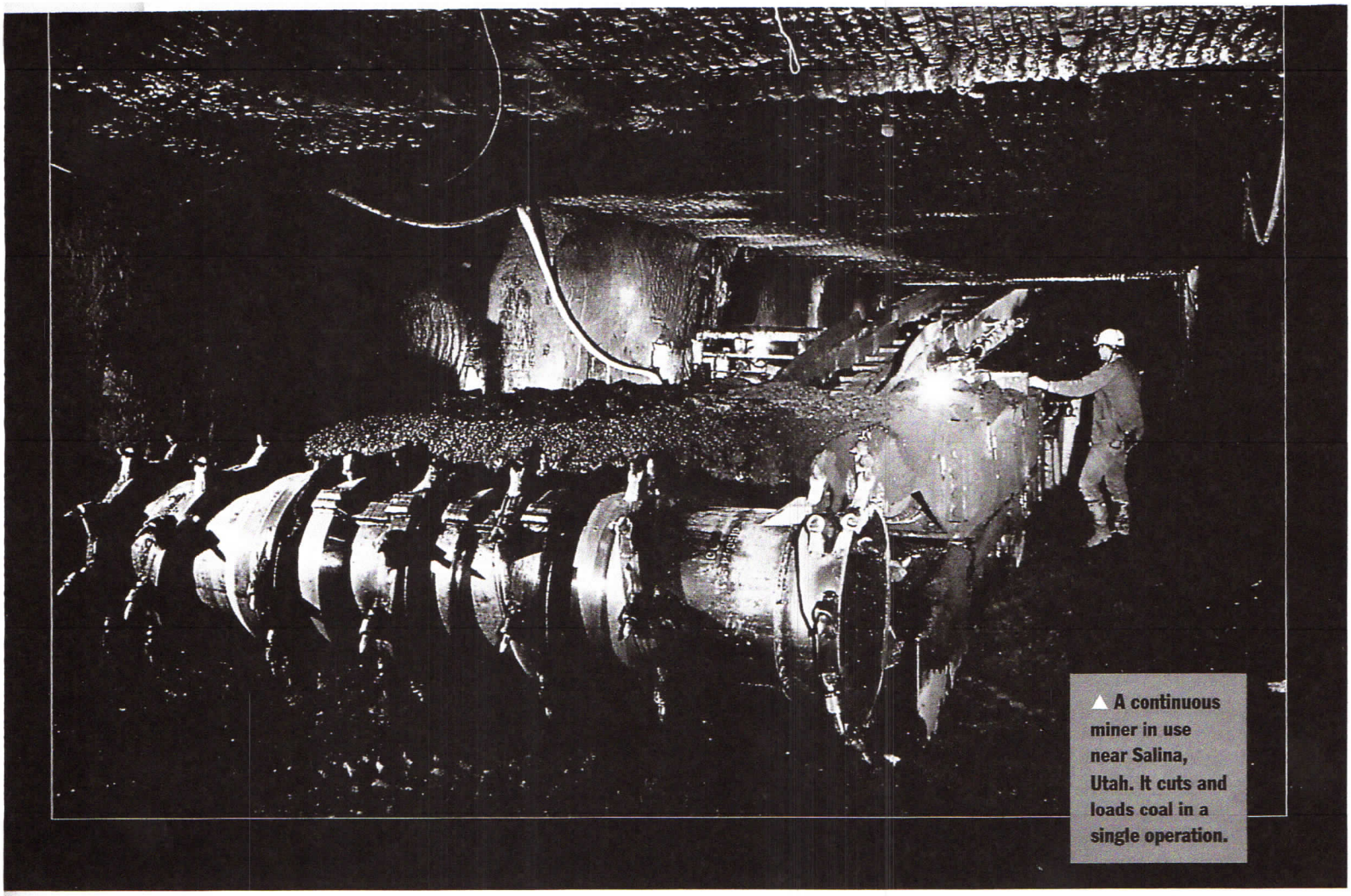
Most mines today are also very clean. The bulk of the coal dust is removed, and water is continually sprayed in the face area to keep excess dust sedated. Damp coal dust is still explosive, but only if it's suspended in the air; spraying helps prevent that. Some mines install massive sprinkler systems. Miners spray ribs and roofs diligently, and dust samples are lab-tested regularly to decrease the risk of explosions.

Ventilation standards demanded by the 1969 act also contribute to mine safety. Old entries where mining is completed are sealed and ventilated. The seals are regularly inspected, but in the event that methane seeps through, ventilation will carry it into the return and away from areas where it could cause an explosion.

Where doors are used in ventilation passageways, they're installed by twos, with a space in between. A miner goes through the first door, shuts it, then goes through the second one. This procedure ensures that air used for ventilation follows the proper path instead of a shorter one having less resistance. Large fans located outside the mine are protected by explosion doors, and auxiliary fans are banned except by special permission. Overcasts and undercasts (concrete tunnels installed a few feet below or above working areas) provide uninterrupted additional ventilation. Although some of these safety measures were used earlier, they weren't federal requirements until 1969.

The future looks even brighter. Last year *Coal* magazine announced a prototype of a new continuous miner, designed and built by a team at the University of Missouri–Rolla and several NASA engineers. Two cutting heads and two lances spew jets of water as they bore into the coal. Studies before the miner was built estimated that it could reduce deaths and disabling injuries by up to 90 percent. Unlike standard continuous miners, the new machine generates very little dust. It also has shields that provide roof support for an entire entry, although roof bolts would still be used behind it.

A process called borehole degasification also offers interesting prospects. Holes are drilled vertically from the surface deep into the coal bed, or horizontally from underground into virgin coal; a pump is installed, and methane is sucked out before miners enter the area. Since the mid-1970s coal-bed methane (CBM) has been recognized as a potential energy source. With a tax credit made available for a limited time to energy firms, many mine operators have sold CBM to these companies and recouped some of the expenses incurred when they installed the gas wells. Most mines, however, can't afford the high cost of



▲ A continuous miner in use near Salina, Utah. It cuts and loads coal in a single operation.

installing a CBM collection system, and it isn't yet known whether CBM will become an important source of energy. If it does, there will certainly be an incentive to make full use of it, and a bonus will be greater mine safety.

For at least one miner, a little good-humored superstition plays a part in safety too. My nephew Ron Hutchcraft, a mining engineer in Dugger, Indiana, has carried a dinner bucket that his grandfather (my dad) used for forty years. Joe Burnett and his bucket survived three explosions. When Ron worked underground in a southern Illinois mine, his co-workers constantly threatened to throw it away when he wasn't looking and buy him a new one. "This bucket has survived a lot," Ron told them firmly. "Touch it and you die."

Since 1900 more than a hundred thousand workers have been killed in United States coal mines. Many thousands more have been injured. The difference between the early and later years of the century, however, is significant. MSHA's official records date back to 1931, with 1,463 fatalities for the nation. In 1990 there were 67 fatalities (for a rate of .22 per million man-hours). As always, some deaths are the result of human error rather than faulty engineering; accidents can occur through simple carelessness on the part of miners, such as going into an area where the roof is unsupported.

In 1981 Illinois became the first major underground coal-producing state to pass an entire year without a single fatality. Since then other states have matched that achievement. Mines with impeccable safety records know they get that way by following safety regulations to the letter.

Recently I toured Kerr-McGee, considered by many to be the showcase mine of southern Illinois. After watching a video on safety procedures and demonstrating that we knew how to use a self-rescuer, three of us walked past the gymnasium area and into the women's dressing room. There we donned regulation jumpsuits (snug-fitting to decrease the chances of getting caught in the machinery), hard hats, safety belts, goggles, and steel-toed boots for our trip underground. I exchanged stories with Leonard Hopkins, the maintenance manager—mine about my dad and his three explosions and Leonard's about a relative who lost a leg when he pushed another man out of the way of a rock fall.

Occasionally we stopped so I could get a better look at some of the machinery. Once I wandered off a little to take a few pictures. Pieces of shale fell regularly from the roof somewhere in the distance. When what must have been a sizable chunk hit the mine floor, making a loud, reverberating noise in the stillness of our part of the mine, I let out a staccato scream.

Leonard rushed over to see what had happened, his face somewhat pale and a little less relaxed. It was a reminder that today, in the 1990s, mine safety is not something anyone takes for granted. ★

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