INVESTIGATION OF FIRE IN THE KINGS MINE

PRINCETON MINING CO., PRINCETON, IND.

BY

C. A. HERBERT, W. A. GALLAGHER, AND F. J. SMITH
INFORMATION CIRCULAR

UNITED STATES DEPARTMENT OF THE INTERIOR - BUREAU OF MINES

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PRINCETON, IND. 1/

By C. A. Herbert,2/ W. A. Gallagher,3/ and F. J. Smith4/

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INTRODUCTION

A fire started about 10 a.m., November 10, 1947, at the Kings mine, Princeton Mining Co., Princeton, Ind., about 1,800 feet inby the main shaft bottom on the main west haulage road at a point estimated to be 2 miles from the faces of the main west entries. No lives were lost, as 27 men escaped from the mine after a series of explosions, which necessitated sealing the mine on the surface.

1/ Work on manuscript completed in April 1948. The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Inf. Cir. 7491."

2/ Supervising engineer, District E, Health and Safety Division, Bureau of Mines, Vinconmns, Ind.


I.C. 7491

This information circular shows how adverse conditions might be overcome, when reopening a sealed mine, by expert planning and close cooperation on the part of various organizations. Conditions found in the mine after it was reopened were comparable to the worst that had been anticipated, yet the mine was recovered with comparatively little difficulty and a minimum of risk. The open workings in the mine covered a vast area, but most of the mine resumed production of coal after being sealed for only 37 days.

The information contained herein also points to the desirability of adhering as closely as possible to a predetermined schedule of operations.

GENERAL INFORMATION

The Vincennes office of the Bureau of Mines was notified that a fire was burning in the mine at about 11:45 a.m., and W. A. Gallagher, F. J. Smith, F. J. Gallagher, J. S. Maleisky, J. P. Sheridan, J. A. McCune, C. M. Dovidas, and Roy Capps were sent to the mine to assist in any way possible. When those men arrived at the mine, no information was obtainable from the officials on the surface as to the extent of the fire, so they entered the mine and assisted in combating the fire.

The Kings mine is about 3 miles south of Princeton, Gibson County, Ind., and is served by the Chicago & Eastern Illinois Railroad. Normally, 540 men were employed on two producing and one maintenance shifts, and the average daily production was 4,125 tons of coal. About 190 men were working underground on the day the fire started.

The mine was opened by three shafts, which range from 450 to 465 feet in depth, into the Indiana No. 5 coal bed, which averages 69 inches in thickness. The hoisting shaft and the elevator compartment of the No. 1 air shaft were return-air outlets, and the second compartment of the No. 1 air shaft and the No. 2 air shaft were intake airways. All three shafts could be used for escape in an emergency.

The immediate roof over the coal bed is shale, and the bottom is a smooth, hard, fire clay.

The following coal analysis was obtained from the company:

<table>
<thead>
<tr>
<th></th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>9.86</td>
</tr>
<tr>
<td>Volatile matter</td>
<td>35.53</td>
</tr>
<tr>
<td>Fixed carbon</td>
<td>48.97</td>
</tr>
<tr>
<td>Ash</td>
<td>5.64</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100.00</strong></td>
</tr>
<tr>
<td>Sulfur, percent</td>
<td>1.55</td>
</tr>
<tr>
<td>B.t.u.</td>
<td>12,338</td>
</tr>
<tr>
<td>Ratio of volatile to total combustible matter</td>
<td>0.42</td>
</tr>
</tbody>
</table>
MINING METHODS, CONDITIONS, AND EQUIPMENT

The mine was worked by a panel room-and-pillar system, but pillars were not extracted. Main and cross entries were driven in sets of four, and room entries were driven in pairs at intervals of 600 feet. Entries were driven 1½ feet wide, rooms were about 26 feet wide, and crosscuts were about 4½ feet apart.

The coal was undercut to a depth of 7 feet with nonpermissible mining machines, some of which were equipped with bug dusters to minimize the dispersion of dust. Airdox was used to dislodge the coal, which was then loaded by 11 caterpillar-mounted and 4 track-mounted loading machines. The track-mounted machines loaded into mine cars, and the other machines loaded into shuttle cars.

Timbering was done systematically, and the general practice was to set safety posts at the faces of the working places.

Ventilation was provided by a 7-foot Aerodyne fan at the No. 2 air shaft and a 12-foot centrifugal fan at the No. 1 air shaft. The fans were operated blowing, and the haulage roads were in return air. The housings and air ducts were fireproof, and all of the usual safety appliances were provided. Approximately 185,000 cubic feet of air a minute was circulated through the mine.

Overcasts, permanent stoppings, and seals were well-constructed with concrete, cinder blocks, and bricks, and air readings in excess of 6,000 cubic feet a minute were obtained in the inby crosscuts between working entries during a recent Federal inspection.

The mine is considered by the Indiana Bureau of Mines and Mining to be gassy and is classified as gassy by the Federal Bureau of Mines. During the September 1947 Federal inspection, 10 air samples were collected in open workings; analysis of these showed methane content as follows:

<table>
<thead>
<tr>
<th>Description</th>
<th>Methane Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return air, 7-8 east, M. S.</td>
<td>1.05</td>
</tr>
<tr>
<td>Face, Room 3, 9 east, M. S.</td>
<td>1.04</td>
</tr>
<tr>
<td>Return, bottom of man shaft</td>
<td>0.38</td>
</tr>
<tr>
<td>Return air, main north</td>
<td>0.57</td>
</tr>
<tr>
<td>Return air, 3 west</td>
<td>0.42</td>
</tr>
<tr>
<td>Return air, 9-10 east, M. S.</td>
<td>0.77</td>
</tr>
<tr>
<td>Return air, 11 east, 3 south</td>
<td>0.39</td>
</tr>
<tr>
<td>Return air, bottom main shaft</td>
<td>0.42</td>
</tr>
<tr>
<td>Return air, main west</td>
<td>1.00</td>
</tr>
<tr>
<td>Return air, 5 west, 3 south</td>
<td>0.45</td>
</tr>
</tbody>
</table>

The haulage roads and working places were comparatively dry, but several small sumps were provided at various places along the haulage roads and at the bottoms of the hoisting and No. 2 air shafts. Two pumps were used to pump excess water to the surface.
The entries and rooms were generally well rock-dusted, and undoubtedly the rock dust that had been applied to the haulage entries prevented widespread explosions that might have wrecked the mine and snuffed out the lives of the 27 men who were in it when the gases distilled by the fire exploded.

Trolley-pole and cable-reel locomotives and shuttle cars were used to transport the coal in the mine. All haulage on the main line was controlled by a signal-light system and a dispatcher.

A step-up, double-drum hoist was used for handling coal, men, and materials, and it was equipped with automatic safety devices.

The power cables entered the mine through boreholes and the main (hoisting) shaft. Fireproof substations were provided in the mine, and seven motor-generator sets supplied 250-volt direct current to all electric face equipment and the trolley circuit. Cut-out switches were installed in the power circuits at frequent intervals and at the beginning of all branch lines.

The mining machines, loading machines, drills, locomotives, and shuttle cars were of the nonpermissible type, and the trailing cables for the face equipment were not provided with fuse protection.

The direct-current feeder and trolley circuits were equipped with reclosing circuit breakers at the substations. However, the breaker in the main west substation did not open when the steel mine cars contacted the trolley wire and short-circuited the system. The short circuit occurred more than 5,000 feet from the main west substation, and the voltage drop in the line limited the current flow to less than that required to "trip" the breaker. Inasmuch as a short circuit of the direct-current system was the direct cause of the fire, the importance of proper circuit-breaker protection is emphasized. In this instance, the short circuit occurred at such a great distance from the substation that the resultant amperage was not as high as the circuit-breaker setting.

To illustrate the point, some curves showing distances from substations plotted against current flowing in copper conductors of various sizes are shown in figure 1. All of the possible conductor combinations are not included, but interpolations can be made for approximate values. The chart was prepared by F. J. Gallagher, mining-electrical engineer, Bureau of Mines, Vincennes, Ind., after exhaustive tests were made.

A 300-kilowatt motor-generator set supplied power to the haulage system through a 500,000-circular mil feeder and a 4/0 trolley wire; the circuit breaker was set at 50 percent overload, and approximately 1,800 amperes would flow on the 250-volt system. The 500,000-circular mil feeder cable, together with the 4/0 trolley wire, equals 711,700 circular miles, or almost the equivalent of a 750,000-circular mil cable. By selecting a point at 1,800 amperes on the vertical scale of figure 1, moving horizontally to the 750,000-circular mil curve and then vertically downward to the horizontal scale, it will be found that the maximum distance from the substation that the circuit breaker would open on a "dead" short would be 4,600 feet. Beyond this point insufficient current would flow to open or "trip" the breaker.
Figure 1. - Effectiveness of circuit breakers with conductors of various capacity.
Many serious mine fires have occurred because of improper or inadequate circuit protection on direct-current systems.

MISCELLANEOUS

Electric lights operated from the mine circuit were provided at the shaft bottom, passing tracks, switches, doors, and other strategic locations. The employees used permissible electric cap lamps for portable illumination. The underground officials used permissible flame safety lamps, which they cleaned, filled, and assembled.

A rule prohibiting smoking in the mine was in effect, and no infraction of this rule was observed when the last inspection was made.

During December 1947, 27 men were trained in mine rescue and fire-fighting procedures by a Bureau of Mines instructor. Many of the officials also had been trained in this work previously.

All permanent buildings were constructed of brick, concrete, and steel, and ample fire-fighting facilities were provided.

Water lines, hose, and fire extinguishers were available around the shaft bottoms, and a high-pressure rock-dusting machine and a fire car were stationed on a sidetrack a few hundred feet from the bottom of the main shaft. Supplies of rock dust, sand, and a fire extinguisher were standard equipment at each substation, and a fire extinguisher was carried on each loading machine.

STORY OF THE FIRE

The fire broke out in a cut-off between 1 and 2 main west entries at the bottom of a sharp grade on which skids were used to help control a descending trip. Fourteen cars of coal and a locomotive made up the trip that wrecked and caused the short-circuit; however, the usual trip from this section was from 16 to 26 cars. Whether the motorman thought that it would not be necessary to use skids under the cars could not be determined, nor was it possible to determine whether skids had been used and lost coming down the hill. It was apparent, however, to those who reached the scene shortly after the accident that the three cars next to the locomotive had buckled and contacted the trolley wire. It was also noted that the locomotive remained on the track. When the trip was stopped, one or more cars were in contact with the trolley wire and caused considerable arcing. The motorman walked to the shaft bottom, a distance of about 1,800 feet, and reported to the motorman that his trip was wrecked and on fire.

The motor boss "pulled" the switch in the trolley circuit at the shaft bottom, but the wire was still receiving power from the motor-generator set in the main west. He then notified the superintendent. The unit foreman at the main west section soon realized that something was wrong, as his cutting and loading machines were not receiving enough power to operate properly. He started to walk out the haulage road toward the substation,
and when he reached that point and found nothing wrong he knew that the trouble was beyond and he continued toward the shaft bottom, pulling the first switch he encountered in the trolley line. This deenergized the wire that was in contact with the cars, but it was estimated that 25 to 30 minutes had elapsed from the time the short circuit occurred until the power was cut off. The foreman continued out until he met the superintendent and other officials at the fire, which was now blazing freely. He then returned to his section and led his men out the intake air course to the man shaft. The other unit foremen in the mine were notified to get all the men out and to assist in fighting the fire. Forty-two men, officials and keymen, remained in the mine to fight the fire. State Mine Inspector J. M. Austin was then notified, and he came to the mine promptly. Fred Conrad, safety inspector for the Lynch Reciprocal Insurance Association also was notified, and he came to the mine as soon as possible and assisted in fighting the fire.

The main west working section consisted of four development entries, of which two were intake and two were return airways. The haulage road and parallel entry were ventilated with return air, and approximately 20,000 cubic feet of air a minute was flowing through these entries to the main hoisting shaft, which was a return-air outlet. This section was considered to be very gassy, and the officials felt that reducing the volume of air passing through it would involve too much risk. The analysis of a sample of the return air from the main west collected during the September 1947 Federal inspection showed 1 percent of methane, and gas was found with a permissible flame safety lamp at the faces of three of the four entries during the inspection.

The first crew of men that attempted to reach the fire by going in the haulage road encountered smoke and fumos a short distance in and had to return to the shaft bottom and go through the intake-air courses. The smoke and fumos also prevented taking the fire car and high-pressure rock-dusting machine in on the haulage track. A steel trap door in the brick stopping between the intake and return airways, about 250 feet in by the fire, provided access to the fire area for the men carrying bags of rock dust and fire extinguishers from the shaft bottom. Rock dust and fire extinguishers also were obtained from the working section in by the fire, and preparations were made to apply water on the fire. Shortly after work was started to extinguish the fire, the shale roof weakened and began to crack, and the area had to be timbered. About 18 timbers were set to provide protection for the men fighting the fire, but the roof immediately over the fire started to cave, and the burning coal was soon covered with rock. Some of these timbers broke later, and more rock fell near and on the previous fall of roof.

Water was bailed from a small sump nearby, poured into a 1-1/2-inch hose, and pressure from the Airdox line was used to force the water through the hose onto the fire. It was soon evident, however, that the sump did not contain enough water to extinguish the fire; therefore, some of the men retreated temporarily to obtain a hand pump and set it up at a much larger sump about 150 feet cut by the fire area in the intake airway.
The Bureau of Mines men entered the mine shortly after their arrival and met the group of men who obtained the hand pump in the intake air course. Some of the men continued to the scene of the fire; the others returned to the shaft to help in carrying supplies for combating the fire. Travel in the airways was difficult and slow because of numerous falls.

Foamite was being applied to the inside end of the fall covering the fire to exclude as much air as possible, and water was being applied directly on the fire, when the Airbox line under the fire ruptured. This occurred about 5:30 p.m., when the fire seemed to be fairly well under control, and the smoldering pile was soon fanned into a blaze. The attendant at the compressors on the surface stated later that the air-pressure gages showed a rapid drop in pressure from 10,000 pounds to 5,000 pounds and he thought the air line had broken, but his instructions were to keep the compressors operating because the compressed air was used to supply force to the water being sprayed on the fire.

Two of the fire-fighting crew were directed to close the valve on the air line, but they thought that the valve that controlled this air line was near the main (hoisting) shaft, where the smoke and fumes made it inaccessible; therefore, they continued to the surface to cut off the air. When, after a reasonable length of time, the escaping compressed air did not diminish in force, another man was dispatched by the superintendent with instructions to close the valve that was near the No. 1 (man) shaft in air that was not contaminated by the fire. It was too late, however, because a dull-red glow was soon observed in the entry outby the fire at a distance that appeared to be about 75 feet. About this time, a plentiful supply of water started to come through the hose that had been attached to the hand pump, but the dull red glow indicating fire farther out the entry brightened and suddenly burst into flame. In a matter of seconds the entry for a distance of 75 feet outby the fire was a mass of flame, and the superintendent, State mine inspector, and Bureau of Mines men decided to stop fighting the fire directly and seal the entries. Accordingly, the top company officials and keymen, the State inspector, and Bureau representatives went to the surface to study the mine map to determine the points at which sealing might be done to the best advantage, and 27 men remained underground to obtain the necessary materials. The day-shift foreman and the assistant foreman on the night shift remained inside to take charge of this work. When those who went outside reached the surface landing they were met by Griff Morris, chief of the State inspection department, and George Tillie, another State mine inspector.

The meeting in the office was concluded, and at 7:02 p.m. a deep rumbling in the mine was heard which was followed by a terrific blast up the shaft, after which a small fire at the head sheaves and several small fires in the tippie were started. All who attended the meeting had started toward the tippie when, less than a minute later, a second explosion occurred and threw flame more than 100 feet above the head sheaves. The local fire department was summoned, and they quickly extinguished two small fires that were still burning.

The second blast that came up the shaft was witnessed by all who had been in the conference and was heard by some mine employees residing several
miles from the mine. It did not seem possible that any of the men working around the bottom of the No. 1 shaft or in the underground shop could have survived the two explosions. (See fig. 2.) It was known, however, that five men had been sent to the No. 2 shaft to reverse the direction of air flow to permit installation of seals on the return-air side of the fire. A hoisting engineer, accompanied by several of the company officials, went to No. 2 shaft to determine whether the five men had been injured or had escaped. Some men remained at the hoisting shaft to insure that no one got too close to it; others went to the No. 1 shaft, which was the normal emergency escapeway. The cage in the No. 1 (man) shaft was controlled by push buttons mounted on the cage and at the top and bottom landings. When the group of men arrived at the top of No. 2 air shaft, they observed that the cage was in operation, and presently a load of men rose to the surface. The cage was returned to the bottom promptly, and a second load of men came to the surface, accounting for 20 of the men who were in the mine.

The mine foreman, Ray Williams, and the assistant mine foreman on the night shift, Everett Jordan, refused to leave with the other men, because they feared that the five men who were still inside might return to the No. 1 (man) shaft and become excited when they encountered the smoke and debris that developed after the explosions. They remained in the air lock provided between the manway to the escape No. 1 shaft and the intake airway, stepping out the short distance to the haulageway occasionally to determine whether they could see the men coming out from No. 2 air shaft. While in the air lock, these two men were knocked down by three more violent explosions; however, these explosions were not observed on the surface. About 10 minutes after the fifth explosion, they saw the lights of men running toward them; these men had felt the concussion from this explosion and realized that something unusual had happened. They stated later that this was the first indication they had that something was wrong. The No. 2 shaft was about 3 miles from the No. 1 shaft by the route they had traveled inside the mine. Messrs. Williams and Jordan got the men into the manway quickly and closed and braced the emergency steel door at the entrance to the manway from the haulage road. The trap doors to the intake air course were then opened to clear the smoke and fumes, which were by that time in the manway and No. 1 shaft, whereupon the men got on the cage, started it, and lay on the floor. Their calmness and foresight in closing the emergency door and opening the trap doors enabled them to get off the cage unaided. All men who had been working near the bottom of the No. 1 (man) shaft were heavily coated with dust, but its light color indicated that a large percentage of it was rock dust. One man sustained a broken collar bone, and another had numerous small heat blisters on his back. These two men were the only ones injured.

There was no doubt in the minds of the men who had seen the flame from the second explosion coming out the shaft that only the extensive rock dusting that had been done could be credited for saving the lives of those men that were in the mine. Analyses of dust samples collected on the main west haulage road just off the shaft bottom during the September 1947 Federal inspection showed the incombustible content of the rib and roof sample to be 92.7 percent and that of the floor to be 87.9 percent. The second explosion occurred before the dust raised into the air by the violence of the
Figure 2. - Large-scale map of shaft bottom and fire areas.
first explosion had time to settle, but the rock dust neutralized the combustible content of the mine dust and prevented extensive propagation of the explosion.

The courage displayed by Ray Williams and Everett Jordan, who remained in the mine after the explosions to help other men escape, was recognized by the Governor of the State of Indiana; both men were awarded plaques commending their heroism.

After all the men had gotten out of the mine safely, the only course open was to seal the mine at the shaft openings on the surface; accordingly, sealing was started about 10:00 p.m. and completed about 11:30 a.m. the next day. The openings were closed by laying 4- by 12-inch timbers across the shafts and covering them with about 30 inches of clay, which was kept moist for several days until it attained the consistency of mortar. The seals were fitted with pipes and valves to permit sampling the mine air.

About 3 a.m., November 12, the seal on the No. 2 shaft was destroyed by an explosion in the mine, and at 8:15 that night the seal on the No. 1 air shaft was jarred loose. Both seals were replaced as rapidly as possible, and no further difficulty was experienced insofar as the seals were concerned.

The fire originated in the main west entries near the center of a swag approximately 1,000 feet long. From contours of the entries it was determined that water poured into the fire area would reach the roof at both ends of the fire area before it would flow to any other part of the mine. It was then decided to drill a borehole from the surface to intersect the main west entries as close to the fire as possible. A special oil-well drilling outfit was obtained, and drilling was begun at 1:30 a.m., November 16. The hole was completed at 6:25 a.m., November 17, at a depth of 440 feet, approximately 29 hours after drilling was started. The log of an old borehole drilled nearby showed the coal to be 448 feet below the surface, indicating that 8 feet of the shale roof over the fire had fallen. Two hours after the drill hole was completed, a thermometer was lowered through the hole. Upon withdrawal it registered a temperature of 140°F. A similar test made 5 hours later indicated a temperature of 149°F. At 1:35 p.m. water was pumped into the mine through the borehole at a rate estimated to exceed 25,000 gallons an hour. This was continued until 10:00 p.m., November 21, at which time it was estimated that almost 3,000,000 gallons of water had been pumped into the mine. Eighteen hours later, a thermometer lowered in the hole indicated a temperature of 93°F. On December 1, a temperature of 72°F was recorded, and only a slight change of one or two degrees was noted thereafter until the mine was reopened.

**PREPARATIONS FOR REOPENING MINE**

The Kings mine is the largest shaft mine in operation in Indiana, and produced a premium grade of coal that was very much in demand. As coal supplies began to diminish and a scarcity of fuel threatened to develop in this area, considerable pressure for quick resumption of operation was brought to
bear by consumers who had no knowledge of the dangers involved in reopening the mine. The mine owners naturally wanted to resume operation, but only under circumstances that would be consistent with safety.

Water had to be pumped to the surface from the main south off 3 west to prevent it from overflowing into the main south working sections, where about 50 percent of the coal was produced, because it was evident that most of the mining equipment therein would be damaged seriously if steps were not taken to prevent submergence. After considerable discussion as to the probable length of time the mine would be idle, a borehole was drilled in the vicinity of the main south sump. A 250-gallon-a-minute deep-well pump was installed to prevent an excessive amount of water from collecting in the workings, and it operated efficiently. The location of this borehole and the one over the fire were determined from the mine surveys by Hugh W. Morris, chief mining engineer; excellent results were obtained with the use of them.

Roy Capps, safety instructor at the Vincennes station, was assigned the task of collecting pertinent data, obtaining samples of mine atmosphere behind the shaft seals and through boreholes, and analyzing some of these samples at his headquarters. Samples could be collected only when the pressure was outward behind the seals and in the boreholes, and Mr. Capps is highly commended for his diligence in collecting and analyzing the samples at all hours of the days and nights that the mine was sealed. Figure 3 shows the results of the analyses of samples made in the Bureau of Mines laboratory in Pittsburgh, Pa., and in Vincennes, Ind., together with the temperatures recorded at the bottoms of the shafts and boreholes. Figure 4 is a property map on which is shown the locations of shafts and boreholes where samples were collected and temperature readings were obtained.

Weekly meetings were held at the mine office to analyze and discuss all available information concerning the opening of mines that had been sealed because of fire and to develop a plan for reopening the Kings mine. These meetings were attended by the coal company officials; J. Ogilvie, superintendent of the Bicknell (Ind.) Mine Rescue Station; F. Conrad, representing the insurance company; Griff Morris and J. M. Austin, of the State mining department; and C. A. Horbert, W. A. Gallagher, F. J. Smith, J. S. Malosky, C. M. Dovidia, and Roy Capps, of the Federal Bureau of Mines.

The general opinion was that because of the numerous explosions the mine atmosphere would reach more quickly than usual the state considered to involve a minimum of risk when unsealing the mine. A sample of the mine atmosphere was collected at the top of the main shaft a few hours after sealing was completed on November 11 and showed the following analysis: oxygen, 16.23 percent; carbon monoxide, 0.70 percent; carbon dioxide, 2.73 percent; and methane, 0.82 percent. Four days later, November 15, four samples collected at the hoisting shaft and No. 1 air shaft were analyzed and showed the following limits: a maximum of 5.5 percent and a minimum of 3.7 percent of oxygen; a maximum of 2.6 percent and a minimum of 2.5 percent of carbon monoxide; a maximum of 7.5 percent and a minimum of 7.3 percent of carbon dioxide; and a maximum of 7.0 percent and a minimum of 6.9 percent of methane. On November 17, six days after the mine was sealed, a sample of
Figure 4. Property map showing locations of shafts and boreholes at which samples were collected and temperature readings obtained.
the atmosphere from the borehole drilled over the fire area showed 1.6 percent oxygen, 2.6 percent carbon monoxide, 8.3 percent carbon dioxide, and 12.2 percent methane. The maximum concentration of carbon monoxide indicated was 2.7 percent on November 14, 1947, and a maximum of 63.2 percent of methane was shown in a sample collected December 17, 1947.

At the meeting held in the mine office December 15, 1947, it was decided to reopen the mine on the morning of December 18, 1947. The oxygen content of the samples collected on December 14 appeared to be satisfactory, and the traces of carbon monoxide were believed to be due to the numerous explosions that had occurred, rather than from burning material. The high positive (outward) pressure that was evident at the borehole over the fire area when samples were collected indicated that the area was sealed effectively by the water that had been poured into the mine. The possibility that the fire had spread to the bottom of the hoisting shaft was considered remote.

The ventilating fans has been kept in operation until all of the men had escaped from the mine and it seemed logical to assume that, other than the first two explosions, which had shot flames out of the hoisting shaft, the subsequent explosions traveled in by on the main west entries into intake air. The men who escaped from the mine after the explosions were quite certain that no evidence of fire was visible near the bottom of the hoisting shaft when they left the mine. Nevertheless, the adopted plan of procedure was predicated principally upon the ability of the workmen to seal the entrances to the main west section quickly. The speaking tube in the hoisting shaft was to be converted into a water line, and fire hose with dual connections and reducing valves was to be taken in by the first crew of men descending the shaft.

On December 2, 1947, C. M. Dovidas, safety instructor at the Bureau of Mines station in Vincennes, Ind., started training 25 mine officials and 2 other key men in the use of self-contained oxygen breathing apparatus. This training was concluded on December 12, and it was arranged that two teams would be available on each shift during the recovery operations. Dovidas and Malek, of the Bureau of Mines, trained with and acted as captains of the teams in practice drills held after the original training was completed.

The curtain wall in the No. 1 air shaft was known to be weak, and it was thought likely that the wall was destroyed by the explosion that shook the seal on top of the shaft; consequently, the No. 2 air shaft and the hoisting shaft were to be used to ventilate the mine during the period of reclamation.

REOPENING THE MINE

The Aerodyne fan at the No. 2 air shaft was capable of circulating 250,000 cubic feet of air a minute; this fan was to be operated exhausting, making the hoisting shaft an intake. Such an arrangement would expedite access to the area around the bottom of the hoisting shaft, where the opportunity for smouldering fire to rekindle seemed the greatest. The fan speed was reduced to a minimum, a door to the motor compartment was opened, and a
blower fan with tubing was installed to ventilate the fan motor to prevent the latter from igniting flammable gas coming out of the mine. A brattice-cloth air duct somewhat larger than the outside diameter of the fan casing, was erected at the end of the fan air duct in such a manner that the injector action of air exhausted from the mine would draw fresh air into the mine-air stream to dilute as much as possible the heavy concentration of methane in the exhausted mine air. The seals were then removed from the top of the No. 2 air shaft by men wearing gas masks and oxygen breathing apparatus. The fan was reversed at 5:20 a.m., December 18, 1947, and the volume of air entering the mine in the main shaft was determined later as slightly more than 90,000 cubic feet a minute. The seal was then removed from the hoisting shaft, and the cages were run up and down to determine whether there was any obstruction in the shaft. The shaft was unobstructed, and a lighted safety lamp was lowered on a cage to the bottom of the shaft, and when returned to the surface 5 minutes later the lamp was still burning. The safety catches of the cage were tested and found to be in good order, after which a signaling device was installed on the cage. A cager was stationed at the top landing to keep a record of all persons entering and leaving the mine.

A fully equipped mine rescue team entered the cage at 6:07 a.m., with a second team standing by near the top of the hoisting shaft. The cage was lowered slowly so that the shaft could be examined carefully; it was found to be in good condition. A thorough inspection was made for methane, carbon monoxide, and deficiency in oxygen in the immediate area around the shaft bottom. Atmospheric conditions were found to be satisfactory, whereupon the team returned to the surface. Two fully equipped teams then entered the mine, accompanied by W. A. Gallagher of the Federal Bureau of Mines, and Griff Morris, director of the Indiana Bureau of Mines and Mining. The rescue teams, with the mine superintendent and mine foreman as members, were captained by C. M. Dovidas and J. S. Maleisky, of the Federal Bureau of Mines. About 7 a.m., a third fully equipped mine rescue team, sponsored by the Lynch Reciprocal Insurance Association, arrived from Bicknell, Ind.; this team was held in reserve on the surface. J. Ogilvie, superintendent of the Bicknell rescue station, and Fred Conrad, safety inspector for the insurance company, accompanied the team and assisted materially in opening the mine.

A fresh-air base was established at the bottom of the hoisting shaft, and the adjacent abandoned entries, shops, and haulageways were explored thoroughly. The steel girders used to support the roof on the bottom were dislodged, and heavy falls were discovered. Steel rails set in brick piers has been used as roof supports on the main west haulag; road, and these were knocked out or sheared off, permitting heavy falls on the main west and the north east cross entries. Evidence of flame was observed in the foremen’s office and pump room on the west side of the bottom of the hoisting shaft, but the wooden benches at the man-trip station and combustible materials in the shop on the east side of the shaft bottom were not even scorched. The main objective of the rescue teams was to determine whether air was flowing into the main west section and to establish the points at which the entries could be sealed. It was found that a small volume of air was entering 2 main west, but further exploration by a crew wearing oxygen breathing apparatus
indicated that the air was flowing in 2 main west only as far as the first crosscut and returning through 3 main west. The return air, however, contained smoke, and efforts to make further examinations for fire had to be discontinued because of the heavy falls encountered.

Preparations were made to erect temporary seals under the overcasts at the mouths of 1 and 2 main west entries and at the point where the regulator had been installed in the normal intake airway, now the return airway. The seal on the return side was installed by the Bicknell mine rescue team wearing gas masks. The other two teams continued to explore surrounding territory that might not have been ventilated adequately but found no indication of methane or carbon monoxide in any of the openings examined.

The temporary seals were completed at 10:45 p.m., and permanent brick seals were built the following day. The seals were fitted with pipes and valves for sampling purposes.

About 7 hours after the seals were removed from the shaft openings, smoke was observed and heat was perceptible at the fall inby the overcast on 2 main west and in a breakthrough between 3 and 4 main northeast entries. Indication of excessive heat also was observed at the inby end of the fall that extended from the shaft bottom to the trapper station near the No. 1 air shaft, but no smoke was visible at this point. The smouldering material in 2 main west was inby the overcast where the seal was to be installed, and a constant stream of water was played on the other two falls that showed smoke and evidence of heat. No active fire developed, and no further difficulty was experienced in exploring and ventilating the rest of the mine. However, it was necessary to clean numerous hoary falls around the bottom of the hoisting shaft, repair the curtain wall and lining of the No. 1 air shaft, dewater several swamps in the working territories, and dry some of the electrical equipment before production could be resumed. An inspection of the working places several days after reopening the mine disclosed that very few falls had occurred while the mine was sealed, but numerous falls occurred after the mine had been ventilated thoroughly; a fall on January 5, 1948, killed a man. Except for the sealed main west section, the mine started producing coal on January 14, 1948.

Placide Mayeur, superintendent of the mine, expressed his appreciation, on numerous occasions, of the services rendered by the Indiana Bureau of Mines and Mining, Lynch Reciprocal Insurance Association, the U. S. Bureau of Mines, and the officials of nearby mines. He was especially pleased with the manner in which his men performed while wearing oxygen breathing apparatus, and he especially commended Mr. Devidas for training the men.

On March 4, 1948, a decision was made to discontinue production and reopen the main west entries, but when a test hole was broken through the 2 main west seal, smoke was observed and carbon monoxide was detected in the atmosphere in the sealed area. It was immediately concluded that the seals were not air-tight and that a further attempt should be made to completely flood the area between the seals at the mouths of the entries and the water seal where the fire had originated, about 1,800 feet inby. The 2 main west
seal was closed again, and water was pumped into the area until it reached a point 3 feet 4 inches above the coal bed on the heavy fall in by the seal. On March 9, the pressure of the impounded water pushed the fire-clay bottom out from under the seal; however, the fire had been extinguished. The seals at the No. 2 shaft end of the main west section were removed March 12, and work was begun to ventilate the section. It was found that all but one of the brick stoppings between the 2 and 3 main west entries, which were somewhat more than 2 miles in length, had been demolished by the explosions that occurred when the fire was raging. No major falls were encountered and this recovery work was completed on March 31.

Because of the deep-seated fire under the 20-foot fall just in by the mouth of 2 main west, it was an extremely difficult task to erect the temporary and permanent seals in this entry; therefore, the permanent seals in 1 and 2 main west entries had to be erected under the overcasts at the main northeast entries from which the main west entries were turned. Time was an essential factor when these seals were built, and if they had not been completed so quickly it would have been necessary to rescale the mine on the surface, thus proving the value of having a preconceived plan and following it as closely as possible.

CONCLUSIONS

It is much more important to devise means of minimizing the hazards of mine fires than to develop a procedure for reopening a mine sealed because of a fire. Conditions in mines vary widely, but under circumstances similar to those prevailing at Kings mine the following conclusions are reached for minimizing the hazards of fire:

1. Airdox lines should be installed in nonhaulage entries.

2. A track should be maintained in the intake air course when the haulageway is ventilated normally with return air; preferably, the haulageway should be in intake air. In this instance, the special fire-fighting apparatus that was available in the mine could not be taken to within 1,800 feet of the fire.

3. Circuit breakers should be installed so that they will protect against short circuits.

4. Adequate means to control trips on descending grades not only should be provided but should be used.

5. Water lines should be installed throughout the mine and should be provided with taps at frequent intervals along the haulage roads. In most mines in Illinois and Indiana, ample quantities of water are impounded in sealed areas, and enough pumps are available to provide this important safety measure at very little expense.