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UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

DISTRICT H

FATAL

FINAL REPORT OF BUMP-EXPLOSION ACCIDENT
SPRING CANYON NO. 4 MINE
SPRING CANYON COAL COMPANY
SPRING CANYON, CARBON COUNTY, UTAH

January 17, 1958

By

E. R. Rodriguez, Mining Health and Safety Engineer
A. Z. Dimitroff, Mining Health and Safety Engineer (Electrical)
Joe Freeman, Coal-Mine Inspector

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District H

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INTRODUCTION

A bump and explosion occurred in the 4 left section off the main slope of the Spring Canyon No. 4 mine, Spring Canyon Coal Company, Spring Canyon, Carbon County, Utah, about 12:30 a.m., Friday, January 17, 1958, resulting in the death of four men (Appendix A) and considerable property damage. The main slope hoistman, the only other person in the mine at the time of the bump and explosion, escaped uninjured.

The accident was believed to have been caused by bumping and caving that occurred in the 4 left section releasing methane which was ignited by an electric arc or spark from the trolley wire.

Three maps are attached to this report showing the following:

Figure 1. Map of Spring Canyon No. 4 mine showing mine ventilation prior to the accident; direction of explosion force; limit of flame; regulators, overcasts and stoppings demolished; and pillar line in 4 left section at time of accident.

Figure 2. 4 left section showing direction of force; regulators, overcasts and stoppings demolished that are within the limits of the map; locations of bodies, falls and equipment; indications of bumps on ribs of pillars; pillar line prior to the accident; and locations of fires.

Figure 3. Detail of fatal accident site showing locations of bodies, trip, fall, end of trolley line, and indications of bumping within the limits of the sketch.

GENERAL INFORMATION

The Spring Canyon No. 4 mine, Spring Canyon Coal Company, is situated at Spring Canyon, Carbon County, Utah on branch lines of the Denver and Rio Grande Western Railroad and the Utah Coal Route, Utah Railway Company.

The names and addresses of the operating officials were as follows:

Paul Shields, President, 320 E. 4th S., Salt Lake City, Utah
C. E. Pauley, Vice President in Charge of Operations, Spring Canyon, Utah
Ray Woodward, Superintendent, Spring Canyon, Utah
George Farrimond, Mine Foreman, Spring Canyon, Utah

A total of 156 men was employed, of which number 117 worked underground on two shifts and produced about 1170 tons of coal daily. Five men were in the mine when the accident occurred.

The mine was opened by a short rock tunnel and a 30-foot shaft and was connected by four airshafts of about 45-foot depth with workings of the underlying abandoned No. 3 mine. The lower workings of the mine were served by the main slope which was about 4050 feet in length with the hoist located underground.

The mine workings were in the Castlegate "B" seam of the Blackhawk formation. The bed of high-volatile bituminous coal varies in thickness from 5 to 10½ feet and averages north 75 degrees west in strike and 5 degrees northerly in dip in the mine.

The strata immediately above the Castlegate "B" seam in the mine area consists in general of up to 6 inches of shale overlain by a laminated hard sandstone up to 3 feet in thickness. This sandstone is overlain by up to 3 feet of fragile shale with one or two thin rider seams of coal. Above the fragile shale is a thick massive sandstone. A sandstone rock split from a few inches to 12 feet in thickness separates the Castlegate "B" seam into two beds in some sections of the mine. The rock split, 2 to 3 feet of top coal, the shale above the coal, or the sandstone above the thin shale bed comprised the immediate roof in the mine workings. The immediate floor consists of hard sandstone or sandy shale.

The analysis of a sample of 6-by 0-inch coal by the Bureau of Mines, dated November 20, 1957, Laboratory No. F-61982, on as-received basis, was as follows:

	Percent
Moisture	5.8
Volatile Matter	42.6
Fixed Carbon	46.2
Ash	5.4
	100.0

The ultimate analysis also showed 0.3 percent sulphur.

The ratio of volatile matter to total combustible matter of this coal, which is an index of explosibility of the coal dust, is shown by the following formula:

$$\text{Volatile - Combustible ratio} = \frac{\text{Volatile matter}}{\text{Volatile matter} + \text{fixed carbon}}$$

$$= \frac{42.6}{42.6 + 46.2} = 0.480$$

Bureau of Mines tests and experiments have shown that coal dust having a ratio of volatile to total combustible matter in excess of 0.12 is explosive. The explosibility of coal dust increases as the ratio increases. The above calculated ratio indicates that the coal dust in this mine is high volatile and is explosive.

The mine records showed that no other explosions have occurred in this mine; however, an explosion in which two men lost their lives occurred in Spring Canyon No. 1 mine, Spring Canyon Coal Company, on May 23, 1924. The Spring Canyon No. 1 mine was situated about 230 feet underneath the present Spring Canyon No. 4 mine.

The last previous inspection of the Spring Canyon No. 4 mine was completed on October 24, 1957.

MINING METHODS, CONDITIONS, AND EQUIPMENT

Mining Methods

Mining was by the room-and-pillar method with loading by means of crawler-type loading machines.

In the 4 left section four entries were driven off the main slope approximately on the strike of the coal bed for a distance of about 3700 feet. The entries were driven about 22 feet in width on 60-foot centers with crosscuts approximately 20 feet in width on 55- to 220-foot centers. Chain pillars varied in size from 35 by 35 feet to 35 by 200 feet. Rooms were driven up the pitch 130 to 160 feet in length starting at the inby end of the entries. Rooms were driven about 22 feet in width on 60-foot centers with crosscuts about 18 feet in width on approximately 65-foot centers. In the vicinity of the accident site (caved area outby the pillar line on appended figures 1 and 2), room pillars were of fairly uniform size, about 38 by 47 feet.

Development of the 4 left entries in the vicinity of the accident site was during the period September and October 1957.

In the 4 left section, room and chain pillars were recovered on retreat, and rooms in general were developed a minimum distance of 150 feet ahead of pillar mining. At the time of the accident, rooms were developed

about 400 feet ahead of the pillar line. A barrier pillar varying in width from 17 to 50 feet was left between the 4 left section and the previously mined 3 left section, and the upper row of room pillars was not extracted. Pillars were extracted by the pocket-and-fender method with the outby end of the pillar extracted last from the crosscut side. Recovery from pillars in the 4 left section was reported to be only about 40 percent because of difficult roof conditions. The retreating pillar line was about 300 feet long. Top coal, that was left on development, was extracted during pillar mining.

The short pillar line and low percentage extraction of pillars in the 4 left section could result in poor caving and consequent impingement of large loads on pillars in the abutment zone. With pillars of greatly variable size, the loads would not be distributed uniformly and could result in excessive loading of some pillars. A barrier pillar of inadequate size between mined out areas or pillar sections could be overloaded.

The possible structural weakness indicated by a gulch above the 4 left pillar section could have contributed to the damage resulting from a severe bump.

Roof support in the 4 left section consisted of three-piece sets on a maximum of 6-foot centers with timber of 8- to 10-inch diameter. These sets were spaced as close as 1-foot centers in some sections. During pillar recovery work, the three-piece sets were replaced by straight props when the top coal was taken down, and props were used in pillar lifts.

Use of roof bolts was started in the mine in 1956 but bolts were not used in the 4 left section. Bolts of the expansion-shell type, 3½ to 6 feet in length, were installed during development in other sections of the mine to support the rock split above the lower portion of the coal seam or the shale overlying the coal seam.

Geologic Conditions

The roof strata above the Castlegate "B" seam consists of massive sandstone, sandy shale, and shale beds with the sandstone in excess of the other rocks. Drill hole logs showed several thick sandstone beds in the overlying strata. According to the limited information available, the massive Castlegate sandstone bed, which is generally believed to contribute to the bump conditions in other mines of the area, is at least 700 feet above the Castlegate "B" seam in the vicinity of the mine and is 200 to 400 feet in thickness.

The thickness of cover above the mine workings varied appreciably owing to the rough surface topography. The maximum cover was approximately 1500 feet.

About 40 to 60 feet of sandstone, sandy shale, and shale beds with some thin seams of coal separate the Castlegate "B" seam from the underlying Castlegate "A" seam. The thick, massive Aberdeen sandstone bed underlies the Castlegate "A" seam. The No. 3 mine workings were in the "A" seam; however, these workings were an appreciable distance from the 4 left section of the No. 4 mine. The No. 3 mine was no longer in operation. Some of the workings in the inactive No. 1 mine in the Spring Canyon No. 3 sub-seam, about 230 feet below the Castlegate "B" seam, were reportedly beneath the 4 left section of the No. 4 mine.

The thickness of cover above the 4 left section in the vicinity of the accident site (caved area outby the pillar line on appended figures 1 and 2) was 600 to 700 feet. Inby the pillar line the cover increased in a distance of about 1300 feet to approximately 1200 feet at the inby extremity of 4 left. Outby the accident site the cover above the 4 left entries varied from 600 to 900 feet. In the adjacent 3 left section, the cover was 600 to 800 feet in the portion immediately up the pitch from the 4 left accident site; inby this portion the cover in the 3 left section reached a maximum of about 1000 feet. In the corresponding portions of 2 left section, the cover ranged from 800 to 1200 feet. Down dip and outside the mining area, the cover over the coal bed immediately opposite the 4 left accident site increased to approximately 1400 feet in a distance of about 600 feet.

The 4 left section crossed under Sowbelly Gulch, a prominent surface feature, in the vicinity of the accident site. This canyon could be the result of and/or could contribute to possible structural weakness in the underlying strata.

The coal bed in the 4 left section was 10½ feet in thickness. About 2½ feet of top coal was left as the immediate roof in advance mining. The strata above the coal consisted of 4 to 6 inches of shale overlain by about 3 feet of laminated hard sandstone which, in turn, was overlain by 3 feet of fragile shale with a 2-inch coal seam at the top and a 4- to 6-inch coal seam about 4 inches below the 2-inch seam. The strata at the highest accessible roof fall, which was the fall covering three of the bodies, failed at the top of the 2-inch seam of coal; sandstone was exposed in the roof above the fall.

No faults or prominent rolls have been noted in the mine area. Cleats in one direction occur in the coal; these are quite pronounced and strike approximately north 45 degrees west and dip approximately 75 degrees southwesterly.

With the exception of minor bumps, which were reportedly a usual occurrence, only one other bump has occurred in this mine according to reports. That bump occurred approximately 3 years ago in "G" panel off main west and extended through the panel and main west in a southwesterly direction. Cover over that area was about 1400 feet.

Ventilation and Gases

Ventilation was induced in the mine by a 6-foot electrically-driven Aerodyne fan located on the surface and operated exhausting. The fan was installed in a fireproof housing equipped with a fireproof air duct and was offset 25 feet from the nearest side of an opening of the abandoned No. 3 mine. The shafts connecting the Nos. 3 and 4 mines were used as return airways. The fan was exhausting approximately 112,000 cubic feet of air a minute at 3-inch water gage pressure on January 24 after ventilation was reestablished in the mine. The fan was operated continuously.

Air for the workings off main west entered the mine from the surface through the No. 1 shaft and was exhausted down the No. 5 shaft to the No. 3 mine and thence through the fan.

Air for the workings off the main slope entered the mine from the surface through the No. 4 mine portal and rock tunnel. The air from the workings to the left of the main slope was exhausted through the No. 3 shaft to the No. 3 mine and thence through the fan. The air from the workings to the right of the main slope was exhausted through the No. 4 shaft to the No. 3 mine. A small volume of air that entered the tunnel passed through the hoistroom and,along with some leakage into the right side slope returns, was exhausted through the No. 2 shaft to the No. 3 mine.

Normally, some of the air entering the mine through the tunnel passed into main west, but this could be reversed so that some of the air from the No. 1 shaft could be used to ventilate the main slope workings. The main west and main slope ventilating systems were also interconnected at the bottom of the No. 2 slope off main west where approximately 2000 c.f.m. of air normally passed into the 2 left entry off the main slope.

The intake and return airways were separated by permanent-type cinder block stoppings and overcasts. Working sections of the mine were ventilated by separate splits of intake air, and line brattice was used where necessary. Mined out areas were ventilated by return air and in some instances some intake air joined the return air. Flow of air was controlled by regulators. No fans were used underground.

The 4 left entries were ventilated during development with the three lower entries on intake air and the upper entry on return air. For subsequent mining, some of the cinder block stoppings between the haulage entry and the upper entry were partly removed, and holes were made in all but a few of the rest of these stoppings. The four entries were then on intake air which passed over the mined out area into a bleeder return off the inby end of the entries, thence through the inactive 3 left and 2 left sections to the No. 3 shaft. A small volume of the air passing into the 4 left entries passed into the main slope returns through a regulator at

the outby end of the 4 left upper entry. This was done to ventilate a fall near the outby end of the upper entry.

This mine is classed gassy in accordance with the laws of the State. Records of the preshift, onshift, and weekly examinations of the mine for methane and other hazards were kept in books on the surface. The analytical results of an air sample collected in the main return near the fan during the last previous inspection indicated that the mine was liberating 311,000 cubic feet of methane in 24 hours. The analytical results of the air samples collected during the last previous inspection are listed in appended Table I.

Dust

The mine was generally dry and was rock dusted, including the back entries. Water piped to the working faces was used to allay coal dust formed during mining operations. Accumulations of coal dust were not observed during the last previous inspection. The analytical results of 8 band dust samples collected at representative locations in the mine during the last previous inspection are listed on appended Table IV, and showed the incombustible content of the mine dust ranged from 67.2 to 85.5 percent, which was above the minimum requirement. The management stated that the 4 left entries had been re-rock dusted Friday, January 10, 1958.

Transportation

Haulage in the mine was accomplished by trolley and cable-reel locomotives, shuttle cars, belt conveyors, and hoists equipped with steel ropes.

Shuttle cars were used in the 4 left section to transport the coal from the face to the loader head where it was loaded in mine cars and taken to the bottom of the slope by a trolley locomotive. A car-spotting hoist operating on direct-current power and having an open-type motor was used at the loader head during loading operations.

Electricity

Primary electric power as 2,300-volt alternating current was transmitted to the underground substations over armored and neoprene cables. The primary distribution system was well sectionalized and proper overload protection was provided. Secondary power as 440-volt alternating current and 250-volt direct current was supplied for use by the face and haulage equipment by delta-delta connected transformers and motor-generator sets.

The primary alternating-current power distribution system in the 4 left entries consisted of a single 2,300-volt neoprene cable which delivered power to two transformer stations. The outby substation branch feeder had been disconnected prior to the explosion and was not in use. Three oil-filled transformers in the inby transformer station reduced the power to 440 volts for use by the permissible crawler-type loading machine which was the only alternating-current equipment in that section. The transformers in both stations had been installed in fireproof enclosures. A cutout switch and magnetic circuit breaker were provided in the 440-volt circuit outby the nipping station, and the loading machine trailing cable was provided with fused nips.

Direct-current power for the 4 left section was provided by two motor-generator sets, which were not operated in parallel at any time. These sets were located in the slope and the power was transmitted in the haulage entry over No. 9 section trolley wire with the track as the negative return. Overload protection was provided at the generators, and the feeder and trolley wire were properly sectionalized.

The cutting machine and post-mounted drill in 4 left section were of the permissible type and were operated on direct-current power. The three cable-reel shuttle cars used in this section were of the explosion-tested type. The trolley locomotive used was of the open type and the motor of the car-spotting hoist was started and stopped by a knife-blade type switch located at the ramp and operated by the shuttle car operator. Tests for gas were made with a flame safety lamp prior to operating and taking electric equipment into the working places.

Illumination and Smoking

Permissible electric cap lamps were used for portable illumination underground, and electric lamps were installed at frequent intervals along the haulageways. Smoking underground was not permitted and smokers' articles were not found.

Mine Rescue

This company is a member of the Emergency Organization Eastern Utah Coal Mines, which was founded January 13, 1953, and whose functions are to assist with rescue and recovery operations in coal mines in eastern Utah. The men on the rescue crews work at various mines in this area and receive mine rescue training frequently. Eight men from this mine completed a course in mine rescue about a year ago. This emergency organization was fully equipped with rescue equipment including two-hour oxygen breathing apparatus.

STORY OF EXPLOSION AND RECOVERY OPERATIONS

Participating Organizations

The following organizations participated in the recovery operations in addition to officials and other employees of the company:

Industrial Commission of Utah

O. A. Wiesley	Chairman
L. L. Arnett	District Coal-Mine Inspector
James Phillips	District Coal-Mine Inspector
George Jackson	Mine Inspector (metal)

Kaiser Steel Corporation

John Peperakis	Manager of Sunnyside Operations
Thomas McCourt	Superintendent, Sunnyside Nos. 1 and 3 mines
Clair Self	Safety Inspector
Two fully equipped rescue crews	

Columbia-Geneva Steel Division
United States Steel Corporation

Robert M. von Storch	General Superintendent
E. C. Olsen	Supervisor, Mine Inspection, Coal-Mines and Quarries
Lyle Burdick	Safety Inspector, Geneva mine
Two fully equipped rescue crews	

The companies that participated in the recovery operations were members of the Emergency Organization Eastern Utah Coal Mines.

Activities of Bureau of Mines Personnel

On Friday, January 17, 1958, at 3:20 a.m., C. E. Pauley, Vice President in Charge of Operations, Spring Canyon Coal Company, contacted Joe Freeman, Coal-Mine Inspector, Price, Utah, by telephone and informed him that a bump had occurred trapping four men in the 4 left entry of the Spring Canyon No. 4 mine and it was believed that a fire had started in the area. Freeman immediately notified the Subdistrict office, Salt Lake City, Utah, and Bureau of Mines personnel in Price, Utah of the reported accident. He then joined J. H. Phillips, District Coal-Mine Inspector, Industrial Commission of Utah, and both men proceeded to the mine which is about 12 miles west of Price, arriving about 4:30 a.m. The two men checked the mine map, were briefed on developments and proceeded underground to the scene. Enroute the air returning from the mine was checked with a permissible flame safety lamp and colorimetric carbon monoxide indicator at the main fan and at the No. 3 airshaft near 1 left entry (fig. 1). Methane and carbon monoxide were not detected at the fan; however, 0.01 percent carbon monoxide was found at the No. 3 airshaft. After establishing that an explosion had occurred, Freeman telephoned to the surface and requested that the Bureau's Salt Lake City office and T. T. Reay, Coal-Mine Inspector, Price, Utah, be notified.

L. L. Naus, Mining Health and Safety Engineer, arrived at the mine at 6:45 a.m., and after learning of the explosion obtained a W-8, permissible, electric methane detector and a colorimetric carbon monoxide indicator and began checking the return air at the main fan. Reay and A. Z. Dimitroff, Mining Health and Safety Engineer (Electrical) arrived at the mine about 12 noon and assisted on the surface with air readings and preparing the necessary supplies to be sent underground. The following work schedule was set up for the Bureau of Mines personnel:

Freeman	7 a.m. - 3 p.m.
Dimitroff and Naus	3 p.m. - 11 p.m.
Reay	11 p.m. - 7 a.m.

A Bureau of Mines representative was on duty underground throughout the full recovery operations checking the air and advising.

Mine Conditions Immediately Prior to Explosion

The 4 left entries had been driven to their limit and the inby one third of the entries worked out.

It was decided to move the loader head to a new location in 4 left and abandon some of the developed pillars outby the pillar line because the roof had been working for some time and small bumps had occurred in this area.

The mine superintendent stated that on Wednesday, January 15, 1958, he visited the pillar section in the 4 left entries and found the area working heavily and heard a few small bumps. He remained in the section on the afternoon shift and at 7:30 p.m. ordered the crew to abandon the pillars and start developing rooms outby.

Thursday, January 16, the day crew worked in the 4 left section developing new rooms off the top entry. The cutting machine broke down twice during the shift and was reported broken down at quitting time. The mine foreman stated that because the cutting machine was down the 4 left section did not operate on the afternoon shift. The night foreman stated that at 8:45 p.m. he and a mechanic went into the 4 left section to repair the cutting machine. The night foreman reported that he checked the area with a permissible flame safety lamp and found no methane, but found five broken crossbars and a small fall of top coal on the haulage entry near the abandoned shuttle car ramp. After the cutting machine was repaired, the night foreman and the mechanic moved the three shuttle cars to what they thought was a safe place, disconnected the power feeder to the nipping station in the recently abandoned ramp, and pulled back the trailing cables, and the switch and feeder for the car-spotting hoist. The night foreman reported that enroute to the main slope to board the man trip at 10:35 p.m., he checked the 2300-volt feeder circuit breakers at the inby transformer station and in the entry immediately below the haulage entry to make sure that they were in the "off" position. This deenergized the alternating-current power feeder and transformers, leaving only direct-current power on the trolley wire in 4 left section.

Because the mine was to be idle until Monday, three days hence, three workmen and a face boss from the 5 right section and the main slope hoistman remained overtime after the afternoon shift, Thursday, January 16, 1958, to pull three pairs of rails and move the mechanic's tools and miscellaneous items out of the recently abandoned area in 4 left section. The night foreman met the face boss and the three workmen at the 4 left parting off the main slope and briefed them on his findings. The crew then boarded a mine car, which was pushed by a trolley locomotive, and proceeded toward the working section.

According to the fire boss' and section foremans' record books on the surface, methane had not recently been detected in the 4 left section. On January 16, 1958, the mine foreman took an intake air measurement for the 4 left entries and found 25,000 cubic feet of air a minute entering the area. This and other air volume readings, taken on January 16, are noted on the mine map, figure 1. The mine fan operated continuously the night of the accident.

Evidence of Activities and Story of Explosion

According to the locations of the bodies and loosened rails on the track nearby, the crew in the 4 left section was engaged in pulling track just outby the abandoned ramp. Material they had removed from the vicinity of this ramp had been placed in the haulageway at the crosscut just outby and on the opposite side from the ramp for the new loader head.

Several persons living at Spring Canyon stated that they felt an earth tremor sometime between midnight and 1 a.m., Friday, January 17, 1958. Another person living at Standardville, about one mile from Spring Canyon, stated that he went to bed shortly before 12:30 a.m., Friday, January 17, 1958, and felt an earth tremor, shortly after retiring, of sufficient intensity to jar the bed.

The townsites of Spring Canyon and Standardville are located several hundred feet stratigraphically below the Castlegate "B" seam and about 2 miles from the 4 left section of the mine. Incidentally, the tremor was not recorded on the seismograph at the University of Utah where tremors have been recorded in the past at the same time that some of the major bumps have occurred in other mines in Carbon County.

G. Farrimond, mine foreman, at home in Spring Canyon, was awakened about 12:30 a.m., January 17, by his wife because she felt what she thought was a mine bump. Immediately afterward, he was notified by telephone by the hoistman that some violence had occurred in the mine as evidenced by a loud noise and strong air movement; the hoistman had also stated that visibility was obscured by dust in the atmosphere which traveled up the main slope into the hoistroom. The hoist was located at the top of the main slope about 3500 feet outby the 4 left parting. After the mine foreman directed the hoistman to the surface, he telephoned R. Woodward,

Superintendent, C. Neuren, Company Safety Inspector, E. O'Green, Night Foreman, and W. Martin, Fireboss and asked them to meet him at the mine. At 1:05 a.m., the five men entered the mine and on the way down the main slope they found some stoppings on both sides of the slope blown out and encountered some smoke and dust near the 4 left parting. The slope trip was standing near the 4 left parting and two wheels of the rope car were off the track. They found the telephone at 4 left parting out of service. At this time the mine superintendent returned to the surface and called eight more workmen and also telephoned John Peperakis, Manager of Sunnyside Operations, Sunnyside, Utah, and requested crews trained in oxygen breathing apparatus.

The extent of major damage was as follows:

1. Pillars bumped and falls of roof occurred in the area of 4 left between the pillar line and the last complete room developed. The full extent of this damage could not be determined but indications were that the damage was probably throughout the area which extended about 400 feet along the entries and 330 feet normal to the entries (fig. 2). Ribs of pillars that showed indications of bumping at the outer fringe of this area are shown on figures 2 and 3.

2. Timber sets were damaged by weight in all four entries in the vicinity of the falls at the inby end of the accessible part of the 4 left entries.

3. Several other falls of roof, mainly at intersections and in the haulageway and the upper entry, occurred along the 4 left entries. (fig. 2)

4. Three-piece timber sets were knocked out along the upper entry for a distance of 370 feet from the last room started (fig. 2).

5. The timber support at most of the intersections and occasional additional sets in the two upper entries and the outby end of the entry below the haulageway, were also knocked out.

6. One shuttle car was caught in the caved area in the next to the last room completed in the 4 left section (fig. 2).

7. Two transformer stations and the cinder block enclosures in the 4 left entries were practically demolished (fig. 2).

8. A motor-generator set in the main slope in the vicinity of the 4 left entries was damaged and the cinderblock enclosure and switch gear were demolished and blown out into the slope entry.

9. The trolley line was knocked down from the inby transformer station (fig. 2) to the inby end and at several locations outby along the 4 left entries.

10. The telephone and the water lines were dislodged in the 4 left entry.

11. Mine ventilation was disrupted by damage to numerous cinder block stoppings in addition to the following which were demolished (figs. 1 and 2).

3 overcasts, namely at the 2, 3 & 4 left entries and the main slope.

4 regulators, namely at the outby end of the 4 left upper entry, at the 3 left intake, at the No. 2 shaft and at the bottom of No. 2 slope.

18 cinder block stoppings along the main slope in the vicinity of 2, 3 and 4 left entries and 4 and 5 right entries.

12 complete and 4 partial stoppings between the upper and haulage entries in the 4 left section.

Water gage pressure at the fan dropped to approximately 2.92 inches with the above damage from a normal of about 3.00 inches.

It was also noted that a body of water in the inby end of the lower entry, that was present prior to the accident, had drained considerably.

A large accumulation of paper fragments lodged against the outby end of the fall that was immediately inby the new loading ramp indicated that this fall probably occurred prior to the explosion.

Recovery Operations

The power was cut off all sections of the mine except the hoist by management prior to the arrival of Bureau personnel.

After the mine superintendent left for the surface, the four remaining men rerailed the slope trip, restored the telephone service to 4 left parting, and proceeded to install brattice-cloth stoppings between the intake and return airways on the left side of the slope to restore ventilation to the 4 left entries.

About 4 a.m., this crew reached the generator room near the 4 left entry where they discovered a piece of brattice cloth burning just west of the generator room (fig. 2) at the corner of a slope chain pillar. The fire was quickly extinguished by smothering. While the men were extinguishing the fire in the slope, the roof fell to a height of about 4 feet at the first intersection outby the overcast in the 4 left haulage entry.

About 5 a.m., Phillips and Freeman arrived at the 4 left parting. They checked the entry immediately below the haulage entry and, since it did

not show much damage and was clear, they were able to advance to the No. 9 crosscut where carbon monoxide was encountered. The haulage entry showed considerable damage; therefore, it was decided to replace damaged and dislodged timber in the entry below the haulage entry for access.

About 8 a.m., Peperakis, McCourt, Self, and 2 rescue crews arrived at the 4 left entry. A second exploratory trip was made to the No. 9 crosscut and, since the carbon monoxide had not cleared and smoke was detected, it was decided to close the crosscuts between the haulageway and the next lower entry. About 10 a.m., after erecting brattice-cloth stoppings, a small fire was discovered in the haulage entry at the inby corner of No. 10 crosscut (fig. 2). A burning paper bag had ignited loose coal on the floor. The fire was quickly extinguished by applying rock dust and water. Since ventilation was restored to that point by the rescue crews, the smoke and carbon monoxide soon cleared.

Inby the No. 10 crosscut, the haulage entry seemed to be in fair condition, so brattice-cloth stoppings inby this location were placed to direct the air into that entry. The crews were able to advance quite rapidly after the air was directed to the haulage entry. A roof fall about 4 feet high and 20 feet long was encountered in the haulage entry inby the new loading ramp. The entry below the haulageway was used as a detour around this fall, and the locomotive and trip were sighted and a search of the area began immediately.

At 11:35 a.m., January 17, the body of Cecilio Garcia was found facing inward in a kneeling position left of the track and next to the back end of the fourth car of the trip. The body was removed to the surface.

Large caves had blocked the four entries at the inby ends. The roof in the area was working and several small bumps were heard. A quick search of the area disclosed no more bodies or signs of life, so it was decided to retreat and timber the area before doing any other work.

During the first part of the second shift, Geneva mine rescue crews were on standby. The second shift continued timbering.

When ventilation in the 4 left entries was partially restored and the return air current began traveling its normal route over the caves at the inby end of 4 left and through the abandoned 2 and 3 left sections, the methane and carbon monoxide content at the No. 3 return air shaft increased. It was decided that if the methane content reached 3 percent, the men would be withdrawn from the mine. However, after the methane content reached a maximum of 2.9 percent at 3:45 p.m., January 17, as indicated by a permissible W-8 electric methane detector, it showed a gradual but constant decrease. The carbon monoxide content in the air at the No. 3 airshaft returning from the 2, 3, and 4 left entries reached a maximum of 0.02 percent at 8:40 p.m., January 17, as indicated by a colorimetric carbon monoxide indicator.

Two air samples were collected during recovery operations on January 18, and the analytical results are shown on appended Table II.

At 9:45 p.m., January 17, the body of William Daniels, face boss, was found under the coal at the edge of the cave on the right side of the track in the haulage entry. The body was in a prone position, roughly parallel with the entry with the head outby. The flame safety lamp, which was carried by Daniels, was not found on or near his body and was not recovered up to the time the investigation was completed. It was pointed out by all his associates that he was very conscientious about taking care of his lamp and always having it with him.

It was believed that the two remaining victims were under the large cave blocking the end of the haulage entry where they should have been working. It was decided to follow the track through the cave. Temporary roof support was set on the cave, and as the fallen debris was removed, additional timber was set. The debris was hauled away in two rubber-tired wheelbarrows. At 6:30 a.m., January 18, the body of Keith Anderson was discovered and was removed at 8:45 a.m. He was in a supine position between the rails, and his head was on the inby end. He was 11 feet inby the edge of the fall and was covered by about 4 feet of coal and rock.

At 8:35 a.m., January 19, the fourth body, that of Russell Nielsen, was found lying roughly parallel with the entry on its side, about two feet away from the track, and the head was on the outby end. The body was under about 9 feet of coal and rock and was recovered at 10:35 a.m.

The outer edge of the fall where Daniels' body was found was approximately 1900 feet from the main slope. The relative locations of the four bodies are shown on figure 3.

Respiratory protective equipment was not used during recovery operations but fully equipped rescue crews stood by.

INVESTIGATION OF CAUSE OF EXPLOSION

Investigation Committee

The official underground investigation of the cause of the explosion was made January 21, 1958.

The names of those who participated in the underground investigation are:

Spring Canyon Coal Company

Paul L. Shields - - - - - - - - - - President
C. E. Pauley - - - - - - - - - - Vice President in Charge of Operations

Spring Canyon Coal Company (Contd)

Ray Woodward - - - - - - - - Superintendent
George Farrimond - - - - - - Mine Foreman
Ernest O'Green - - - - - - - Night Mine Foreman
O. A. Troseth - - - - - - - Chief Mining Engineer
Clair Neuren - - - - - - - - Safety Inspector
H. C. Babbs - - - - - - - - Chief Mechanic and Electrician
A. Larsen - - - - - - - - - Electrical Engineer

United Mine Workers of America

Harry Mangus - - - - - - - - President, District No. 22
Malio Pecorelli - - - - - - International Board Member
Thil Marshall - - - - - - - President, Local Union No. 6210
Elijah Averett - - - - - - - Safety Committeeman
Willard Hughes - - - - - - - Safety Committeeman
Laurence Buckley - - - - - - Safety Committeeman

Industrial Commission of Utah

L. L. Arnett - - - - - - - - District Coal Mine Inspector
James Phillips - - - - - - - District Coal Mine Inspector

United States Bureau of Mines

R. D. Reeder - - - - - - - - Subdistrict Supervisor
E. R. Rodriguez - - - - - - Mining Health and Safety Engineer
A. Z. Dimitroff - - - - - - Mining Health and Safety Engineer (Electrical)
Joe Freeman - - - - - - - - Coal-Mine Inspector
T. T. Reay, Jr. - - - - - - Coal-Mine Inspector

Some of the United States Bureau of Mines personnel continued the underground investigation through January 27, 1958.

Methane as a Factor in the Explosion

The mine is gassy. Company officials stated that fairly large volumes of methane gas have been liberated in some instances in the mine when falls of roof exposed the thin rider seams of coal. Methane was detected at the No.3 return airshaft with permissible W-8 electric methane detectors and permissible flame safety lamps during the recovery operations. Six samples of mine atmosphere were collected during the investigation and the analytical results are listed in Table III. Sample No. 3203, collected in the bleeder from 3 and 4 left sections, contained 1.66 percent methane. Methane was not detected with a permissible flame safety lamp in the 4 left entries during recovery operations and the investigation.

Evidence observed during the recovery operations and during the investigations indicated that methane was the primary factor in this explosion and that it was probably released in the caved areas of 3 left and the inby portion of 4 left sections.

Flame

Two small fires were found after the explosion (fig. 2). Evidence of heat and flame in the form of soot and charred paper was observed throughout the top and haulage entries and the inby end of the entry below the haulage entry in the 4 left section and extending up the main slopes to between 2 and 3 left entries (fig. 1).

The exposed parts of the victims' bodies were badly burned and the flesh under the clothing was blistered. According to report, the intensity of these effects was, in general, the same on all sides of the bodies.

There was no evidence of burned explosives. According to the location of the bodies and the work the men were instructed to do, it is unlikely that a detonation of explosives could have been a factor.

Evidence of coking is shown in the analyses of the dust samples on Table V.

The only indication of electric arcing on the trolley wire found during the investigation was a blister outby the new loader head. It is believed that considerable arcing could have occurred at other points where the trolley line was covered by falls. Arcing or sparking at the sectionalizing switch on the trolley line inby the new ramp was also possible if a load was on the line at the time of separation of the wire from the switch. Such a load would have resulted from use of the locomotive or, if parked, current supplied to the headlights. Arcing of the controller on the trolley locomotive was also a possibility although the locomotive did not appear to have been in use even though the controller was found in the "on" position. The controller could have been moved to the "on" position (second point) by flying debris; furthermore, from the position and location of the motorman's body, it does not appear likely that the motor was being used immediately prior to the explosion.

Since the flame safety lamp was not found on or near the body of the face boss and was not located or accounted for during the recovery operation and investigation, it cannot be ruled out as a possible source of ignition.

Forces

The explosion forces appeared to have traveled in all directions from the area in the haulageway in 4 left section between the new loading ramp and the inby transformer station (see direction of force on fig. 2). It was also indicated that the main force traveled out the haulage and upper entries with greater magnitude in general in the upper entry. Most of the cinder block stoppings between these two entries were thrown into the haulage entry. The forces appeared to have gained in magnitude as they approached the intersections with the main slope. The two lower entries showed very

little evidence of force. The forces traveled up the main slopes carrying debris as far as 1 left entry (fig. 1) and dust up to the hoist. The recording chart at the fan showed that the water gage pressure dropped from 3.00 to about 2.20 inches at the time of the explosion.

Probable Point of Origin

The point of origin could not definitely be established. However, it was believed that the explosion could have been initiated at any one of several places between the inby transformer station and the inby end of the trolley wire.

The most likely locations appear to be: the point where the blister was found on the trolley wire outby the new loader ramp; the point where the trolley wire was covered under the fall just inby the new loader ramp; and at the sectionalizing switch where the trolley wire was pulled out from the switch.

Other possible locations are at the fall by the old loader ramp and at the trolley locomotive. Since the flame safety lamp of the face boss was not found, and the possibility of the lamp as a source of ignition cannot be eliminated, the place where it was hung or left could be a possible point of origin.

Factors Preventing Spread of Explosion

The major factor in preventing the spread of the explosion was rock dust. During the investigation, eleven band dust samples were collected from the area involved and the analyses listed in Table V show the incombustible content of the mine dust ranged from 36.7 to 71.2 percent. Although the incombustible content of nine of the eleven samples was less than 65 percent, this does not necessarily indicate the conditions relative to the adequacy of rock-dusting prior to the explosion. Note Table IV, analyses of mine dust samples collected during the inspection in October, 1957.

Summary of Evidence

The evidence as to the occurrence and cause of a bump and an explosion, the source of methane gas and the origin and propagation of the explosion in brief are as follows:

Bump

1. A tremor was felt on the surface in Spring Canyon and Standardville at about 12:30 a.m., January 17, 1958. That this could have resulted from an explosion of the indicated intensity is believed unlikely.

2. Minor bumping had occurred in the 4 left pillar section for some time prior to the accident and the roof was working. This continued during recovery operations and the investigation.

3. Indications of bumping of ribs of pillars at the outby fringe of falls in the 4 left pillar section were evident at locations noted on figures 2 and 3.

4. The 4 left pillar section was under a canyon.

5. Draining of a considerable body of water from the inby end of the bottom entry of the 4 left section indicated possible fractures in the coal rib and/or cracks in the floor strata.

6. There were indications that the fall immediately inby the new ramp occurred prior to the explosion. This fall knocked the trolley wire down.

7. There were massive sandstone members in the roof and floor strata; such natural conditions are recognized as conducive to bumps.

8. Although the thickness of cover above the affected area in the 4 left pillar section was only 600 to 700 feet, cover in adjacent mined out areas was up to 1200 feet in thickness.

9. Chain pillars were of variable size in the 4 left pillar section.

10. The barrier pillar between the 3 left mined out area and the 4 left pillar area was only 17 to 50 feet wide.

11. Percent of pillar extraction in the 4 left pillar section was reported as low.

12. The pillar line in 4 left section was only about 300 feet in length.

Explosion

1. Methane gas was not detected with a permissible flame safety lamp in the 4 left pillar section prior to the accident and in the 4 left entries during recovery operations and the subsequent investigation, but high percentages of methane gas were detected in the returns from 3 and 4 left sections after the accident.

2. The liberation of fairly large volumes of methane gas from falls exposing the rider seams has been known to occur in this mine.

3. Two fires were encountered during recovery work, and indication of flame in the 4 left section was shown by burns on the bodies, charred paper, soot and coke.

4. There was extensive damage to permanent electrical equipment, stoppings, regulators, overcasts, and timber in the 4 left section and in the vicinity of its intersection with the main slope.

5. The positions of the bodies and burns on them indicated that an explosion was the cause of the fatalities and that it occurred prior to the fall which covered three of the victims.

6. There was no 2,300-volt power in the 4 left section inby the switch in the entry below the haulageway as substantiated by reports and evidence. Therefore, there was only direct-current trolley wire power in this section.

7. The trolley wire was knocked down from the inby transformer station to the inby end and at several locations along 4 left haulageway outby this transformer station.

8. A blister was found on the trolley wire near the new loading ramp indicating that the power was on when it contacted the rail.

9. The trolley wire could have arced at the sectionalizing switch where it pulled apart since the wire was energized at the time.

10. Several falls covered the trolley wire. Two of these falls were inby the new ramp.

11. The controller of the trolley locomotive was found in the "on" position (second point) but could have been knocked into this position by debris from the explosion.

12. The flame safety lamp belonging to the face boss was not found during recovery operations and was not accounted for during the investigation.

13. The switch and feeder for the tugger hoist were found during recovery operations near the track where they were reported to have been placed, indicating that the hoist was not being used by the victims to pull rails.

14. The explosion forces appeared to travel inby and outby from approximately the location of the new loading ramp.

15. The main forces traveled out the two upper entries.

16. The explosion forces were essentially limited to the 4 left entries and their junction with the main slope. Rock dust evidently prevented propagation of the explosion to other sections of the mine.

Cause of Explosion

The Federal investigators believe that the explosion was caused by the ignition of an inrush of methane gas released due to bumping and caving which occurred in the 4 left pillar section, and that the gas was pushed into the entries against intake air. Some coal dust may have been involved in the explosion.

The explosion was probably initiated by an arc or spark from the falling energized trolley wire at one of several points between the inby transformer station and the inby end of the trolley line. The trolley wire was knocked down as a result of the bump.

Factors that probably contributed to the bump condition in the 4 left pillar section were: the presence of massive sandstone members in the roof and floor strata, the thickness of cover, the variable size of pillars, the narrow width of the barrier pillar between 3 and 4 left sections, relatively low percentage of pillar extraction, and the short length of the pillar line.

RECOMMENDATIONS

Compliance with the following recommendations may prevent accidents of a similar nature:

1. The coal in the barrier pillar between 2 and 3 left, 3 and 4 left, 3 and 4 right, and 4 and 5 right should be abandoned because the influence of the adjacent goaves is conducive to bumps.

2. The pillars already developed in the barrier between 3 and 4 left should be abandoned. If the recovery of the remaining chain pillars in 4th left is desired, additional development should be made in the virgin coal along the dip, which should not penetrate farther than the last inby pillar not extracted on the present pillar line. This should be done prior to any further pillar mining in 4th left.

3. In the future where barrier pillars are left, they should be of sufficient width to eliminate an override from adjacent goaves, and the coal within these pillars should not be mined.

4. In the future development pillars of uniform size and shape should be planned.

5. The pillar line should be long enough to assure good caving, and the pillars should be extracted in uniform sequence.

6. In advance mining top coal should not be left and roof bolts should be used for the support of the overlying strata where they can be anchored effectively.

ACKNOWLEDGMENT

The writers gratefully acknowledge the courtesies extended and help given by all parties concerned.

Respectfully submitted,

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