Report on

Castle Gate No. 2 Mine Explosion

Castle Gate, Utah

March 8, 1924

by

B. W. Dyer
Chief Mine Inspector and
District Engineer, U.S. Bureau of Mines

John Crawford
State Coal Mine Inspector

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Coal Mining Engineer
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INTRODUCTION

On March 8, 1924, shortly after eight o'clock in the morning, an explosion occurred in Castle Gate No. 2 mine of the Utah Fuel Company at Castle Gate, Utah, resulting in the death of 171 men, the total number in the mine. This explosion was followed by a second explosion which occurred about one and a half minutes later. A third explosion was reported by many; however, the writers are without proof of this explosion. Those who saw the third explosion, which was about twenty minutes after the first, say only a puff of smoke issued from the mine. It is thought that this puff was probably due to a cave. There was a cave of considerable size in the motor road air course and in the back entry of the 4th Right Dip Entry. The pillars had been pulled above the 1st Right Rise Entry and a cave of considerable extent could have occurred here.

The first explosion forced out of the mine escapeway timbers from along the escapeway and a piece of sheet iron which was located near the entrance of the escapeway and shot it for a distance of 1,500 feet. The force

"Jan. 4, 1924 - Gas in No. 2 Room on 6th Left, gas extending back from face 70 feet. This gas was removed about 10 A.M. and made safe. Signed Ed Cox - Fire Boss."

"Jan. 8, 1924 - Gas found in No. 2 Room on 6th Left caused by a larger feeder. Signed E B C. Gas found on Jan. 8 was all cleared Jan. 10, 1924. Signed E B C."

"Jan. 22, 1924 - Gas found room 8th Right extending 90 feet back from the face caused by brattice down and feeders at the face. Signed E B C. The exception on the 22nd was cleared and ready for miners to work in. Signed E B Cox."

"Jan. 28, 1924 - Gas was found in No. 2 Room 6th Left extending 60 feet from face. Signed Ed B. Cox. This exception was removed by ventilation and made safe. E B C."

"Feb. 16, 1924 - Gas was found in No. 2 and 2A on 7th Left extending 60 feet from face by large feeder at the face. Signed E B C."

The rooms in which this gas had been reported were about 20 feet wide, 8 to 10 feet high where the top coal had been left up and from 15 to 18 feet high where the top coal had been taken down. In most of these rooms the top coal had been taken down to a comparatively close distance to the face; thus leaving a large area for the accumulation of gas. Since all the reports showing gas, report the gas extending 70 to 90 feet back from the face, the volume even on a single report was comparatively large.

The explosion occurred shortly after eight o'clock in the morning and it is doubtful if the miners had sprinkled down in a thorough manner before starting to load their first car. It is the general practice to load the cars as soon as they are obtained and to sprinkle the workings while waiting for cars. It seems safe to assume that in general the fine dust made during the blasting after the previous shift had not been wet down. Also, many of the miners were loading coal and this put a certain amount of coal dust into suspension. Therefore, it is fairly safe to assume so far as coal

of the explosion at the fan entry and the main portal was not as great as at the escapeway. The explosion doors at the fan were blown open and the reversing door was forced about halfway up to the reversing position where it stuck due to the springing of the fan housing; otherwise the fan was not damaged. A few sets of timbers at the entrance of the main portal were blown out and the portal was filled about three-fourths full of dirt for a distance of about 30 feet.

Soon after the explosion the fan was started and ran until about 2:00 P.M. before it was noted that the reversing door was out of place. The fan was then closed down and not started again until about 6:00 P.M. About three o'clock in the afternoon an air measurement on the escapeway or first left entry showed 37,000 cubic feet of air was traveling in along this entry and this was one reason for believing the fan was normal. It was not until after the air started to back out in this entry that it was suspected the fan was not in proper condition.

The Mine Inspection Department of the Industrial Accident Commission was notified of the explosion about 9:00 A.M. by the general offices of the Utah Fuel Company at Salt Lake City and the Bureau of Mines Safety Car 9, which was located at Butte, Montana, and Car 2, which was located at Trinidad, New Mexico, were moved by special train to Castle Gate, Utah. Car 9 arrived at Castle Gate at 4:30 A.M. Sunday and Car 2 arrived at 3:30 P.M. Sunday afternoon, March 5th. A special train carrying the officials of the Utah Fuel Company, other prominent mining officials and representatives of the State Mine Inspection Department and the Bureau of Mines left Salt Lake City at 11:00 A.M. and arrived at Castle Gate at 3:00 P.M. The officials of many mining companies located near by, together with the general superintendents and practically all

dust is concerned that the mine was in its poorest condition to resist an explosion at the time it occurred.

GENERAL INFORMATION

Location, Ownership, etc.:

The Castle Gate No. 2 Mine is one of a group of mines being operated by the Utah Fuel Company. It is located at Castle Gate, Carbon County, Utah, and is served by the main line of the Denver & Rio Grande Western Railroad.

Mr. F. B. Cameron, Judge Building, Salt Lake City, Utah, is Vice-president and General Manager.

Mr. William Littlejohn, Castle Gate, Utah, is General Superintendent.

The Utah Fuel Company operates in addition to Castle Gate No. 2 Mine, Castle Gate No. 1 Mine at Castle Gate, Utah, Utah Mine at Clear Creek, Utah, Clear Creek Mine at Clear Creek, Utah, Winter Quarters Mine at Winter Quarters, Utah, and the Sunnyside Mine at Sunnyside, Utah.

The production of Castle Gate No. 2 Mine at the time of the explosion was about 1,400 tons per day.

Coal Occurrence:

The coal at Castle Gate No. 2 Mine is being produced from what is known as the "D" seam, a Mesa Verde formation and Cretaceous age (U.S.G.S. Bulletin No. 316). The seam varies in thickness from 30 to 36 feet and dips about 6 or 7 degrees to the North. The coal is massive and of good quality being moderately low in moisture and ash. It has a bright luster and breaks

the local officials of the various mines of the Utah Fuel Company were at the mine when the special train from Salt Lake City arrived at Castle Gate and had the recovery work well under way.

On March 1, 1924, due to the shortage of market for coal the Utah Fuel Company closed their Castle Gate No. 1 mine and transferred most of the married men and old employees of the company to the Castle Gate No. 2 mine.

The explosion at Castle Gate No. 2 mine was extremely violent. This is shown by the fact that the flames and violence reached all parts of the mine and at no time did any of the men have any possible chance to barricade themselves.

Three sprinklers had been continuously employed at this mine besides the miners sprinkling their own working faces. This mine had been fairly well sprinkled so far as all the active workings were concerned. Supporting evidence of this is that after the explosion at almost any place in the active workings one could scratch below the top layer of dust and coal which had been deposited by the explosion and could find the underlying dust and fine coal so damp that it would ball in the hand. It is probable that some of the air courses and old workings were drier than they should have been. There was a pipe line and sprinkling hose in all working places and pipe line with hose like in all places that were not working. However, in the old workings the same amount of moisture could not be found in the floor that was found in active places and in many old workings upon digging to the floor it was found that they were positively dry showing that they had not been sprinkled for some time or that the sprinkling was not properly done.

A comparatively small amount of gas had been reported in this mine and below are the fire boss' exceptions to the mine being clear of gas.

long surface exposure without slacking, making it particularly desirable for storage purposes. Due to its physical and chemical properties, the coal in this district is rated as high grade bituminous, excellently adapted to domestic and steaming purposes.

MINING METHODS AND EQUIPMENT

Mining System:

The Castle Gate No. 2 Mine of the Utah Fuel Company, is opened by means of a tripple entry system driven from the surface in what is known as the "B" seam. This tripple entry is driven off the true strike of the vein sufficiently to give a suitable grade in favor of the loaded trips. The center entry of the system is used as a main haulageway, while the north or lower entry serves as a main return air course. The south entry is not in use at the present time.

History:

The first work carried on from these entries consisted of a development to the rise in the "B" seam. This territory was opened by a double entry from which cross entries were turned off, right and left until the work approached to workings of the Panther Canyon mine of the United States Fuel Company. This development in the "B" seam was abandoned some years ago due to low coal and restriction of available territory.

In 1914 it was decided to prosecute the development in the upper or "D" seam. Accordingly a double entry rock tunnel was turned approximately at 90 degrees to the "B" seam main haulage. After cutting the "D" seam, these entries were turned again to the original strike grade and driven to the point

at which the slope and rise entries were turned off.

Plan of Workings

In general, the system of development employed at Castle Gate No. 2 Mine consists essentially in driving a double entry on the dip of seam, from which cross entries are turned off right and left at distances ranging from 400 to 500 feet. As a rule, left entry haulage curves are turned off the main slope just below the back entry crosscut of the corresponding right entry.

From the cross entries, a room, called No. 1 room, is turned up the dip parallel to the main slope. A barrier pillar 200 feet wide is left between this room and the adjacent slope. On the left side of the dip and the right side of the rise, the second room is turned off the main entry at a distance of 100 feet from No. 1 room and at an angle of 45 degrees with the main entry. The triangular block of coal thus left is split by rooms parallel to Room No. 1 and turned off Room No. 2, called Rooms 1 off 2 and 2 off 3. The successive rooms inby are turned at 45 degrees with a 50 foot room pillar separating them. Crosscuts are driven between rooms at distances ranging from 50 to 100 feet. When rooms are driven to destination, the faces are connected by a top or barrier crosscut driven parallel to the cross entries. Cross entries are driven sufficiently off the strike of the seam to give a grade in favor of the loaded cars. The pillar between main and back entries is maintained at approximately 70 feet, and is split at intervals with ventilation crosscuts and haulage slants. The pillar between main and back slope entries is maintained at 100 feet.

This general scheme of development is carried out on both right and

Ventilation:

Ventilation is effected by means of a "Jeffrey" 6 x 12 fan rated at 300,000 cubic feet per minute at 6-inch water gage, and operating exhausting. The fan drift is located on a 45 degree offset from the main return air course. In addition, the fan proper is located on a short 90 degree offset from the fan drift. The explosion door is located at the end and on direct line with the fan drift and is so constructed that it will be blown out by any explosive force traveling out through the return air course. The fan drift and a portion of the air course are lined with concrete for a distance of about 400 feet. In the mine, circulation is maintained by concrete stoppings and overcasts. In places generating methane, line brattices are constructed from the last crosscut to face. In general, each working panel operates on a separate split of air, the only exception being noted in the ventilation of abandoned panels where two or three districts may be ventilated with a single split.

In general, the ventilating system may be described as follows: There are two intakes: the motor haulage or main entry and the 1st left escapeway. The total return is conducted to the fan through the back entry of the haulage road. The intake is split on the main slope, part of the air being drawn to the rise entries and the balance to the dips. In ventilating a given panel, the air intakes on the main entry, circulates through the rooms, returns through the last crosscut between main and back entries out over the back entry and to the back slope return by way of the panel overcasts. See map of ventilation system.

Lighting:

Lighting on the main motor road circuits is operated on 110 volt

left sides of the slope, with the exception that rooms on the right side of the dip and left side of the raise are turned toward the slope at an angle of 45 degrees instead of at the same angle away from the slope, as on the opposite side. This plan was adopted after it was determined that trouble was encountered from roof falls on the east side of the slope where rooms were driven at 90 degrees to the rooms on the west side.

Methods of Mining:

All coal is undercut by electrically driven mining machines of the shortwall type, operating on 500 volts direct current. Rooms are cut 20 feet and entries 10 feet wide. After a room is necked, the top coal is taken down with the advance.

Shot Firing Practice:

Shooting "off the solid" is prohibited in all parts of the mine and only permissible powder is used for shooting purposes. Electric detonators are employed and all shots are fired from the surface after all men are out of the mine. Miners carry their own powder into the mine and store it in wooden boxes provided by the company for this purpose. They also drill and load their own holes. Toward the end of the shift, the electric detonators are distributed by the shotfirers, the miners placing the primers and connecting the leads to the shooting lines. Holes which are on the solid, or which are not properly placed, are turned down by the shotfirers at this time. In addition, working places must be thoroughly sprinkled before shots are fired. There are two double pole, single throw switches located between the feed lines and the shooting wires. One switch is exposed and the other is enclosed in a locked

currents from transformers located on the surface. Where only 500 volts direct current is available, two 250 volt lamps are connected in series across the feeder circuits.

At the time of the explosion, this mine was operating on an open light basis. In other words, carbide lamps were used exclusively for illumination. Electric cap lamps of a pattern tested and approved by the U. S. Bureau of Mines had been ordered some time before and were delivered to the company about six weeks before the explosion but due to all the charging equipment having not been received had not been put into service. These electric lamps are now in service and will be used hereafter in this mine.

Flame safety lamps of the type commonly known as the "Ety Wolf" with single gauze are used by fire bosses for gas testing purposes. A quantity of large "Wolfe Key" and "Magnetic Lock" lamps were noticed about the property at the time of the disaster but it is believed that they were not in common use.

Dust:

The coal at this property is brittle and has a tendency to make a large amount of fines. Tests run on this coal at the Experimental Mine of the U. S. Bureau of Mines show that it produces the most inflammable and explosive coal dust known in this country. These facts, coupled with the experience gained at Scofield in 1900, early impressed Utah coal operators with the necessity of affording an efficient method of rendering this coal dust inert. Little, if any, information was available as to rock dusting at that time, whereas sprinkling had been used with considerable success in various parts of this country. A very elaborate system of sprinkling was installed in all mines of the Utah Fuel Company and it may well be said that

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box. These switches are thrown in by the shotfirer, on his final round of inspection before going to the surface. After all inside switches are closed, the power house is advised and the main feeder switch thrown in. The shooting switch located at some convenient point is then closed and the shots fired.

Shot Inspection:

After shots are fired, the inspectors make a second run through their districts, examining each place and noting the presence of missed shots and fires.

Haulage:

The coal is loaded at the face into wooden cars of the loose end gate type. Gathering of loaded cars and distribution of empties on the entries is done by horses and mules. After a loaded trip is gathered at the entry parting, a red light signal is used to advise the slope rope rider of the fact. Trips are hoisted on the slope by means of an electric single reduction drum hoist located at the top of the main rise entry. Loaded trips from the slope are dropped onto the main inside parting from which point they are hauled to the tipple by electric trolley locomotives operating on 500 volts direct current.

Timbering:

In view of the fact that a coal roof is maintained in nearly all portions of the mine, very little timber is used. Some timbering is present at the haulage portal and also at various points along the motor road.

this company spared no expense in the installation and operation of their sprinkling system. This company has diligently attempted to make the miners wet down the working faces each morning before starting to load coal, but to strictly enforce this rule is almost impossible as the miners will load coal if a car is available and do the sprinkling afterwards while waiting for cars. Also, the company had three men regularly employed as sprinklers whose duty it was to sprinkle all other parts of the mine which were not sprinkled by the miners. In the recovery work, the body of a sprinkler was found in one of the rooms off the 2d left dip entry with his hose connected. He was undoubtedly sprinkling in this district which, because of its close proximity to one of the main intake air courses, would be more likely to be drier than the dead workings on the right side of the dip. At the time the mine was inspected on February 13th, a sprinkler was noted to be working in rooms off the left entry workings.

In brief, the system consists of a storage tank, of about 30,000 gallon capacity, located at an elevation of 400 feet above the mine opening and 137 feet above the highest workings in the mine which is kept filled with water pumped from the power house. Neglecting friction this gives a pressure of 59 pounds at the highest point in the mine and it is safe to say that with friction the pressure at the nozzle would be at least 40 pounds which is ample to reach the roof and highest point of rib. In the dip entries the pressure will be about 300 pounds at the lowest points and at the 6th left where the explosion originated, 888 pounds. All pipe lines are laid in the return air courses where the temperature is always at least 60° F. and never gets to a freezing point.

From the storage tank, headers are run to the various distributing points within the mine. As a usual practice, 1-3/4 inch lines are laid in all

cross entries. From these laterals 3/4 inch lines are laid to every working face. On laterals or cross entry lines, bibbs are left at 100 feet intervals for sprinkling the entries. Where back entries are dry, 3/4 inch branch lines are laid to such entries through the crosscut stoppings. Lengths of hose are supplied at each working place and miners are required to keep their places well sprinkled. There is no doubt that the sprinkling work and the system itself is as effective as natural conditions will permit.

Under "Mining Methods", it will be noted that mention was made of the fact that rooms are driven 15 to 20 feet high. In many places, especially on the slopes and outby ends of cross entries equal heights are maintained. These conditions present difficulties which it is practically impossible to cope for with known methods of sprinkling. It is reasonable to suppose that sprinkling is effective on rib surfaces up to 10 feet in height, while it is equally reasonable to suppose that above that height, accumulations of fine rib dust cannot be effectively removed by this means. In addition, it is on these surfaces, in entries and rooms having large cross sections with low air velocities that the finest and most dangerous dust is found.

Due to the dry, friable character of the coal, considerable dust is produced in the operations of machine cutting, shooting and loading. Cars are "topped" about 12 inches above the car bodies, causing considerable spillage along entries, slopes and motor haulage ways. This road coal is quickly pulverized by the passage of trips, men and animals, the fine dust being thrown into the air currents to be later deposited on rib ledges, and timber. Existing speeds of around 800 feet per minute on the main slope against a ventilating current velocity of 600 to 700 feet per minute, giving a relative velocity of about 1,400 to 1,500 feet per minute, causes considerable amounts of fine

ferred to the 1st left inclinery which presented no obstruction to travel, and air measurements showed an intake of around 60,000 cubic feet per minute. Temporary stoppings were erected in several room necks on the 1st left main entry and a large regulator placed across the main entry at the last crosscut for the purpose of deflecting a large portion of the air through the 1st left back entry and thence to the 2d and 3d left dip entries by way of the breakthrus in the barrier pillars. (See map of temporary ventilation.) Temporary stoppings were also placed in the crosscuts between the main and back dip entries and also at the entrance to all dip entries on the right dip side. The air current thus produced on the main dip slope was then deflected into the main entries of the left dip panels as exploration and recovery work was carried forward.

Soon after the ventilation had been partially restored, it was found that several mine fires existed in various parts of the mine. One of the first fires encountered was located in room 2 off the 2d left dip. This fire covered practically the full width of the room for a distance of 30 feet, the greater part of this area showing a smouldering action with some flame near the upper edge. This fire was extinguished by a bucket crew, and was carefully watched by a fire patrol for possible re-ignition.

Evidence of additional fires was noted by the smoke issuing from the fan. The presence of fires in undetermined positions, coupled with the possibilities of serious accumulations in some of the dip entries and a temporary ventilation system, presented a very dangerous condition, calling for extreme care in order to prevent a second disaster.

With these conditions in mind, a conference of company, State and Federal officials was called for the purpose of formulating a definite plan

dust to be swept from the trips and thrown into the air currents, later to be deposited on ribs, roof and floors.

Safety Measures and Equipment:

The company maintains a rescue station equipped with five sets of Paul apparatus with the necessary supplies and repairs. A sufficient number of trained apparatus men are available at all times. In addition, the mines at Castle Gate are fortunate in being located at a short distance from the Spring Canyon Mine Rescue Station at Standardville. Apparatus teams are also quickly available from the company's camps at Sunnyside, Inter Quarters, Clear Creek and the Utah mines. The mines of the U. S. Fuel Company are also equipped with rescue apparatus, and maintain efficient corps of men for immediate call. These facts are mentioned under this head merely to show the equipment available in addition to that maintained by the company.

An underground first-aid station is located at the motor parting and is fully equipped with stretchers, blankets and a plentiful supply of first-aid materials.

STORY OF THE EXPLOSION

The explosion at the Castle Gate No. 2 Mine occurred shortly after 8:00 A.M. on the morning of March 8, 1924, there being a normal shift of 171 men in the mine at the time. According to statements made by company officials, and others who were on the surface at the time, there were two distinct explosions. Statements were also made by various individuals to the effect that a third explosion occurred but to date no positive evidence is available on this point.

of attack. As a result it was decided that the recovery work should be carried forward on the left dip entries toward the slope bottom, fresh air being carried ahead as each entry was explored. In addition, it was ordered that any major changes in the ventilation be made at night with only the necessary men on shift. After the left dip entry had been explored and the recovery work on that side completed, the work was to be carried up the right side. With the completion of the dips, the rise entries were to be explored.

From the time of the explosion, much discussion was heard regarding the fate of the men working in the extreme upper portion of the mine, namely in the rooms being driven to the turned coal areas off the 5th left raise. Going on the theory that the explosion had its inception in the dip workings, it was argued that the force and flame would be largely dissipated in the large open areas of the rise entries and that the men in this district would have a good chance of being alive. In order to determine if conditions in the raise were such as to warrant hopes of finding living men, it was decided that an apparatus exploration be made up the main slope to the raise. The apparatus crew making this trip consisted of Messrs. D. W. Dyer, Chief Mine Inspector of the State of Utah, and District Engineer of the U. S. Bureau of Mines, E. Harrington, Supervising Mining Engineer of the U. S. Bureau of Mines, H. H. Dunn, Mining Engineer in charge of Car 2, U. S. Bureau of Mines, Fred Goethke, Mining Engineer, U. S. Bureau of Mines, and W. T. Sullivan, Foreman Miner, Car 2, U. S. Bureau of Mines. The observations made on this exploration trip showed conclusively that the violence in the raise was at least as great as any noted in the dip and that no hope could be held for any of the miners working in this district. This fact made it possible to follow

The Mine Inspection Department of the Utah State Industrial Commission was notified of the disaster at about 9:00 A.M. by the general offices of the Utah Fuel Company. U. S. Bureau of Mines Car No. 6, located at Butte, Montana, proceeded immediately by special train, arriving at Castle Gate at about 4:30 A.M., March 9th. The Denver office of the U. S. Bureau of Mines was notified of the disaster by the Associated Press at about 1:00 P.M., March 8th. Bureau of Mines Car No. 2, located at Trinidad, New Mexico, received word of the disaster at 1:37 P.M., and left immediately for Castle Gate by special train, arriving there at 3:30 P.M., March 9th.

Shortly after the explosion occurred, rescue teams were rushed to Castle Gate from surrounding mines. Short explorations were made in the main haulage road by men wearing oxygen breathing apparatus, but no bodies were found. Repairs were started on the caved haulage road portal, it being necessary to do this work with apparatus men on account of the gas issuing at this point. During one of these preliminary exploration trips, Geo. Tilson, captain of the Standardville No. 1 rescue team, was killed by inhalation of carbon monoxide due to the removal of his nose clip in the presence of after-damp.

In the meantime the necessary repairs had been made to the fan which had been little, if any, damaged by the explosion. The explosion door, directly in line with the main fan drift, was blown out and one of the reversing doors partially displaced. This damage was easily repaired and work was started on the restoration of ventilation. The first line of attack was through the main motor road but was abandoned later due to the difficulty of removing obstructions in the way of timber, wrecked cars and other debris in the vicinity of the main parting. Rescuing operations were then trans-

the plans for recovery without deviation.

The organization effected for carrying out the plans for exploration and recovery work were as follows:-

Operating Crews: The mines operating in the vicinity of Castle Gate are exceptionally well equipped with oxygen breathing apparatus. Surrounding companies contributed their own apparatus and repairs as well as trained crews of rescue men. In all, 51 sets of apparatus with the necessary supplies were available within a short time after the explosion.

Supervision: General supervision of recovery work was detailed to three superintendents for each eight hour shift, - one in charge of the apparatus crews at the wash-house, one at the last left cabin, and one underground. Later, when work was conducted simultaneously in rise and dip districts, two superintendents were on duty underground.

The rescue work was divided into three shifts with eight apparatus crews on duty for each eight hour period. In actual work, two crews worked together, one crew exploring and recovering bodies, while the second crew acted as a reserve at the fresh air base. As soon as the first crew had completed its time limit in the apparatus, a third crew was called in for reserve duty. In this manner, crews working under oxygen were at all times backed up by a reserve team. Constant use was made of the life line, in spite of the fact that no considerable amount of smoke was present, and every possible effort was exerted to prevent accidents to crews working under oxygen. Telephone communication was maintained at all times between the fresh air bases and the surface. Upon the recovery of a body by an apparatus crew, the data relating to the exact location of the body as well as any other pertinent facts regarding the condition at the point of recovery were tele-

pinned immediately to the outside. In addition, a slip of paper containing duplicate information was pinned to the body, thus giving a double check.

From the fresh air base, the bodies were carried to the surface on stretchers by fresh air men. A receiving room was established on the surface near the 1st left Escapeway. Here the bodies were searched for life checks and other means of identification and all available records taken. From the receiving station, bodies were transferred by auto hearses to the morgue.

Care of Apparatus: Soon after the apparatus work started, the importance of thorough examination and recharging of the machines was realized. An outdoor apparatus base was established in the washhouse near the main haulage portal. Work benches were erected and facilities installed for the repair and recharging of the apparatus. The work of inspection, testing, repairing and recharging was put in direct charge of U. S. Bureau of Mines apparatus men whose training made them particularly fitted for this duty. All machines coming off duty were repaired when necessary, recharged and subjected to exhaustive tests before being placed on the table ready for use. Some difficulties were encountered, but this was to be expected, especially in view of the fact that many of the replacement apparatus men had had little or no experience in this work. On the whole, the results were extremely satisfactory and too much cannot be said in praise of the men who worked in the apparatus as well as of those who took the responsibility of its care and operation.

Doctors' Organization: Medical aid was quickly supplied from the district and consisted of physicians and surgeons from Castle Gate and other Utah Fuel camps as well as medical men of surrounding towns. Dr. A. L. Murray, Surgeon of the U. S. Bureau of Mines was active in effecting the doctors' organization.

Five doctors were detailed to the receiving station. These doctors

by the following:

William Littlejohn, General Superintendent, Utah Fuel Company

R. R. Negrew, " " United States Fuel Company

S. Berrington, Mining Supervisor, U. S. Bureau of Mines

H. H. Nunn, Mining Engineer, U. S. Bureau of Mines

Fred Isetbie, " " U. S. Bureau of Mines

B. P. Dyer, District Engineer, U. S. Bureau of Mines, and Chief Mine Inspector, State of Utah.

The sampling was done by the following:

M. F. Sullivan, Foreman Miner, U. S. Bureau of Mines Car 2

F. E. Keegan, First Aid Miner, U. S. Bureau of Mines Car 2

E. W. Fesler, " " " U. S. Bureau of Mines Car 2

J. D. Davis, Foreman Miner, U. S. Bureau of Mines Car 3

Due to two explosions, the second which undoubtedly originated in the upper left side of the mine and was the most violent, it is impossible to trace the exact course traveled by either explosion. In many parts of the mine absolute evidence of the force having traveled in one direction can be found and within 100 feet of this point there is likewise an convincing evidence that the force traveled in the opposite direction.

That the initial explosion was not caused by a runaway trip is borne out by the fact that all three rope trips were still on the rope after the explosion. The motor trip was on the motor parting, evidently waiting for another rope trip before going to the surface.

Source of the Explosion:

In No. 2 room, 6th Left Dip Entry, there appears to be enough evidence to believe the explosion started at this point. Top coal had been

examined the bodies as they were brought to the surface, made notes on material available for identification purposes, and dispatched them to the morgue.

At least two doctors were detailed at the lower station who made the necessary medical examination of men wearing the breathing apparatus, and supervised the disinfection of mouth pieces. In addition, men in recovery work were required to wash in antiseptic solution, cuts and bruises were dressed and the men's general health attended to.

The camp physician was placed in charge of the morgue, his acquaintance with the men and their families making his services at this point especially valuable. One doctor was detailed to the company hospital, it being his duty to administer to any cases sent there in addition to caring for the general health of the camp.

Welfare Work: Two canteens were established near the mine, one at the first left opening and the other at the lower check cabin. Hot coffee, sandwiches, cigars, cigarettes, and chewing tobacco were available to the men at all hours. Baskets of food and large urns of hot coffee were continually being carried by fresh air men to the men employed underground. Complete outfits of working clothes were supplied to those men engaged in recovery work, and complete changes supplied to those whose clothes came in contact with the bodies. The Salvation Army and local posts of the American legion were active in administering to bereaved families.

Patrol Work: As the air currents were carried ahead, and entries explored, it became necessary to patrol these districts for the presence of fire and possible accumulations of explosive gas. Crews, consisting of two experienced fire bosses, equipped with flame safety lamps and canary birds, were detailed to this work. Each crew was given a definite district and reports as to

shot down in this room the night before the explosion. The body of the fire boss was found with his flame safety lamp disassembled on the inside of this pile of top coal. The bodies of two miners were found on the outside of the pile close to a car of coal which had evidently been loaded that morning. The rib and coal roof were badly burned and the coal distilled to a considerable extent on the outside of the coal pile. The remains of a line brattice up Room No. 2 was badly burned but showed no signs of violence. It appears that the fire boss found gas near the roof in this room on his first examination and went back with the miners to remove it. He had evidently got on top of the pile of coal which had been shot down the night before and raised his lamp to ascertain the exact amount of gas when his lamp became extinguished. He then got down from the pile of top coal, opened his lamp and was in the act of relighting it when he or one of the miners ignited the gas. The gas could have been stirred up by the fire boss while he was testing. The body of one of the miners was found partially covered with a fall of coal. This fall was evidently just before or at the time of the explosion and this could have pulled the gas down to a point where it could have been ignited by the open lights being used by the miners.

Three loaded cars were found on the entry between rooms 2 and 3 and were badly burned. These cars evidently had been standing just outside the latches of Room No. 2 when the explosion occurred and had been pushed to the position formed by the second explosion. The sprags in the wheels of these cars showed they had been pushed inbye on the entry.

The explosion of gas aided by the coal dust that had not yet been completely sprinkled down from the blasting of the previous night together with a certain amount of dust that was in the air from the loading of the cars

conditions in that district were made at the end of each eight hour shift. These patrols performed a very important work as it was largely due to their inspections that fires and gas accumulations were located and reported. In addition, the patrols located several bodies which had escaped the attention of men wearing apparatus.

In summarizing the results of the work, it may be stated that approximately 90 per cent of the bodies were recovered by men wearing oxygen breathing apparatus. With the exception of the fatal trip made by the Standardville No. 3 team shortly after the explosion, no serious difficulties were encountered. Considering the number of men employed in this work, and the amount of apparatus used, we believe that a very enviable record has been established for work of this class.

[illegible]

The first day there was much speculation as to the cause of the explosion. It was conceded that the explosion was one of dust and the cause of ignition was thought to have been caused either by a runaway or wrecked trip throwing quantities of fine dust into suspension, which became ignited by an open light or electric arc, or through the explosion of a small pocket of gas which in turn threw into suspension and ignited coal dust.

During the course of the rescue work the body of one of the fire bosses was found near the face of No. 2 room 6th left lying on the inside of a pile of top coal, which had been shot down the evening before, with his safety lamp dismembled. In No. 2 room 7th left, the fire bosses' danger board marked "Danger - Keep Out" was found face down in the center of the track opposite the crosscut about 60 feet from the face.

On March 17, 18, 19 and 20th an inspection of the mine was made

that morning aided in propagating the explosion.

The initial explosion traveled down from No. 2 to the entry. On the entry the explosion split and traveled both inbye and outbye on the entry which was about 600 feet in length. The inbye forces traversed rooms 3 and 4 through the last two crosscuts into and out the back entry. The outbye forces traveled out over the parting to the slope. The main explosion traveled up No. 1 room to 5th left entry and down No. 1 room of the 7th left dip entry to that entry. (No. 1 room in all cases is a room driven parallel to the slope and is used as a manway.)

The force traveling down No. 1 room to the 7th left dip entry traveled in on the 7th left main entry traversing the room and through the last crosscut into the back entry. (The 7th left dip entry is approximately 700 feet in length.) In No. 2 room off this entry there was a considerable amount of gas and this became ignited and aided in propagating the explosion. That there was gas in No. 2 room on this entry is supported by the following evidence. A fire bosses danger board was found in the center of the first face down badly burned on both sides and opposite the last crosscut which was 25 feet from the face of the room. In this room there had been extreme heat. The roof and rib showed a large amount of distillation and some coke. The line brattice in the room was almost completely burned but showed no violence. In No. 3 room there was also a very intense heat. The roof and rib were badly distilled and showed some coking. The insulation on the blasting wires was completely charred. In No. 6 room the line brattice was badly burned but showed no violence. The rib and roof in this room as in rooms 2 and 3 showed that considerable distillation and some coking had taken place. There was considerable heat in the main entry from room No. 3 to 15 feet inside the last crosscut. The heat went down this crosscut but apparently died out before

running the back entry. A new car in the back entry and in front of the crosscut and the body of a white horse found just outbye of the crosscut showed no evidence of heat.

The top coal had been taken down within a distance of 30 to 40 feet from the face in the rooms of the 6th left Dip Entry and from the evidences of heat found in these rooms there is little doubt but the offset left by the removal of the top coal was filled with gas.

The initial explosion then traveled down the manway between the 7th and 8th Dip Entries and inbye on the 8th left Dip Main Entry through the last two crosscuts and out the back entry to the main slope and the main slope air course.

The explosion coming out of the 8th left Back Entry split, part going down the slope and part going through the crosscut directly opposite the 8th left Back Entry into the slope air course. The force split as it entered the slope air course, part going down the air course to the faces of the slopes and into the 9th Right Dip Entries. There was little evidence of heat in the 9th Right Dip Entries or in the faces of the slopes. Both of these places showed very great violence but this violence was undoubtedly from the second explosion.

The main force of the explosion then went up the back slope to the 8th Right Main Entry, in this entry and through the rooms. There was considerable soot in Rooms 1 and 2 but no indications of heat. There was considerable heat in the necks of Rooms 6 and 7. The greater part of the explosion then traveled up the slope air course to the 7th Right Dip Entry. The explosion evidently went in on the main entry up Room No. 1 through the room crosscuts into Rooms 2, 3, 4 and 5 and down these rooms and inbye

The force then went through the crosscut, which is directly opposite where No. 5 room holed to the 2d left back entry, into the 2d left main entry. Here the force split and trampled bodys and outbye. The main part of the outbye force traveled by No. 5 room to the 1st left back entry, in the back entry to the last two crosscuts, through these crosscuts to the main entry and out the main entry to the surface.

Second Explosion:

It is certain that the second explosion was largely a dust explosion and originated in the few active workings above the 5th left inlet entry. The force of the first explosion had traveled mainly up the slope air course from the motor road extension and had forced several empty cars from the 1st left inlet having out onto the slope. The force also went to the top of the slope air course, through the top crosscut and down the main slope, striking the main hoist which sets on the main slope between the last two crosscuts from the rear. A trip was being hoisted at the time of the first explosion and the hoist made one and a half revolutions after the explosion struck it before stopping. To substantiate this, a piece of manila rope about a foot long was forced by the explosion under the hoisting cable and was covered by one and a half laps of the hoisting cable.

The explosion coming from the lower part of the mine had dissipated itself considerably in passing through the right dip workings and in passing out through the escapeway and motor haulage to the surface, and it is believed the flame had been extinguished at least by the time it had reached the 2d left inlet entry and that the force traveled all workings and put into suspension a large amount of coal dust. It is also believed that the first explosion

along the main entry. In Room No. 8, a machine was cutting at the face and this room showed high heat for a distance of 50 feet back from the face. This heat was probably due to the ignition of the fine dust in suspension due to the cutting machine. In No. 9 room, a blind crosscut on the right showed evidence of high heat.

From the 7th Right Dip Entry the explosion in general traveled the slope air course and No. 1 room (the manway to the 6th Right Entry) and traversed the 6th Right Dip Entries and rooms. Rooms 13, 14 and 15 on this entry showed considerable evidence of heat.

The force traveled from the 6th Right Dip to the 5th Right by the way of the manway and No. 6 room which is holed to the 5th Right Back Entry and then evidently traveled in on the entry and up No. 1 and No. 6 rooms to the 4th Right Back Entry.

From the 4th Right Dip Entry, the explosion traveled up the slope air course and manway to the 3d, 2d, and 1st Right Dip Entries and due to the large amount of open workings had dissipated itself to a considerable extent.

Some coking and considerable distillation had taken place at the face of the 2d Right Dip Main Entry and at the face of No. 3 off No. 16 Room.

While the explosion was traveling from the 6th Left and Right Dip Entries up the right side of the mine and the slope air course, there was undoubtedly a strong force up the main slope. A small sinking heim was located on the main slope between the 7th Left and the 6th Right Dip Entries. The overshoes of the holetson and the corrugated sheet iron which formed the hoist house were blown up the main slope to or past the 7th Left Dip Entry and when the second explosion occurred were blown in on the 7th Left Parting into the loaded trip on the low side of the parting.

did not kill the men working above the 5th left Boise Entry but did extinguish their lights. After these men recovered from the shock of the first explosion they lighted their lamps and this in turn ignited the fine coal dust in suspension and caused the second explosion. The force of the second explosion came down rooms 20, 11, 12, 13, 14, 15 and 16 of the 5th left Boise Entry to this entry. Upon reaching the entry the force split, part going outbye on the entry to the manway and down the manway to the 4th left Boise Entry, and part directly down the rooms to that entry. Upon reaching the 4th left the explosion traveled outbye in both the main and back entries and down through rooms 14, 10 and 6 of the 3d left to that entry.

The explosion traveled out the 3d left Boise Main Entry and out through the top crosscut of the rooms from this entry. The forces coming out the 3d and 4th left Boise entries went directly to the main slope and down the main slope entering the 1st, 2d and 3d Right Boise entries. The pillars had been pulled in these three entries and it cannot be stated what part, if any, this section had in the explosion. It is felt, however, that this area took no active part in aiding the explosion.

The trip of empty cars which had been forced by the first explosion from the 3d left Boise Entry parting to the slope were blown by the second explosion down the slope for some distance and wedged against the ribs to such an extent as to almost completely block the slope. The second explosion followed the main slope to the motor road and the motor road extension, passing out the motor road to the surface, and went in the motor road extension to the faces.

Evidently the second explosion did not enter the 1st and 2d left Boise Entries and if it did, did very little damage.

The explosion traveled up the manway and slopes from the 1st right Dip Entry to the motor road and the motor road extension. (The motor road is the main haulage to the surface.) Considerable of the force then passed out the motor road extension.

Between the motor road and motor road extension, the only connections with the mine workings are the slopes. When the explosion which was somewhat dissipated reached this restricted area, it increased its velocity and reached the 1st left Drive workings with considerable violence. The force then traveled through the 1st left Drive workings from here to the 2d, 3d, 4th and 5th Drive Entries through the manway and various openings through the barrier pillars. The left side of the mine from the 1st left to the 5th left Drive Entries comprises a large area, the workings of which are all dead except a small amount of pillar work and a few rooms advancing on the inside of the 5th Right Drive Entry. From the wet condition of the partings, manways and slope in the mine workings on the right side of the mine, it is believed that the flame was extinguished before it had extended any considerable distance above the 1st Right Drive Entry but that the force of the explosion had been sufficient to traverse all the mine workings and stir up considerable dust.

The force of the explosion which traveled from the 6th left Dip Entry up No. 1 room traveled in on the 5th left Back Entry through the last crosscuts into the main entry, out this entry to the slope and up No. 1 room to the 4th left Dip Back Entry where it went in the back entry and out the main.

The main part of the explosion traveled from the 4th left Dip Entry up No. 1 room which is holed to the 3d left Back Entry, into this entry and through the first outlye crosscut into the 3d left Main Entry. Here the force divided, going inlye, outlye and up No. 1 room to the 2d left Dip Back Entry.

From the motor road to the 1st left Dip entry the explosion followed the main slope entering this entry and passing in on it to the surface. The main force followed the main slope until it reached the 2d left Dip entry. Here it entered this entry and followed down the county on the left side to the bottom of the mine. The forces crossed from the main slope to the back slope through the slope crosscuts between the 2d and 3d Right Dip Entries, went in on the 3d Right Dip Parting, back entry, and the first crosscut below the 3d Right Back Entry and followed the slope air course to the face. From the first slope crosscut below the 3d Right Dip entry all forces are down and outward toward the slope.

A car was blown from the 7th Right Dip Parting and down the slope air course within 30 feet of the 6th Right Main Entry. Also, a car was blown from the 6th Right Dip Parting down the slope air course within 30 feet of the 5th Right Main Entry.

Just how the explosion traveled in the dip workings other than that in main it traveled the slope air course and the left county is impossible to determine. It appears that it gained its maximum violence at about the 7th Right Dip Entry and entered all workings below that point with extreme violence.

DISCUSSION AND CONCLUSIONS

General:

There is no doubt that the explosion in Castle Gate No. 2 Mine on March 8, 1924, started in No. 2 room off the 6th left Dip Entry, and was caused by the ignition of a body of methane which had accumulated in an effort in the roof left by the removal of top coal. Three men were found in this room, - two loaders and a fire boss. The miners had been loading a car from

a heavy top coal shot which had been brought down the night before. The fire boss was found with his flame safety lamp disassembled and ignition was undoubtedly due to his attempting to relight his safety lamp by either a match, or carbide lamp, after it had become extinguished. The ignition of this body of methane caused a local explosion of sufficient violence to stir up and throw into suspension quantities of fine dust which had been formed by a heavy top coal shot the night before. In addition, it is very probable that much fine coal dust existed on the upper portions of the ribs which had not been sprinkled, and this material assisted the primary explosion in gaining sufficient force to leave the entry. Also, it is probable that considerable dust was in suspension from the loading operations of the two miners, which would further aid in the propagation of the flame.

The fact that the mine was reported clear of gas on the morning of the explosion would indicate that considerable laxity existed as to gas reports. That gas was present in the 6th and 7th left dips cannot be denied, this condition being evidenced by the presence of extreme heat after the explosion, like brattices which had been erected for gas removal and audible gas feelers in the floor. Having these evidences in mind, we are forced to the conclusion that all gas accumulations were not reported by fire bosses, or at least gas which was considered under control was not reported. Just why such conditions or methods of gas reporting were allowed to exist, we are unable to say. Certainly gas should be reported when it is found, and should be systematically reported until it has entirely disappeared or can not be detected by approved means.

The practice of taking top coal with the room advance presents a condition particularly favorable to gas accumulations. The dangers of this system will be seen by noting the attached sketches showing profiles of rooms

structure with the result that much finely divided dust is produced during the operations of loading and machine cutting. This fine coal dust is thrown into suspension in the air currents, later to be deposited on floors, rib and roof ledges. The practice of taking top coal on the advance, with consequent heavy shooting, also tends to produce dangerous accumulations of dust.

Leaving long panels of standing rooms, in which ventilating currents are more or less sluggish, affords a dangerous settling place for fine dust. High ribs, ranging from 15 to 25 feet cannot be effectively sprinkled, and present an ever present hazard in case of an explosion.

Ventilation:

While this mine is not considered as "gaseous" in the commonly accepted use of the term, still there is no doubt that it does generate sufficient methane to constitute a hazard, especially so in the case of interrupted ventilation. From the records available, it would seem that methane has been found in increasing quantities with an increase in depth. The 6th and 7th left Entries were known to generate considerable quantities of explosive gas, and attempts were made to remove it by the erection of line brattices, but these efforts were largely nullified by the height of the roof and consequent lack of air velocity.

According to the record of air measurements on file in the office of the Chief Mine Inspector, the fan draws on an average around 150,000 cubic feet of air per minute into the mines. The fan installation is certainly adequate, having a rating of 300,000 cubic feet per minute, which could be supplied in case of necessity. In general, each working panel

in which methane accumulations existed. Rooms 30 feet wide and 18 to 20 feet high cannot be efficiently ventilated. The offsets produced by taking 10 to 15 feet of top coal afford a considerable reservoir for explosive gas, and attempts to remove it by line brattices are futile. It is stated that it was common practice at Castle Gate to remove these roof accumulations by spraying them with a sprinkling hose. It is not considered likely that this was being done in Room 2 off the 6th left as the hose line was pretty well covered by fallen coal.

The outstanding feature of this explosion is the fact that the explosion or the combination of the first and second explosions reached every part of the mine and with considerable violence. Men were killed outright at their work, bodies were badly burned, mangled, and in some cases dismembered. With the exception of the district comprising the 6th and 7th Dip entries, evidences of extreme violence were present everywhere. Loaded cars were thrown considerable distances and in one case a loaded trip was forced out of the entry parting onto the main slope and then down the slope by a force coming from the upper end. In many places empty cars were completely stripped of everything except the binder irons.

With but few exceptions, concrete stoppings and overcasts were completely demolished. In some places it was impossible to find any remains of what had been a solid concrete stopping eight inches thick. One case was found where a loaded car standing on a parting had been thrown through a concrete overcast. These examples are given for the purpose of giving some idea of the destructive force of the explosion.

operates on a separate split off the main ventilating current, which is certainly good practice, and especially so in a mine generating explosive gases. Concrete stoppings and overcasts, air locks with iron doors are all in line with the best ventilation practice.

As a part of the investigative work following the explosion, air samples were taken at various points in the 6th and 7th Dip Entries by Bureau of Mines Engineers. At the time these samples were taken, ventilation had been partially restored in these entries, making it possible to determine the amount of methane actually being generated. The analyses of these samples, as well as analyses of coal and dust, are not available at this time due to rush of work at the laboratory of the Bureau at Pittsburgh. However, they will be incorporated in the regular Explosion Report to the Bureau of Mines, and a copy of this report will be furnished to the State Industrial Commission for their files and information.

Shot Firing:

The Utah Fuel Company has long been considered the pioneer in the development of successful electric shot firing systems. About 1908 the first electric shot firing system in use in the West was installed at Castle Gate, and its success led to its adoption at other camps of the company. While this explosion was not connected with blasting, it is well, from the property standpoint, to recall the fact that the dust at Castle Gate is extremely explosive, and all possible safeguards should be thrown around the system to prevent an explosion from this source.

The shooting practices at this mine are good - only permissible

Dust.

The evidences of extreme violence and widespread propagation bring to mind the fact that the coal dust produced from Utah mines is the most inflammable and explosive ever tested at the Experimental Mine of the U. S. Bureau of Mines, a fact which has been known to Utah coal operators for several years. It has been calculated that 70 per cent of inert material must be mixed with this dust to render it non-explosive and incapable of propagation, and probably 80 per cent would be necessary in the presence of 1 per cent of methane in the air current.

From observations made after the explosion, it was impossible to determine the amount of dust which existed in the mine under normal operating conditions. The company's policy has always been to load out road dust accumulations, in active districts, at least once each week. Undoubtedly large quantities of dust were standing in abandoned or idle panels, this material being composed largely of old track ballast, rib dust and coal, and quantities of very fine coal dust produced in mining operations.

After the explosion the presence of abnormal amounts of very fine dry dust in every part of the mine can only be accounted for in one way: this dust was made by actual abrasion of the ribs and roof by the explosive force. Examination of coal surfaces throughout the mine, with the possible exception of dead ends, revealed the fact that the sharp edges and corners of the ribs had been rounded off by the forces traveling through the opening. It is probable that the explosion may have traversed well sprinkled areas, but due to its force and the inflammable, friable character of the coal, sufficient dust was abraded from the ribs and roof to give propagation.

Conditions in the Castle Gate mine are particularly favorable to the formation of dust. The coal in general is quite dry and of a laminated

powder is used, coal is undercut, cable stemming is used and working places are thoroughly wet down before blasting and an electric shooting system used whereby all men, including shot firers, are out of the mine before the shots are fired. These precautions together with the class of equipment used should make for safety in this branch of the operations.

Mining system:

This mine has a large coal acreage available under lease from the U. S. Government and in the interest of safety as well as of efficiency and coal conservation we believe that earnest consideration should be given to the idea of conducting operations in this leased territory upon a Panel System, such as is used at Hele, Wyoming, and described in Technical Paper No. 154, U. S. Bureau of Mines, pages 11 to 14, and in volume 1 of the Proceedings of the Rocky Mountain Coal Mining Institute, pages 43 to 48. In this system all rooms are driven to the strike, thereby greatly facilitating machine work. Moreover, with this system, when a panel is worked out, the placing of a few concrete stoppings, effectively seals the workings and isolates abandoned territory from live workings. Much smaller areas are blocked out for each panel operation, from 16 to 18 rooms on each side being considered good practice, thereby reducing the dangers attendant to leaving large, non-utilized workings open for the accumulation of gas and dust, as with the present system. In addition, the panel system is much easier to ventilate, and in case of an explosion starting in a panel, it can readily be confined by the installation of rock dust barriers at the few openings required for ordinary operation.

Sprinkling:

The sprinkling system employed at this mine is very elaborate and efficient as far as the actual equipment is concerned. Large header lines are provided and ample pressure is maintained at all times. Pipe lines are laid to every face and liberal quantities of hose are furnished. The water available for sprinkling purposes is pumped from the power house to the tank above the mine. In addition, plans are being made to utilize the water pumped from the mine. While the mine makes about 30,000 gallons per day, in general it may be considered a dry mine, very few coal faces showing evidences of moisture.

As before mentioned, there is no doubt that sprinkling was carried out in this mine as effectively as natural conditions would permit. Utah operators have placed great confidence in their sprinkling operations, even to the extent of believing that it was impossible to have an explosion occur at any mine in which the system was properly used. Their belief was strengthened by the fact that no large explosions had taken place since the Scofield disaster in 1900, and the immunity was attributed largely to the sprinkling methods employed. We are advised of cases where a mine of this company was actually closed down in the height of the production season until frozen pipes could be thawed and sprinkling operations resumed. All accessible parts of mines were kept wet at all times, and sprinkling was considered the most important part of the safety measures.

In late years, there seems to have been some tendency to relax or entirely disregard the earlier sprinkling practices. One of the first evidences of this condition has to do with the installation of "sprinkling cars" on main

and was generally conceded to be a very safe mine and the news of this disaster came as a distinct surprise to all who were acquainted with Utah coal operations.

The fact that a widespread explosion, reaching as it did every part of the mine, and killing 171 men as they worked, and this in a mine which was apparently kept well sprinkled, has raised a doubt in the minds of mining engineers and operators as to the efficacy of watering systems for explosion prevention. Until quite recently, sprinkling has been almost universally adopted in this country as a means of rendering coal dust inert, or at least incapable of propagating an explosion. In England, and in some other foreign countries, rock dusting has been extensively used, with sprinkling practically abolished. Recently considerable work has been done with "adobe" dusting in some of the mines in the Rocky Mountain District, these efforts being attended with considerable success.

In the high, dry climate of Utah with extreme cold during the winter months, it is difficult if not practically impossible to keep intake haulageways properly wetted down. Many Utah coal mining men know that an intake haulage road may be well sprinkled at the start of the shift and yet be in a dry, dangerous condition within eight hours, not to mention the dangers of freezing pipe lines, with consequent interruption of sprinkling operations. In addition, it is difficult to employ men who will water a mine thoroughly and conscientiously and this is especially true where the work has to be done on intake air courses in the winter months.

With rock, or "adobe" dusting, the work is of a much more permanent nature, and not subject to serious variation within short periods of time. There spillage from passing cars and trips is reduced to a minimum, the dust

hosings in place of manual sprinkling. These sprinkling cars do wet the floor and a portion of the rib, but they are ineffective on the higher parts of the ribs, timbers and roof.

Although quantities of wet coal dust were formed in active workings under the deposits left after the explosion, it was impossible to find similar conditions in abandoned workings where several inches of dust could be removed without the slightest indication of moisture. It is reasonable to assume that sprinkling of these standing panels had been discontinued, or at least ineffectively carried out.

It is agreed that watering or sprinkling is an effective means of stopping or limiting explosions if thoroughly done, but in very few mines is this work so thoroughly carried out that an explosion will not be propagated if a source of ignition is present. Dryness of the floor and ribs is insufficient to stop an explosion if coal dust is present in cavities, on rib ledges and timbers that can be dislodged by the pioneering wave. Again it is difficult to obtain employees who will be sufficiently conscientious and take enough interest in their work to do it effectively, thereby rendering useless the attempts of the management to protect life and property.

Electricity:

Experience in recent years has proven that electricity is one of the greatest aids, as well as one of the greatest hazards in modern coal mining.

At Castle Gate, electrical installations are well made and care is taken in the upkeep. Trolley wires, carrying 500 volts direct current, are carried on metal hangers, and good clearance and alignment are maintained.

need not be removed for weeks, or even months. The dust can be applied to ribs, roof and timbers, either by hand or mechanical means, thereby presenting at all times sufficient incombustible material to quench an explosion. If a light colored dust, such as "adobe" dust, is used a great advantage is obtained in the increased illuminating effect, thereby preventing many haulage road accidents.

RECOMMENDATIONS

Castle Gate No. 2 Mine was among the best kept mines in Utah. The ventilation was adequate and the air properly split. Over 180,000 cubic feet of air entered the mine per minute. The mine was among the best sprinkled mines in the State. A sprinkling hose with adequate water pressure was furnished at each working face. All other rooms and entries contained water lines with hose bibs at frequent intervals. Besides this, three sprinklers were regularly employed.

In the face of this, this mine exploded and in hopes of preventing a similar disaster the following recommendations are made.

1. All coal mines be compelled to use nothing but closed lights of type approved by the U. S. Bureau of Mines. Also, means should be taken to insure that the lamps be kept up to permissible requirements by suitable current inspection, maintenance and repairing.

2. Where flame safety lamps are used, including those used by fire bosses, foremen, etc., nothing should be allowed but up-to-date types of magnetically locked lamps approved by the U. S. Bureau of Mines and equipped with automatic relighting device.

3. In excluding open lights from all Utah mines there should also

A submarine type cable carries 4,000 volts alternating current from the surface to the transformer located on the 8th Left Dip. From this point the current is carried on separate conductors at 440 volts to the pump station. At the top of the rise slope, the large hoist operates on 440 volts, the current being carried at this potential on separate conductors through a bore-hole.

In general, it may well be said that electrical installations are made in keeping with the best underground electrical practice.

General Safety Conditions:

Some of the most dangerous practices, which evidence shows were prevalent at this mine, have to do with the methods used in handling gas accumulations, and the laxity of gas reports. In addition, men were allowed to work with open lights in regions known to generate methane. Electric miners lamps had been ordered and were in stock at the time of the explosion, but had not been put into service due to all the charging apparatus not having been received. Miners were allowed to carry matches and smoking material underground - this being the general condition in all "open light" mines. Those using flame safety lamps either did not realize the dangers of methane and the limitations of the flame safety lamp, or deliberately ignored them, thus risking their own lives and the lives of every man in the mine, to say nothing of risking the destruction of the mine itself. The flame safety lamps used by fire bosses were of the key-lock type, which could be opened underground and relighted by means of matches or carbide lamp in case the flame became extinguished and the igniter refused to work.

Castle Gate No. 2 was considered the model operation of the company,

be stringent measures against smoking in mines, against use of fuse or squibs, or of open flame of any nature. And frequent search should be made to prevent carrying of matches underground and a heavy jail penalty imposed on any person found trying to take matches or smoking materials underground, or using them underground.

(See Section 1919, paragraph 9 of the Coal Laws of Utah.)

4. Moving of methane accumulations while the shift is in the mine should be absolutely prohibited even when all mines are on a closed light basis. Fire bosses should be required to report on the fire bosses' book, all gas found even if only a small amount and even if a small amount should be found in numerous places and on repeated occasions.

5. It is believed the Burrell Gas Indicator should be used to detect gas when the shift is in the mine and flame safety lamps excluded from all mines when the shift is working, the flame safety lamp to be used only by fire bosses on their general examination before the coming of the shift.

6. All underground electrical machinery should be of permissible type where such equipment is available.

7. Underground pumps, hoists, etc., where electrically driven should be placed on intake air wherever feasible. Particularly should pains be taken to prevent pulling of methane by cars, etc., when electric motors operating pumps, hoists, etc.

8. Where feasible power wires should not be placed on main haulage roads as they may be ruptured and possibly short circuited by wrecked trips or falls and possibly cause dust explosion as at Delcasite, Alabama, in 1920, or Dawson, New Mexico, in 1923. While bare feeder cables paralleling trolley locomotive lines are held by electricians to be good practice, it is believed

that these bare cables constitute a second menace (the trolley wire being the first) and trolley feeder cables should be of well insulated material either buried in the floor or placed in a groove along the rib.

9. Where at all feasible storage battery locomotives should be used in place of trolley locomotives. It is strongly recommended that the experiment soon to be tried at Dawson, New Mexico, in which a storage battery is to be used to operate undercutting machines, should be carefully observed and if successful there, similar installations be made in Utah coal mines.

10. Water lines with water of good pressure and large quantity should be kept within a few feet of every working face. And each working face should be supplied with sufficient quantity of water hose to enable all portions of the face region to be thoroughly sprinkled.

11. Face workers should be required to have region of working face wet at all times, this to include the loose coal and particularly the ribs, roof and adjacent gob. And the company should have a sufficient force of sprinklers to insure that all other open portions of all mines are kept wet except such places as may be rock dusted. It should be borne in mind that the most dangerous dust is that which is very finely divided hence settles on ribs, roof and timbers, consequently while necessary to keep floor sprinkled it is even more necessary that ribs, timber caps, and roof be kept well washed. If sprinkling cars are used to wet floors, they should be supplemented by men with hose to reach roof and ribs; sprinkling cars are not likely to be effective where roof is 8 or 10 feet and up to 30 feet above the floor. Region around underground stations having electrical machinery, (hoists, pumps, fans, etc.) should be kept especially well sprinkled.

be taken at intervals to make certain that there remains at all times enough inert material to prevent ignition or propagation, and that the dust is in proper condition as to size, dryness, etc., to act effectively.

16. At every opening from each working level or panel there should be rock dust barriers so placed that an explosion originating in that level or panel cannot extend beyond that level or panel nor can an explosion originating outside of the level or panel penetrate into it. To be effective these rock dust barriers must be of correct design and must be correctly installed and be filled with dust of suitable nature, and the U. S. Bureau of Mines will give definite information as to rock dust barriers upon request.

17. No mine in Utah should be allowed to use black powder or dynamite in the shooting of coal and no shots should be fired while any person is in the mine. In other words, nothing but permissible explosive should be used in blasting coal and all blasting should be done by electricity from the surface. In using permissible explosives, not more than three sticks (1-1/2 lbs.) should be used in any one hole. More than this amount is dangerous and unnecessary as better results can be obtained by use of a greater number of holes and restricting amount of explosive per hole to 1-1/2 pounds (3 sticks) or less. It is also recommended that no explosive be allowed in the mine during the working shift, the shot firer bringing in the explosive and loading and firing the holes after the shift has gone home, the miner having drilled the holes and prepared the clay "dummies" during the shift.

18. It is advisable insofar as it may be feasible, that all advancing workings (entries, rooms and crosscuts) be kept on an even height and grade as to roof. The practice of having entries and room necks driven

12. One of the most effective dust destroyers in a coal mine is the use of water at the cutter bar on mining machines and every undercutting machine should have water spray on intake side of cutting chain and machine man should be discharged if found cutting without use of water. It is probable that water can also be used on cutter bar where overcutting or sheering is done.

13. Provision should also be made to spray the top of all loaded cars on main partings underground before hauling on main entries especially on main intake air courses as the air currents remove fine, dry dust from top of loaded cars, this most dangerous material being later on deposited on ribs, roof and floor.

14. The use of continuous, permanent (stationary) water sprays is recommended on air courses which are beyond reach of freezing in cold weather. Such sprays are of particular utility in return air courses; and return air courses contrary to general belief, usually have decided dust hazard even where the return air is thought to be nearly saturated with moisture.

15. Main intake air courses are difficult if not impossible to keep safely moist especially in winter and it is strongly recommended that these be kept thoroughly rock dusted especially where the main intake air course is also the main haulage way. The rock dusting should be done to points at least as far as freezing extends during coldest part of winter; and as rock dusting is held by many authorities to be more effective than sprinkling in preventing explosions or their propagation, the dusting may well be extended into all working entries. It is essential that suitable material be used for rock dusting and that proper methods be used, and the U. S. Bureau of Mines is prepared to examine proposed material or to suggest suitable material or methods for rock dusting. After having dusted a mine or portion of it samples should