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FINAL REPORT ON
MATHER MINE EXPLOSION
PICKANDS-MATHER AND COMPANY
MATHER, PENNSYLVANIA
MAY 19, 1928.

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Introduction:

On May 19, 1928, at 4:07 P.M. a gas and dust explosion occurred in the Mather mine of the Pickands-Mather and Company at Mather, Pa. This explosion occurred at a time when the day and night shifts were changing. Four hundred and sixty-two men were employed on the day shift and 151 on the night shift. Many of the day shift men had left the mine but there were about 270 men in the mine when the explosion occurred, of these 209 were within the area involved and about 61 escaped from the unaffected area without assistance, although some of those who escaped received minor cuts and bruises. Of the 209 men in that part of the mine affected by the explosion 14 escaped safely, 2 died in hospitals after being rescued and 193 were killed outright by violence or were suffocated by afterdamp. About two-thirds of the persons killed were in the path of the explosion and were killed by violence or burned to death and one-third were overcome by afterdamp within an hour or two after the explosion. One group of 6 men, on the west side of the mine, attempted to erect a brattice cloth barricade at a point about

500 feet beyond the flame zone. Another group of 4 men congregated at another point nearby but were overcome before they had made any attempt to protect themselves. A third group of about 16 men, on the east side of the mine, were overcome at a point some distance from their working places while trying to escape; there was no evidence that these men had made any attempt to protect themselves.

The explosion originated in the extreme northwestern corner of the mine (see mine map appendix I, also appendix II) in solid workings where it appears that an accumulation of explosive gas was ignited by sparks or arcs from a non-permissible storage battery locomotive. This accumulation of gas may have been due to an interruption in the ventilation, possibly a door had been left open. Notwithstanding the fact that the explosion covered an area about a mile wide and a mile and half long, it should be classed as one of moderate violence. The area involved is about one-fifth of the entire mine. The greatest distance that flame traveled, as measured along the haulage roads, is about 8500 feet. Property damage consisted of the destruction of doors, stoppings and overcasts, slight damage to a number of empty mine cars, and the knocking down of timber sets resulting in extensive roof falls.

It is believed that the extensive use of rock-dust, although not applied in accordance with the recommendations of the Bureau of Mines and the American Engineering Standards Com-

mitted, materially diminished the violence of the explosion and prevented the extension of propagation to other parts of the mine. A number of rock-dust barriers, none of which however were of the types tested at the Bureau of Mines Experimental Mine, were installed; two of these barriers may have been instrumental in lessening the violence of the explosion, especially the barrier at the foot of the air shaft about a mile and a quarter from the main shaft. Relief of pressure through this air shaft may also have been a factor in limiting propagation. Water was used on the cutter bar of all coal cutting machines and provision was made for attaching hose to the water pipe lines at more or less regular intervals along the haulage roads but there was no evidence that these had been used systematically.

The Pittsburgh office of the Bureau of Mines received notification of the explosion at 6 o'clock P.M., and the following men of the Bureau's staff arrived at Mather at 10:30 P.M.: Messrs. J. J. Forbes, G. S. McCaa, G. W. Grove, E. J. Ristedt, H. Burdelsky and H. C. Howarth. Bureau of Mines Car No. 3 with Mr. McLellan arrived the following morning at 5 o'clock. Members of the Bureau's staff took active part in cooperating with State and mine officials in advancing the recovery work by accompanying and assisting with the direction of rescue crews, controlling and extinguishing incipient mine fires, were present by invitation at many of the conferences on ways and means of advancing the recovery work, and also were included in the State's commission to

investigate and report on the cause of the explosion.

A number of nearby coal companies sent rescue teams and equipment to the mine immediately after the explosion. They assisted in advancing the recovery work and in building stoppings. The list will be found in appendix X.

Location:

The Mather Colliery is located in the State of Pennsylvania, Greene County, Morgan Township. The mine is served by the Monongahela Railroad, a branch connecting with the Pennsylvania Railroad. The mine post office is at Mather, Pa. The main office of the Pickands-Mather and Company is located in Cleveland, Ohio.

The principal officers of the company are as follows:

Mr. Frank Armstrong, general manager, Union Trust Building,
Cleveland, Ohio.

Mr. J. Herbert Evans, general superintendent, Mather, Pa.

Mr. George Weightman, mine foreman, Mather, Pa.

G. S. Eaton and Company, Consulting Engineers.

Number of Employees:

The mine normally employs inside 613 men, 151 of these are employed on the night shift. The night and day shift forces of the mine produce 3600 tons of coal daily.

Openings:

The openings to the coal seam at the Mather mine consisted of 3 shafts each of which were 340 to 350 feet deep. The main hoisting shaft is located near the center of the acreage

owned and is equipped with self-dumping cages. This shaft also serves as an intake shaft for ventilation. The second shaft is about 850 feet north of the main shaft and is divided into 2 compartments, one of which is used for return air, the ventilating fan being connected to the top of this compartment. The other compartment is used for lowering and hoisting men and material and also serves as an intake airway for ventilation. The third shaft which is about 8500 feet north of the main shaft is used as an intake airway for ventilation and is equipped with a stairway for an exit in emergencies. Several men were rescued from this opening.

Coal Bed:

Mather mine is operating in the Pittsburgh coal bed which at this place has an average thickness of about 78 inches and has a slight average dip to the southwest. The coal is friable, of high volatile content and is used principally as coking and gas coal. There are 2 slate partings 3 to 4 inches apart about 3 feet from the bottom. Immediately overlying the coal bed there is a bed of shale or drawslate a foot or more in thickness, which falls readily when unsupported. In order to hold this drawslate and maintain a fairly good roof condition without timbering, about a foot of top coal is left to support the drawslate.

Analysis of Coal:

Two face samples of the coal bed were taken within

the explosion zone. A composite analysis is as follows: Moisture 3.2 per cent; volatile matter 34.15 per cent; fixed carbon 55.1 per cent; ash 7.55 per cent. Two face samples were collected by G. N. McLellan on June 19, 1928. These samples were analyzed at the Pittsburgh Laboratory of the Bureau of Mines. For detailed analysis reports by H. M. Cooper see appendix III. Comparison with typical analysis of coal from the Bureau's Experimental Mine; moisture 1.85 per cent; volatile matter 36.43 per cent; fixed carbon 54.68 per cent; ash 7.04 per cent, as given above, shows that the coal from the Mather mine has a slightly lower ratio of volatile combustible to total combustible matter and is slightly higher in fixed carbon and ash. The slight difference in composition is not sufficient to make any appreciable difference in the explosibility of the coal from these two mines and results of experiments obtained with dust from Experimental Mine coal may be applied to Mather mine.

Methods of Mining:

A map of the mine showing the general plan of the workings will be found in appendix I. The mine is laid out for a large scale mining operation, having ample openings for ventilation, haulage and travel. The mine is cut north, south, east and west by five and six parallel unfolding ^{or development} entries, with face main entries of less importance in sets of threes and fours. Butt entries are turned off the face entries in pairs and rooms

turned therefrom on one hundred foot centers. The method of extraction is by what is generally known as single panel full retreat. The method used for the extraction of coal has a tendency to keep the roof in pillar areas in a sound physical state and the gas can more easily be kept free in the extracted area, as well as permitting the maximum extraction of the seam. No mechanical loaders or conveyors are used in the mine. The roof of the main entries is kept clear of loose material and well timbered where top coal is down. In entry sections of the mine where top cutting machine has been used very little timber is required to keep the roof in a sound state. In sections of the mine where pillars are being extracted, adequate timbering is maintained.

Ventilation and Gases:

Mather mine is ventilated by means of a steel and masonry encased reversible, primarily exhaust, fan, which, prior to the explosion, was running 135 r.p.m. and was exhausting 300,000 cubic feet of air a minute against a 2.6 inch water gage. This fan is double inlet, 6 feet by 14 feet, and was built by the Jeffrey Manufacturing Company. The entire mine was divided into 12 or 14 ventilating districts or splits, 9 of which provided ventilation for the north side of the mine where the explosion occurred. Three main intake airways which served as haulage roads and traveling roads were provided for carrying the ventilation into the body of

the mine where it was delivered to the workings in what appeared to be ample quantities. The main intake airways were flanked on both sides by return airways. The intake and return airways were separated by good substantial stoppings of masonry and the return airways were carried over the intake airways by means of well constructed overcasts of masonry. Brattice cloth was used extensively to carry air to the working faces and several doors were in use near the advance workings. As is the case in the ventilation of every mine, these doors and line brattices are the weak points in the ventilation of this mine. However, the percentage of gas in the return air at any point is reported as being less than one-half of one per cent. The mine is rated by the Pennsylvania Department of Mines as gassy and in addition to the mine foreman, 5 assistant mine foremen and 4 firebosses were employed, also several shotfirers and rib bosses, two of the assistant mine foremen and one of the firebosses being employed on the night shift.

On June 13, 1928, methane was being liberated at the rate of 550,486 cubic feet in 24 hours, see samples 45678 to 81234 inclusive in the table of air samples, appendix IV. In this same table samples 45678-9 show that the workings of 24 butt and the 12 north faces where the explosion originated were liberating methane at the rate of about 288,140 cubic feet in 24 hours, or enough gas every hour to fill a 1375 foot length of single entry with an explosive mixture of gas and air consisting of 6 per cent or more of gas.

Haulage:

Electricity at a potential of 250 volts is used very extensively in the operation of the mine, being used for lighting at the shaft bottom and on mains, also for haulage by main line trolley locomotives which are confined to main intake airways. The coal cutting and pumping are also done by electricity. Non-permissible storage battery locomotives and draft animals are used for gathering coal from the face of the working places to collective points from where it is taken to the bottom of the main shaft by main line trolley locomotives. The trolley wiring and manner of attaching it to supports is of adequate form, having cutout switches at intervals and at all branches where development justifies such an installation. There are 650 mine cars at the mine, some of steel, others of wood, both are of the end gate type. The track gage is 44 inches, having 60 pound rails for main haulage with 40 pound rails for butt entries and 25 pound rails for rooms. The width of clearance between cars and ribs is over 2½ feet in most parts of the mine, with shelter holes at frequent intervals and having trolley wire and power lines located on the opposite side of track.

Lighting:

The miners work exclusively with permissible electric cap lamps. In addition to the electric cap lamps, each machine crew is provided with a permissible magnetically locked

flame safety lamp. The foreman, assistant foreman, firebosses and face bosses all use permissible magnetically locked flame safety lamps. Fixed incandescent electric lights are installed at the bottom of shafts, at pumps, doors, and the principal switches along the haulage roads.

Mining Machinery:

Mining machinery underground is both of the permissible and non-permissible type. All coal cutting machines are of the cable reel permissible type. The storage battery locomotives, while of the closed type, were not permissible, and did not carry a permissible plate. The electric wiring, where it had not been torn down by the force of the explosion, was well installed. All of the power lines were in intake air currents.

Explosives:

Hercules CLF and one of the Union Company were the permissible explosives used exclusively; size of cartridge $1\frac{1}{4}$ by 8 inches, diameter of hole 2 inches; depth of hole $5\frac{1}{2}$ to 6 feet. The miner carries the explosives into the mine, and shotfirers carry the detonators and explode same with electric shot-firing units. Only clay stemming is used.

Drainage:

The mine is wet in some dip sections, and the pipe line is arranged so that the water can either be pumped to the surface or into the mine pipe water line. There were 14 pumps, electric driven, three of which pumped 200 gallons each per minute to

outside for 6 hours per day, a total of 216,000 gallons per day.

Dust:

Large quantities of coal cuttings from the top cutting machines are found on the ribs which have numerous ledges due to the entries and rooms being wider at the top than at the bottom. After the explosion large quantities of fine dust were found in all parts of the explosion area. The quantity of dust was so great as to attract the attention of the most casual observer. Men of all classes, engaged on the recovery work, were heard commenting on the quantity of dust.

Tabulation and discussion of dust samples collected after the explosion will be found in appendix V.

Water is piped to all parts of the mine and is used on the cutter bar of mining machines to allay dust as the coal is being cut. There was no definite plan for wetting down the coal at the working faces or sprinkling the dust along the roadways.

Rock-Dust:

This mine is partially rock-dusted. The mine is rock-dusted on main face entries, parallel mains and butt entries where track is laid. The aircourses on main, face and butt entries are not cleaned or rock-dusted. A considerable quantity of rock-dust was used in the Mather mine. It is said that each weekend about 400 bags of limestone dust was distributed by a crew of men who were engaged on other work during the week. It has

been estimated that 80 to 90 per cent of this quantity of rock-dust would be required to rock-dust the territory opened up in a week's time in a mine the size of Mather mine. The mine officials say that an effort was made to advance the rock-dusting as the working faces advanced and that a period of about 3 weeks was required to cover the advancement of entries. This means that the face of an entry would not be more than 3 weeks, or about 75 feet in advance of the rock-dusting. The man who distributed the rock-dust repeatedly made the statement that rock-dust was distributed at the rate of 20 pounds per linear foot of entry, however, the writers of this report failed to see any part of the mine where rock-dust had been distributed in such quantities. At a number of places adjacent to the explosion zone the working face was 150 to 200 feet beyond the rock-dusting.

The mine dust was not sampled regularly before the explosion and there is no record of the quantity of incombustible matter present. No record was kept of the quantity of limestone dust used nor of the section of the mine in which it was distributed.

A total of 14 rock-dust barriers, none of which were of the types that have been tested, were located in various parts of the mine. These barriers consisted of a large platform of boards placed in the entry about midway between the roof and

floor. The barriers were supported on a miscellaneous collection of props and sticks and the quantity of dust in each barrier was about 7000 pounds. The position of the barriers and the method of supporting them was such that only the most violent explosions might possibly operate them, and then most of the barrier dust would fall to the floor in an unbroken mass. However, one of these barriers which was located at the foot of the airshaft near the intersection of No. 5 main and 24 butt may have materially reduced the violence of the explosion in the airshaft as an employee observed smoke and dust but no flame projecting to a height of 150 to 200 feet above the shaft landing. A second rock-dust barrier located in one of the entries paralleling No. 14 right haulageroad was demolished by the force of the explosion and may have had some influence in limiting the length of flame in this branch of the explosion.

Mine Conditions Prior to Explosion:

The mine conditions prior to the explosion were normal. The mine was working ^{practically at capacity} 1/2 but many of the day men had reached the surface before the explosion occurred. The night shift men had just about time enough to reach their working places when the explosion occurred. The firebosses' report for the day did not show any unusual conditions nor unusual accumulations of gas, however, this report did show that gas had accumulated at the face of the place where the explosion may have originated. The fireboss and brattice men testified that ventilation had

been extended to the face by means of line brattice and that there was no gas in the place at 9:00 A.M. or 7 hours before the explosion occurred. The testimony of men working in close proximity to ^{the point} where the explosion probably started, stated that they left this section about 2 hours before the explosion occurred, and there was no unusual conditions at that time in the mine.

Previous Explosions:

Previous to this time there had been no explosions in this mine. The Gates mine explosion is the nearest one that had occurred to the Mather mine and it was a gas and dust explosion.

Property Damage:

The explosion was one of moderate violence. Many stoppings, doors, and overcasts were destroyed, however, many of the stoppings within the explosion area were left unimpaired. Many timber sets were blown out allowing extensive roof falls to take place. A number of empty mine cars were slightly damaged and the cover plates were blown off all the locomotives within the area traversed by the explosion. The first two or three flights of steps at the bottom of the air shaft were torn loose.

The mine was operating at full capacity two months after the explosion occurred.

Mine Maps:

The mine map, appendix I, shows the magnitude of the affected area, the probable origin, the location of dust and

air samples, the direction of explosion force, the end of flame, the end of material force, the location of fires left by the explosion, and the approximate location of two live men found 66 and 147 hours after the explosion. The map does not contain the location of bodies, for the locations were not all marked as the bodies were found.

Appendix II is an enlarged section of the mine map showing point of origin and forces radiating from same; the location of storage battery locomotive, the probable cause of the explosion; the direction of air current prior to the explosion; and the location of bodies that were found near the origin.

Forces:

The direction of major forces and the path followed by the explosion, as indicated by the destruction of doors, stoppings and overcasts, deposits of debris, the damage to mine track and mine cars, is shown on the mine map. See appendix I. Beginning at the point where the explosion originated the paths of the several branches of the explosion are described as follows: The direction of forces radiates from the storage battery locomotive which was found on 12 north off 24 butt at a point approximately 90 feet from the face. The large wooden cover plates of this locomotive and the track outby the locomotive were blown outby or towards 24 butt. The body of the man who worked in the cut-through 35 or 40 feet inby the locomotive

was blown into the empty car which it is presumed had just been placed by the locomotive, and debris was blown inby from the locomotive toward the face. Inby the last cut-through on 11 north the explosion had been very violent and the track was thrown in various directions. Inby the last cut-throughs on 13 and 14 north the end-gates of cars were bent inby or toward the face. In one of the last named places the miner was decapitated and completely dismembered, the torso being found some distance from the other parts. Outby the last cut-throughs in 11, 12, 13 and 14 north the direction of the movement of all debris was toward 24 butt. The large wooden cover plates of a battery locomotive found on 13 face 300 feet from 24 butt were blown toward 24 butt. An empty car at the face of 25 butt off 14 face was driven toward the face as was an empty car at the face of No. 2 room off 24 butt. The explosion traveled inby on 24 butt from 14 face but did practically no damage. Four loaded cars on 24 butt between 13 north and 14 north were not disturbed, except that coal was blown off the top toward the face of 24 butt. Between 10 north and 11 north 24 butt is made up of four parallel entries, the two entries in the center are used as intakes and the two outside entries as returns. The greatest force developed in this zone was in the extreme right and left hand parallel entries blowing most of the stoppings toward the haulage road, the entry which had been rock-dusted, the indication being that the rock-dust in the haulage road retarded the explosion and permitted it to develop more

rapidly in the back entries. At 9 face (7, 8, 9 and 10 north) the explosion branched north and south as well as continuing directly outby on 24 butt. The branch of the explosion which traveled directly outby on 24 butt was very weak, 11 of 13 stoppings on this entry outby 7 face were not damaged and only the upper half of one of the other two was blown out.

The branch of the explosion traveling north in 7, 8, 9 and 10 face off 24 butt was violent. Stoppings were blown out with considerable force, doors and overcasts were demolished, empty mine cars were wrecked and slightly damaged and timber sets were knocked down causing extensive roof falls. This branch of the explosion extended to and into the upper end of 29 butt for a distance of about 450 feet. Evidence of the force of this branch of the explosion was found in 30 butt where the canvas stoppings in the last three or four cut-throughs were torn loose at the corners.

The most extensive and most violent branch of the explosion passed from 24 butt through a single entry (9 north) into the section of the mine between 24 butt and 8 butt. It is believed that a properly designed rock-dust barrier placed in the single entry referred to above would, in all probability, have stopped this branch of the explosion, but as it was this branch of the explosion spread west to 17 face off 15 butt and east to a point 1000 feet beyond the set of face entries on the east side of the mains, making a total distance of approximately

8000 feet from the extreme eastern to the extreme western limits of the explosion. The extreme eastern limit of the explosion was on 22 butt off 4 face right where the explosion died out, possibly due to a combination of conditions including ^{at least to a slight extent} compression of air in advance of the explosion in the dead end, relief of pressure behind the explosion at the air shaft and the presence of rock-dust on the haulage roads, ^{as well as other factors.} On 1, 2, 3 and 4 face right the force of the explosion extended north of 22 butt, a distance of about 500 feet to between 23 butt and 24 butt, or within about 1000 feet of the face. On this same set of face entries the extension south of 22 butt was about 1500 feet or to a point between 17 butt and 18 butt. On 2 face right just outby 20 butt, a mining machine was slightly damaged, stoppings along this set of face entries were blown out with considerable force and timbers were blown out causing extensive roof falls. In 17, 18, 19, 20 and 21 butts between the right faces and the mains the explosion was rather violent, mine cars were damaged and stoppings and doors were blown out with much force. There was no evidence of force of flame in 1, 2, 3 and 4 right face outby 17 butt, except that the explosion traveled into 14 butt right off the mains for a distance of 600 or 700 feet where the tops were blown out of two overcasts. In the back entry near these overcasts a platform loaded with rock-dust to serve as a rock-dust barrier was demolished and may have taken some part in limiting the extension of flame in this entry. Another similar platform nearby was not disturbed.

In the mains the tops were blown out of two overcasts at 9 butt. From this point inby to 27 butt stoppings, doors and overcasts were blown out and some of the mine cars were damaged. Most of the stoppings were blown toward the haulage road, indicating that the explosion was most violent in the back entries. At the entrance to 11, 12, 13 and 15 butts off the mains deposits of debris showed that the explosion started into these places. In 15 butt from a point about 300 feet inby the main faces to a point about 600 feet outby 9 north face, a distance of 800 feet, there was but little evidence that an explosion had occurred. The ribs in this zone were still coated with limestone dust. The explosion traveled from 9 north face through 23, 22, 21, 20 and 19 butts into the mains. Outby 22 butt a study of the direction of forces showed that the explosion traveled outby, and inby 22 butt the explosion traveled inby toward and beyond the air shaft to 27 butt as stated above. The mine officials state that large shelves or platforms at the bottom of this air shaft were loaded with rock-dust to serve as barriers. There was no evidence of such barriers at the shaft after the explosion and it is supposed that they were blown out and may have limited the extension of flame in the shaft. However, an employee (rib boss) saw large clouds of dust and smoke, but no flame, forced from the top of the air shaft, which is 350 feet deep, to a height of more than 150 feet. There was no damage in the shaft and only one or two flights of steps at the shaft bottom were disturbed.

As stated above the south branch of the explosion also extended into the workings west of 9 north, the westernmost limits of force being 15 north face. Nearly all the men working in the rooms west of 18 north face were overcome by afterdamp. It was in this section that six men attempted to build a barricade at the face of a room and the bodies of four men were found in a position which indicated that they may have been discussing their predicament when they were overtaken by the afterdamp. The explosion traveled outby on 7, 8, 9 and 10 faces south of 15 butt to No. 9 butt and on 11, 12, 13 and 14 faces to No. 11 butt, the explosion in these last named places was not violent. Men working at the bottom of the hoisting shaft and at the bottom of the supply shaft felt the concussion but none of them were seriously injured.

Evidence of Heat or Flame:

The extreme limits of heat or flame as indicated by the presence of coked dust, burned bodies, timbers charred or other evidence are shown by proper symbols on the mine map, appendix I.

Bodies found on No. 5 main face haulage road at 6 butt were not burned but there were a few small deposits of coked dust on both the inby and outby sides of timbers at 9 butt, indicating that flame died out at or near this point. In this zone the entries are dry and but very little sand is used on the haulage roads, the grade being in favor of loaded trips. The

dust samples, A-42705 and A-42706, taken at 9 butt after the explosion were low in inert matter, possibly due to the dust being carried to this point by the explosion. These samples of dust contained small amounts of coke particles indicating that flame extended to or beyond this point.

In 9 north flame extended to between 8 and 9 butts or a point about opposite the end of flame on No. 5 main face. There were deposits of coked dust on timbers at 9 butt and some of the timbers were slightly charred at a point about 200 feet outby 9 butt. All of the dust samples taken at this point contained coke particles additional evidence of the presence of flame. The total incombustible in the samples of dust (A-42701-2) taken at this point on the haulage road contained about 60 per cent incombustible matter but those taken in the parallel entries (A-42831-2 and A-42857-8) contained only about 35 per cent. These dust samples do not indicate that inert material stopped the explosion; but it is possible that relief of pressure in the worked out area and the air shaft inby this point in addition to the rock-dusted roadways limited the extension of flame. In 14 right off No. 5 main face coke particles in dust samples (A-42711-12) was the only evidence of heat or flame beyond the overcasts that were blown out at a point 700 feet from 5 main face. Samples of dust collected on the haulage road in 14 right contained nearly 62 per cent incombustible matter. This and a platform in the right parallel entry loaded with rock-dust may have limited the

flame in this branch of the explosion.

There were deposits of coked dust on props and on the ribs all the way along the gob line in 17, 18 and 19 butts off No. 2 face right. In 20, 21 and 22 butts off No. 2 face right the explosion traveled from No. 5 main face toward 2 right face depositing coked dust on exposures facing away from 5 main face. The limits of flame on 2 face right are between 17 and 18 butt on the outby end and between 23 and 24 butt on the inby end. The limit in 22 butt was at a point about 1000 feet inby 2 face right. Samples of dust were not taken in this section of the mine.

There was no evidence of flame or heat inby 25 butt on No. 5 main face. At 25 butt there were deposits of coked dust on inby exposures on the ribs. In a zone extending from 25 butt along 5 main face and up 29 butt to No. 12 room there was no evidence of heat or flame; the ribs were still coated with rock-dust. In the rooms at the inby end of 29 butt off 5 main face and at the face of 7, 8, 9 and 10 face entries there were very heavy deposits of coked dust; also the coal was coked in place. The flame traveled into 29 butt from 7 face for a distance of about 300 feet toward 5 main face. The road dust (sample A-42707) in 29 butt was high in incombustible matter and may have prevented propagation of flame in this direction. Particles of coke in the dust sample also indicated that flame extended beyond this point.

Flame extended inby on 15, 18 and 19 butt to 17 north

face but there was no flame in the rooms on the west side of 13 north face. It was in this section of the mine that bodies were found in groups and there was evidence that some of the men had attempted to build a barricade. Although the dust samples collected in this section were low in total incombustible the moisture content was about 10 per cent and may have been sufficient to prevent formation of a suitable dust cloud for propagation of flame, if this condition existed prior to the explosion.

Flame on 11, 12, 13 and 14 face south off 15 butt traveled a distance of about 800 feet to a point beyond 12 butt. There appeared to be large quantities of dust in this section and it is probable that the stopping of this branch of the explosion was due ^{at least partly} to relief of pressure in the worked out area and at the air shaft inby this point.

As indicated on the mine map, appendix I, there was no evidence of flame or heat in 15 butt left off 5 main face for a distance of about 1000 feet. This section extended from a point about 150 feet inby 5 main face to a point about 450 feet outby 9 face. Since the flame of the explosion extended to 9 butt on both 5 main face and 9 north face or about 1500 feet outby this section it is difficult to understand why flame did not extend into this section also.

A total of about 12 small fires were found in the panel bounded on the north by 24 butt, on the east by 6 main face, on the south by 17 butt and on the west by 7 north face. Three of these small fires were found in 23 butt, 4 in 22 butt, 4 in 21

butt, 1 in 6 face between 20 butt and 21 butt and 1 at the first cut-through between No. 5 and No. 6 rooms off 20 butt. With the exception of the location last named these were all very small fires and appeared to be deposits of transported incandescent dust; none of these were difficult to locate or extinguish. These fires caused considerable apprehension for a time and delayed recovery work while they were being extinguished and other sections were inspected for fire. The fire in No. 6 room off 20 butt was the largest and gave off smoke in large quantities making it difficult to locate. Once it was located, the efforts of the entire force of men in the mine at the time were concentrated on the business of extinguishing it. Rock-dust was used extensively in controlling this fire. The details of extinguishing the fire are given in appendix VI.

Samples:

Two face samples of coal were taken within the explosion area and are discussed under analysis of coal. See analysis reports appendix III.

Eighteen air samples were taken and are discussed in appendix IV. Analysis reports are attached to this appendix.

A total of 75 road and rib dust samples were taken subsequent to the explosion to determine whether there were large quantities of incombustible matter present. A tabulation and discussion of these dust samples will be found in appendix V, also analysis reports.

State Inspectors' Conclusions and Verdict of Coroner's Jury:

A copy of the State Inspectors' report is attached to this report as appendix VIII. The writers of this report were requested to serve with the commission of inspectors who formulated this report and are in full accord with the conclusions as to the cause and origin as set forth in the report.

The verdict of the Coroner's jury is included in this report as appendix VII.

Summary of Evidence:

Deposits of coked dust on timbers, mine cars and the coal surfaces, also particles of coke present in practically all dust samples, are evidence that propagation was aided by the presence of coal dust. A thorough and searching study of the direction of major forces leads to the conclusion that the explosion originated at a non-permissible storage battery locomotive near the face of 12 north off 24 butt. It is the judgment of the Bureau's investigators that inflammable gas was ignited at the storage battery locomotive referred to above, the presence of this gas being due to an interruption in the normal flow of air at the working faces in the section of the mine referred to.

Lessons to be Learned:

There are two lessons to be learned from the conditions as they relate to this explosion. The first is that very careful and unrelenting supervision and attention be given to the ventilation of coal mines to maintain an uninterrupted flow

and adequate quantity of air at the working faces. The second is that effective rock-dusting can not be done without regular and systematic sampling and supervision; also, that it is not sufficient to extend the rock-dusting at irregular periods with reference to the advancement of the working faces. It is the opinion of the Bureau's investigators that rock-dusting, to be effective, should also be extended to include all entries paralleling the haulage roads. The fact that a majority of the stoppings between haulage roads and parallel entries were blown into the rock-dusted haulage roads strengthens this opinion.

Recommendations:

Investigations of mine disasters are made by engineers of the U. S. Bureau of Mines with the hope of securing information which may aid in preventing the recurrence of similar disasters. The officials in charge of Mather mine are duly commended for their efforts to reduce to the minimum the hazards of coal mining by the adoption of such modern practices as the use of permissible explosives fired electrically and by authorized shot firers, electric cap lamps for lighting and permissible type mining machines for cutting coal. However, these additional safe practices are offered as recommendations with the hope that they may aid in preventing a similar disaster in the future.

1. It is recommended that special attention be given to the maintenance of an uninterrupted flow of air at all working faces, especially places where inflammable gas is likely to be

liberated. This air should be free from poisonous gases and by analysis contain not more than 1/2 of 1 per cent of inflammable gas nor less than 20 per cent of oxygen.

2. It is recommended that temporary stoppings or doors built of brattice cloth or wood be dispensed with and that only permanent substantial stoppings and doors be used in directing the flow of air currents.

3. It is recommended that the ventilation of the mine be so designed that overcasts of masonry will be used instead of doors, but where doors are necessary they should be so arranged that the opening of any door will not interfere with the normal flow of air at the working faces. Provisions should also be made for promptly taking care of the ventilation in case of damage to any door.

4. It is recommended that rock-dust be distributed in every part of the mine, whether damp or dry, in accordance with specifications given in Bureau of Mines Serial 2606 and recommended by the American Engineering Standards Committee "Recommended American Practice for Rock-Dusting Coal Mines", quoted in Bureau of Mines Information Circular 6050. Copies of both the serial and the circular may be obtained by request from the Director of the Bureau of Mines. Propagation of an explosion by coal dust can not occur if the mine is properly rock-dusted.

5. It is recommended that rock-dust barriers of a reliable and dependable type and substantial construction be installed supplementary to generalized rock-dusting. Only such

and found effective
type of barriers that have been tested/should be used in any
case.

6. It is recommended that water be used in sufficient quantities in all working places to keep the ribs free from machine cuttings and that the coal be thoroughly wetted before loading. Since water is piped to the face of all working places for use on the cutter bar of coal cutting machines, this recommendation may be adopted readily.

7. It is recommended that the empty mine cars be sprinkled with water before they are sent into the mine as an aid to preventing the accumulation of coal dust.

8. It is recommended that all mine cars be kept in dust-tight condition and that topping be limited in order to prevent spillage of coal along the haulage roads.

9. It is recommended that only permissible type electric mining machines, storage battery locomotives and other permissible electrical equipment be permitted inby the last permanent or substantial fireproof stopping, or past open rooms or entries which within a distance of 300 feet have faces or workings giving off methane. When trolley or non-permissible storage battery locomotives are employed, they should be used only in air absolutely free of explosive gas.

10. It is recommended that all permissible electrical machinery shall receive frequent systematic inspection/with prompt efficient repairs to insure its maintenance in a permissible condition at all times.

11. It is recommended that power lines shall not be placed in return aircourses, extended beyond breakthroughs closed with permanent stoppings or placed in any position where inflammable gas is likely to be encountered.

12. It is recommended that supervision be increased in frequency and intensity during working hours, and especially during the period when workmen are changing shifts.

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