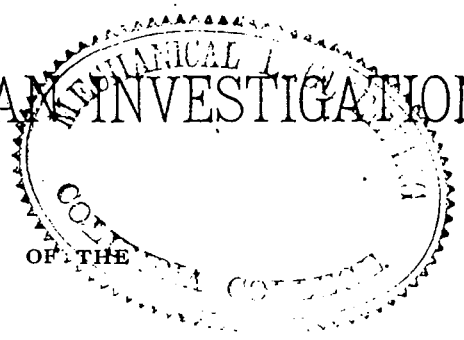
REPORT OF AN INVESTIGATION



OF THE

COAL MINE EXPLOSION

—AT—

RICH HILL, MISSOURI,

MARCH 29, 1888.

—BY—

WILLIAM B. POTTER, E. M.

ST. LOUIS, MO.:
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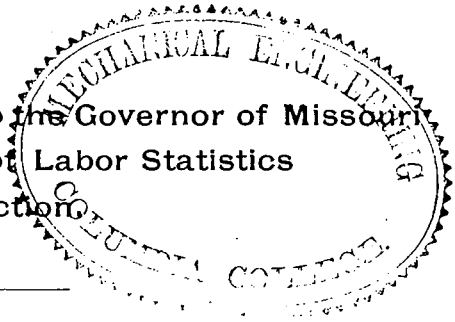
From a Special Report made to the Governor of Missouri by the Commissioner of Labor Statistics and Inspection.



ST. LOUIS, MO., June 1, 1888.

MAJ. O. KOCHTITZKY,
Commissioner Labor Statistics and Inspection,
JEFFERSON CITY, MO.

DEAR SIR—In accordance with your request, I visited Mine No. 6 at Rich Hill, Mo., on the 13th of April, and made a careful examination for the purpose of determining the cause of the disaster of March 29, 1888, and I present the following report embodying the results of that examination. I regret that unavoidable absence from the city has made it impossible for me to present the report at an earlier date.

Mine No. 6 is located about five miles from the town of Rich Hill, Mo., and is owned and operated by the Keith & Perry Coal Company, a company working a number of other coal mines in Southwest Missouri and Eastern Kansas, with general offices at Kansas City, Mo.

The mine is a comparatively new one, having been opened about the 1st of September, 1887, and the underground work is therefore not very extensive. The coal is worked through a main vertical hoisting shaft 247 feet deep, 11 feet by 7 feet in the clear, divided by partition into cage-ways. The up-cast or ventilating shaft is bratticed off from the main hoisting shaft by the usual wooden brattice work, and is 7 feet by 4 feet 2 inches in the clear with wooden stack carried up 35 feet above the landing.

The surface plant is well arranged for convenience, economy and safety of working, and the machinery and mechanical appliances for hoisting the coal and ventilating the works are of ample

capacity and strength for operating a mine of this class. The hoisting engine is of the usual double cylinder, link motion type, with cylinders 14 inches by 20 inches and drum 10 feet 10 inches in diameter, the engine shaft being geared to the drum shaft 6:1. The cages are provided with the usual dog and spring safety clutches and hoods, and the shaft-way with gates closing when the cages are down. These are all of reasonably good construction and were in fairly good condition at the time of my examination.

The ventilating fan is of the type commonly seen in the Illinois and Missouri mines, and was made at the Joplin Machine Works, Joplin, Mo. It is 10 feet in diameter, with six blades, each 3 feet by 4 feet, and designed to run up to 150 revolutions, furnishing about 40,000 cubic feet of air per minute. This is set in the up-cast air-way at the shaft landing.

The mine is worked underground by the method so prevalent in the bituminous coal mines of this country, and known as the double-entry post and stall, or pillar and room method. In order to make the important features of this case more clearly understood, the accompanying drawing is submitted, showing plan of underground workings, with ventilating air courses. It is based upon a plan of the mine furnished by Mr. David Mackie, General Superintendent of the Keith & Perry Coal Company.

From this drawing it will be seen that there are two main double entries, one running west from the shaft, and the other east. "The Main West Entry" carries the fresh air from the down-cast or hoisting shaft, to the "First North Entry" and the rooms connecting with it on the east side, thence returning by the "Back North Entry" and rooms connecting on the west side to the lower end of the "Back South Entry," returning by the "First South Entry" to the "Main Entry," and thence by the "Main West Return Air Course" to the up-cast air compartment of the shaft through which it is drawn and discharged by the fan.

For the ventilation of the workings on the east side, the air is carried along the "Main East Entry" to the "First North Entry" through the working places, and around back to the "Main East Entry" and thence to the "Back South Entry" and its rooms to the "First South Entry," and thence by the "Main East Return Air Course" to the up-cast shaft.

The plan of ventilation provided at this mine is a very satisfactory and efficient one. The "splitting" of the air into two main courses has the advantages over one air course in securing better air to all the workings with less loss of head from friction, and in making the east and west districts independent of each other, and thus affording greater safety to the mine and men working there. The appliances for carrying out the plan are quite sufficient for the needs of the case both in arrangement and construction. The doors are well made and set, and the canvas curtains are so hung as to cause little loss of air by leakage, and seem likely to secure greater certainty of action than the doors in case of disturbance from any cause, especially concussions from heavy shots or explosions. The permanent stoppings seem, in all cases examined, carefully made of good roof shale and well packed. Those used to shut off connection with the old intermediate north workings west of the shaft, and shown at B B, are of heavy double walls of well packed shale, with thick puddle of clay between. It was in these old workings that the fire occurred last February, which will be referred to later on in this report.

At the time of my examination of Mine No. 6, (April 13th) the mine was, according to the sworn statements of Mr. David Mackie, Superintendent of Keith & Perry Coal Company's mines in Kansas, and Mr. G. R. Sweeney, the Superintendent of Mines at Rich Hill, in the same condition as just after the explosion (March 29th) except that the brattice of air-shaft, and some of the doors and stoppings, injured by the explosion were restored to their normal condition. The entries and rooms were in good

working condition, showing little or no signs of the explosion. The entries are 9 to 12 feet wide, and the rooms usually about 25 feet wide. The roof is usually a black shale with a light gray shale overlying this at a distance varying from 3 to 10 feet. In some places, however, the gray shale forms the roof immediately above the coal. In all cases, the roof is of fairly good character, requiring no great amount of timber, and no unusual treatment for controlling it.

There is but one place where there seems to have been at any time any considerable disturbance in the roof. This is at a distance of about 200 feet from the shaft in the "main west entry," where, according to the sworn statement of the Superintendent, Mr. Sweeney, a fall of roof occurred soon after the entry was driven, which formed an arched opening 25 feet along the top of the entry, 12 feet wide, and 15 to 18 feet high. This was timbered with "legs" and "crowns," lagged with "props" and the space above filled with the shale rock which had fallen out. Gas seemed to accumulate slowly in the open spaces about the timber in this place, and on two occasions considerable volumes of gas were fired by the lights attached to the miners' hats, not sufficient to cause any general explosion, but enough to burn any one passing beneath at the time. According to the sworn statement of Mr. Sweeney, the following precautions were taken to protect the men: "A curtain was hung at the extreme west end of the timbered space containing gas and one foot below the timbers, so that the suction of the air passing up close to the timbers would mix it with the gas, making it harmless, and carrying it off." The men were required to put out their lights when passing this place, and a boy was stationed there with a safety lamp to light them past. According to the sworn statement of W. W. Young, one of the miners working in No. 6, "there was strict orders not to pass under the timbers in said mine on west without safety lamp. A

man was stationed under the timbers on the west with safety lamp to conduct men through, and two men at firing time."

Mine No. 6 is a remarkably dry and dusty mine. There is but one place (on the east side) where water appears outside the shaft, and there only in small amount. The water in the shaft enters some distance above the workings, and the quantity is very small. According to the Superintendent's (Mr. Sweeney) statement, "the water accumulating in No. 6 in sixty hours was pumped out by a 6½ Knowles pump in forty minutes." This would indicate only about one gallon per minute for the whole mine.

The coal seam worked in No. 6 lies in gentle swells or rolls, and ranges from 4 feet to 8 feet in thickness, with a general average of about 5 feet. It carries no persistent clay parting at any horizon, though partings of limited extent are generally present in some portion of the seam. The coal is a medium soft bituminous coal, with well-marked cleat or vertical joints. There is but little evidence of disturbance or alteration of any kind in the coal seam or the enclosing formation. An occasional fault or slip of a few inches may be observed, such as occurs in nearly all bituminous coal seams, and at the east end of the mine the dip of the seam is rather strong for a hundred feet or so. There is nothing, however, in the character of the coal or in its position to suggest conditions favorable for the development of serious quantities of gas. A careful examination of all points of the mine at the time of my visit failed to show more gas than is to be found in most of the coal mines in the Mississippi Valley. In cavities formed in the coal breasts where shots had been fired, and in corners and hollows of the roof, out of reach of the ventilating current, the presence of small quantities of gas was frequently detected when the naked lamp flame was applied, to such an extent, in some cases, as to cause a faint glimmering flash, reaching several feet from the lamp flame. In some of the rooms and entries to where the last work was done, the faint singing sound telling of the escape of

gas under pressure from minute cracks and openings in the comparatively fresh coal breasts, was frequently heard. These are, however, phenomena to be observed in almost any bituminous coal mine, and they only prove the development in the open workings of small quantities of gas, such as are easily controlled by the simplest and most commonly applied systems of ventilation. A careful test with a safety lamp of many of the old workings and high places where gas would be likely to accumulate, showed in all cases but comparatively small and harmless volumes of gas. Nor is there any evidence from the testimony of the Superintendent or any of the men employed in this mine, that there has ever been at any time any sudden or unexpected development of dangerous quantities of gas, such as could not be readily disposed of by the means of ventilation provided, if reasonably applied.

The men working in the mine, as well as the pit boss and Superintendent, testify that the air was at all times good in Mine No. 6, and that it was so on the day of disaster, March 29th.

Mr. Sweeney, Superintendent, under oath testifies: "To secure the safety of the men in No. 6 I required a night watchman to inspect every part of the mine with a safety lamp before 6 o'clock in the morning, and report to the pit boss condition of mine. Then the pit boss was required to examine with a safety light before any men were allowed to enter the mine. This report was made to me every morning at 7 o'clock by telephone. I got usual report on morning of March 29th, 1888, that the mine was all right and free from gas. I was at the mine that day from 9 a. m. till 11 a. m., and pit boss again reported mine free from gas and in good shape."

John Cooper under oath testifies: "I am night watchman, to see that nothing is wrong and to prevent men from going down if anything was wrong. The air was good on the morning of explosion. There was a small portion of gas in the south entry on the east side; you could scarce observe it, and none anywhere else."

Marion Hobbs, the engineer at Mine No. 6, under oath testifies: "The fan was not stopped at any time on day of explosion. I have orders to allow no man to go down when fan is stopped. On day of explosion was running fan at regular speed."

At the time of my visit (April 13th) the fan was making 95 to 100 revolutions per minute. I made several measurements of the air with a standard anemometer in the main east and west entries near the shaft, and found an average of 18,645 cubic feet a minute. This amount of air, though at least 30 per cent. less than that supplied on the day of the explosion, according to the statements of the Superintendent and engineer, was quite sufficient to give good ventilation to all parts of the mine, and was fully within the requirements of the law, which calls for "100 cubic feet of air per man per minute, measured at the foot of the down-cast." The number of men employed in the mine at the time of the accident was 82, making the minimum volume of air required 8,200 cubic feet per minute, or less than half that furnished.

A careful examination of Mine No. 6, then, shows that it is provided with a good system of ventilation, of ample capacity for much more extensive workings than at present developed, and the testimony of the men employed in the mine, as well as those in charge of its operations proves that the ventilating system was in good condition on the day of the explosion, and supplying an abundance of good air; that there has never been any serious quantity of gas developed in the mine at any time, and that on the day of the explosion there was no more gas than usual. It will be necessary, therefore, to look for other facts and conditions to explain the cause of the disaster of March 29, 1888.

The practice followed in Mine No. 6 in "getting the coal," though similar to that in other mines of the district, differs greatly in some respects from that usually employed in all other bituminous coal mining districts. The usual practice of "undercutting," "kirving" or undermining the coal by cutting out the lower part

of the seam, or the under clay, with picks or coal cutting machines and then wedging or blowing down with powder the overhanging mass of coal, seems to be unknown in Mine No. 6. Even the side cutting or "shearing" in narrow work, such as headings and advance breasts in rooms, to free the coal before being blown down, seems to be but rarely applied. The coal is got at this mine entirely by "blasting in the solid," that is, boring blast holes perpendicularly in the face of the solid coal, with little or no angling, charging them heavily with powder, tamping hard with fine coal, and blasting without regard to consequences.

The evils resulting from this system of "getting the coal" are many and great, and there is nothing to recommend it to any one, except the miners, who are thereby saved the labor of undercutting and shearing the coal. The excessively heavy shots employed with such a brutal system of blasting coal, are productive of a large proportion of fine and waste coal, the consumption of an unnecessarily large amount of powder, besides endangering the lives of the men and the property of the company.

In all parts of the mine, the evidences of this pernicious system of "blasting in the solid" were apparent at the time of my examination, and particularly in the heading of second north entry, where the last shots were fired at the time of the explosion. In this place the entry is 12 feet wide, and the marks of the last three shots fired are plainly visible. The left and center holes were 6 feet and that on the right 5 feet deep. The two side holes were perpendicular to the face, as proved by the marks in the side walls, and the center hole not over 5 degrees from the perpendicular, as shown by 2 feet of the bottom of the hole left in the face of the coal. According to testimony taken, such holes were loaded with from 2 to 3½ feet of powder, and the holes being 2½ inches in diameter, this would be equivalent to from 4 to 6 pounds of powder to each hole. The shots were fired at the same time, and the effect of three heavily charged holes like these fired at one

time from the end of a long 12-foot wide entry, would undoubtedly be such as to justify the terms "cyclone" or "windy" shots, which the miners in No. 6 are wont to apply occasionally.

Mr. Sweeney, the Superintendent, in his sworn testimony makes the following statement concerning such shots: "There are two causes for what miners call "windy" or "cyclone" shots: one is too much powder, with too small a grip in the coal; the other kind is bored straight into the solid, with too heavy a grip. The first don't have resistance enough to expend the power of the powder—the powder blows out in a blaze. The second kind has too much resistance, blows tamping out, and all comes out in a flame. I have seen windy shots blow my hat off 200 feet away from the shot, and flame 50 feet. Have seen boxes 500 feet from the shot blown into the sump, and seen empty powder kegs fly down the entry like leaves. I have used every means known to me under existing laws of this State to compel miners to use the proper amount of powder. I have a rule that any miner causing a "windy" shot is to be at once discharged, and have discharged miners for doing so, but it is almost impossible to get one miner to tell on another in such cases. We have had over a dozen men in the last four years burned with "windy" shots at No. 5, and several at No. 6."

William Taylor, one of the miners working at No. 6 at the time of the explosion, states under oath: "I use 3½ feet of powder in a shot of 5 or 6 feet of coal. 'Windy' shots are caused by heavy overcharges of powder or hole drilled too deep. Have seen 'windy' shots fire an entry with flame that would travel 40 or 50 yards. Have known men to be burned by fire from windy shots. Remember a "windy" shot at No. 6."

The effect of the three heavy shots in the heading of second north entry (west) were very plainly visible at the time of my examination. Fragments of coal were to be seen scattered down the entry a hundred feet or more, and at a distance of 84 feet from the

place where the shots were fired was a mass of coal found by trial to weigh 195 pounds. A new 25-pound powder can was found far down the entry, bearing strong evidence of having been exploded.

There would seem to be little doubt, therefore, that of the three shots fired in heading at second north entry (west) one at least was a "cyclone" or "windy" shot, and it is not improbable, judging from the way in which these holes were placed and charged, that all three shots were such as to justify the application of these terms. In this connection it is important to note that Elijah Wilson, a miner working in the second south entry, testified under oath that at about 11:15 on the morning of the explosion he sat in second north entry talking with John Gray, who worked at heading of latter entry, and that Gray said he was "going to blow hell out of it."

It is customary in Mine No. 6 to fire all shots, either before noon, beginning at 11:45 a. m. or just before closing time in the evening, starting at 5:45 p. m. The firing begins at the working places on the return air course, nearest the shaft on the west side, and goes in order through the entries and rooms on the south side, thence along the rooms on the west to the north entries, and then through the rooms east of the first north entry. The firing is then taken up in the workings on the east side nearest to the shaft, and followed in the same regular order. In this way the men are able to fire their shots, and come out to the bottom of the shaft without running any risk or interfering with one another, and as the firing is in reverse order to the direction of the air current, the powder smoke and foul gases are retired to the up-cast without getting near the men. It is usual also for the men who have shots to fire to wait in the entry at the entrance of their rooms to receive notice of their turn to fire from the men passing out.

The places where shots were fired on the morning of the disaster, March 29, 1888, and the order in which they were fired, is

indicated by the numbers 1, 2, 3, etc., on the drawings accompanying this report. It will be seen that shots were fired at eighteen places previous to the explosion, and that the last shots fired were the three already referred to at the heading of the second north entry (west).

Two distinct and fatal explosions occurred on the day specified, one on the west side, a few minutes before noon, resulting in the death of thirteen men, whose bodies were found between C and D, [see drawing] and the other on the east side some 40 or 50 minutes later. The second explosion was unquestionably induced by circumstances brought about by the first explosion, and the immediate cause of the latter must be charged to the three shots fired in the heading of the second north entry. The effect of these heavy shots fired nearly at the same time from the end of a 12-foot wide entry filling the air with fine coal dust produced by the blasts and with that which had accumulated on the floors and sides of the entry and mixed with only a small amount of gas would be such as to cause an explosion capable of producing all the results observed in the case.

During the past ten or twelve years large contributions have been made to our knowledge of the influence of coal dust in colliery explosions through experiments and investigations carried on by government commissions, engineering societies and individuals, especially in Great Britain, France and Prussia. The conclusions arrived at, and apparently now pretty well established, may, so far as they affect the case under consideration, be briefly stated as follows:

1. With the best means at our command at present for testing the presence of fire-damp in the air of a mine, nothing less than two per cent can be detected, and with the ordinary safety lamp, in the hands of the usual observers, three per cent would be the general limit. A mine, therefore, reported after trial to be free from gas, may have up to at least two per cent of fire-damp.

2. A mixture of coal dust and air is inflammable if it contains one per cent of fire-damp. In other words, a mine whose air is charged with coal dust, is liable to have an explosion although, after a careful test has been made, the mine is reported "free from gas." The dust-charged air is sufficiently sensitive to explode when there is an amount of fire-damp present less than can be detected by the carefully adjusted flame of a safety lamp.

3. Coal dust, as found in collieries, differs in degree of inflammability, dependent mainly upon the amount of conbustible volatile matter the coal dust contains.

4. Dust which is perfectly non-conbustible, provided it be very fine and porous, will determine the instantaneous ignition of a mixture of gas and air bordering in composition upon that which will just ignite upon the approach of flame, but which would not ignite in the absence of dust.

5. In the absence of fire-damp air charged with coal dust is capable of transmitting flame and producing results similar to a gas explosion. The comparative suddeness of the gas explosion produces greater destruction and less burning effects than the comparatively gradual explosion or rapid burning of a mixture of coal dust and air, or of such a mixture in the presence of a small proportion of fire-damp.

In this connection, I may quote the words of Sir Frederick Abel, the distinguished Chemist of the British War Department, who may justly be considered as a leading authority on this subject :

"Now, although the existence of gas to that (2 per cent.) or even to a decidedly larger amount in the air of mines, which is free from dust, or in a locality where no dust can be raised and suspended in the air by a disturbance of any kind, involves no danger, the presence of a very inflammable dust, even only in small quantities, in air containing such a proportion of fire-damp, or a less inflam-

mable dust thickly suspended in the slightly contaminated atmosphere, will render the mixture of air, gas and dust susceptible of explosion by the flame from a 'blown-out' shot. The reciprocal influence of coal dust and of fire-damp in bringing about explosive effects under conditions, as regards the proportions in which they exist in air when *either* would be harmless if the air contained *it* alone, is not only interesting, but constitutes the chief element of danger of dust in a mine.

"In carrying on shot firing, the concussion and blast produced by the shot, and the breaking up of coal by it give rise to a considerable amount of dust, independently of any that may pre-exist in close proximity to the shot hole. In order, therefore, to guard against the addition to possible danger in consequence of the raising of dust, in places where a number of shots are to be fired at one time in proximity to each other, it is either necessary to fire such shots simultaneously or to allow a sufficient interval between the firing of the individual shots to give time for the dust, raised by the effects of the explosion, to subside or to be carried away by the ventilating current.

"The only possible way other than the removal of dust and application of water, by which the dangers arising from the getting of hard coal or the removal of stone in the vicinity of coal in the presence of coal dust and fire-damp, can be avoided, would be, as pointed out by the Royal Commission on Accidents in Mines; the discovery of thoroughly reliable means for preventing the possible occurrence of 'blown-out' shots; the adoption of particular explosive agents or of particular methods of using such agents, which will deprive a blown-out shot of its danger by guarding against the possibility of a projection of flame, or of a highly heated solid matter by the shot; or, lastly, the substitution, for explosive agents, of some similarly efficient method of bringing down coal and stone which is free from the special dangers attending the use of such agents.

"Formidable danger frequently attends the employment of blasting powder in coal mines, on account of the flame which generally attends, though to a very variable extent, the firing of a shot tamped in the usual manner; and especially on account of the larger volume of flame which is projected to a considerable distance, either when a blast hole is overcharged or when the preponderating strength of the material operated upon gives rise to what is termed a 'blown-out shot,' the tamping being projected from the hole like a shot from a gun."

Sir Warington Smyth, the well-known English authority on mining, in the discussion of Sir Frederick Abel's paper says: "With regard to 'blown-out' shots, there can be no doubt that they have been the origin of a great many accidents of late years. Why should these shots be blown out? It arises from mistakes in charging or in applying them, or in not sufficiently cutting away the ground below or at the side, to take fair advantage of the direction in which the shot was likely to blow. Such accidents are far less frequent in metalliferous mines. Why should that be the case? I believe it is simply because the men, instead of putting in a charge at right angles to the face of the work, are accustomed to weigh carefully every place in which they have to put a hole. They consider the physics of the subject, the direction of the joints, the surface of the face and the nature of the material, and then they put in the shot to correspond with these joints, taking care, by means of a little heavy pick work, to break away the rock in such a direction as to be able to take advantage of the line of least resistance."

In order to obtain some knowledge of the combustibles involved in the case under consideration, I have had analyses made in the laboratory of the St. Louis Sampling and Testing Works, of the average samples of the lump, nut and pea coal produced in Mine No. 6, also of the dust taken from the floor of the entry in which the three heavy shots were fired previous to the explosion.

Analyses were made of the dust as taken from the floor, and of that portion of it passing a 40-mesh screen. The proportion of the latter to the whole sample was 23½ per cent.

	Lump.	Nut.	Pea.	Average Dust.	Screenings through 40-Mesh Screen.
Moisture	5.05	5.16	4.50	6.00	6.40
Volatile matter . . .	34.40	35.48	34.95	33.08	31.44
Fixed Carbon . . .	44.50	37.24	36.57	34.67	30.75
Ash	16.05	22.12	23.98	26.25	31.41
	100.00	100.00	100.00	100.00	100.00

It will be seen from these analyses, that the proportion of volatile matter even in the lump coal is quite large, while the small coal, and especially the fine dust which is especially concerned in the explosion has a larger amount of volatile matter than of fixed carbon, forming nearly one-third of the weight of the whole material notwithstanding the large increase in the proportion of the incombustible mineral matter or ash. Indeed such results are to be expected from the nature of the coal. The bright pitch-like layers of the coal are richer in volatile hydro-carbons than the dull black layers alternating with these, and are at the same time much more brittle and likely to yield a larger amount fine powder when roughly handled.

The three heavily charged shots in the back or second north entry (west) though fired at the same time are not likely to have been discharged simultaneously since they were fired with tape-fuse or squibs and not with a battery. Any perceptible interval of time between the discharges would result in the charging of the air in the heading at each shot with the fine dry coal dust of the inflammable nature shown in the above analyses. Not only this, but as each shot was discharged at the end of a long narrow entry a partial vacuum would be produced by the rush of gases and this

would cause a larger quantity of gas to be drawn from the minute cracks and openings in the coal faces.

From the facts before us it is evident that any one or all of the three shots may have been "cyclone" or "blown-out" shots. The middle one, however, was undoubtedly of this class, as shown by the two feet in the bottom of the hole left unbroken, the latter condition being probably due to the weakening of the "collar" of the hole by the previous discharge of the other two shots. By the successive discharges then of the two side holes a somewhat increased quantity of gas would be drawn into the entry, and the air far down the entry would become heavily charged with coal dust produced by the crushing effect of the heavily charged shots, and the powdered coal used for tamping as well as the dust stirred up from the floor. The long sheet of flame attending the subsequent discharge of the middle "blown-out" shot would readily ignite the sensitive mixture and produce the explosive effect which caused the death of the men at C and D [see drawing].

The ventilating system having been deranged by this explosion, such gas as the east side of the mine naturally produced, increased by such as might be forced into the open entries by the concussion of the first explosion or the few shots that were fired subsequently on the east side, as well as unburned gas developed from the heated coal dust in the first explosion would be likely to accumulate in the workings. The firing of this explosive mixture near the main east entry and not far from the shaft, by the naked lights of the men waiting for the hoisting shaft to be put in order was undoubtedly the cause of the second explosion.

Sir Frederick Abel referring to secondary explosions says: "Secondary or back explosions in mine-ways, of which the existence of distinct indications has been observed by Galloway in his careful examination of the effects produced by some disastrous explosions in mines where coal dust had evidently played an important part, have been noticed in the course of the experiments of the

Prussian Commission, and were also observed by the author in some of his coal dust experiments; they appear to be due either to gaseous combustible matter which has been developed from the highly heated coal dust remaining unburned, or to gaseous products generated from them immediately after the first explosion; in either case, an explosive mixture would be formed at once upon the inrush of air, and would be fired by either incandescent or burning matter."

The rumor has been prevalent in the neighborhood of Rich Hill that the old shut-off workings near the shaft, and north of the west entry, closed by the stoppings shown at B B on the drawing, were in some way connected with the cause of the explosion. The testimony of Messrs. Mackie and Sweeney taken at the time of my examination of the mine, effectually disposes of this, and a careful personal examination convinced me of the impossibility of there being any such connection.

In view of the facts and considerations above presented, I am clearly of the opinion, that the disaster at Mine No. 6, Rich Hill, Mo., on the 29th of March, 1888, was due to the discharge at one time of three heavily charged and badly placed holes in the face of the back or second north entry (west) producing an explosion in the manner above described, the effect of which was to derange and render ineffective the system of ventilation, and this resulted in the accumulation of gas, which was ignited by the naked lights, causing a second explosion in the way already described. I am of the opinion also that if any one of the three shots had been fired at one time, or if the three had been fired with a sufficient interval to permit of the clearing of the atmosphere after each shot, no explosion could have taken place; also that it could not have taken place if a proper amount of cutting had been done to free the coal, and the holes had been suitably placed and charged, no matter how many shots may have been fired at one time.

That there is an unnecessary waste of powder at Mine No. 6 is apparent from the following figures taken from the books of the company, During the month of March, up to noon of the 29th inst., the time of the explosion, 6,340½ tons of coal were mined by 310 miners, working a total of 1,193 days, with expenditure of 337 kegs (25 pounds each) of powder. This is equivalent to an average of 18.81 tons of coal per keg of powder, 5.31 tons per day per man, and over 7 pounds of powder per man per day. From the Mine Inspector's report, recently published, it appears that the output of coal during the year for Mines Nos. 5 and 6 was 200,000 tons, in mining which 11,000 kegs of powder were used. This gives an average of but little over 18 tons of coal per keg of powder. In comparison, it may be stated that the Mine Inspector reports that the total production of coal for Missouri, for the year ending October 31st, was 2,865,996 tons, and that the total amount of powder used in mining this was 34,900 kegs, giving an average for the whole State of 82.12 tons of coal per keg of powder.

In the State of Illinois, 7,320,240 tons of coal were mined during the year 1886, with a consumption of 122,821 kegs of powder, or 59.6 tons of coal per keg. In St. Clair County, Ill., where so large a proportion of the coal mined in Illinois is produced, 194.3 tons were mined per keg of powder, or more than ten times as much coal as at Mine No. 6, Rich Hill. The seam averages about 6 feet in St. Clair County, while that in No. 6 averages 5 feet in thickness. In other respects the coal is no harder to mine at the latter place. The difference in the amount of powder used is due almost entirely to the fact that in the St. Clair County mines the coal is undercut and sheared, and only moderate blasts are required to bring it down.

Surely no argument is needed to prove the increased risk to the miners working underground due to such an unnecessary and wasteful burning of powder in getting the coal, and none should be needed to show the importance of immediate action to secure an

abatement of this evil. The present law provides many means of safety for the men working in the coal mines, but it is not too much to say that these are all of little or no importance compared with provisions for restricting the brutal system of "blasting in the solid" as practiced in Mine No. 6 at Rich Hill, Mo., and probably other mines in the district. Messrs. Mackie and Sweeney, Superintendents of the Keith & Perry Coal Company, seem to be alive to the risk incurred by this system of getting coal, and as shown in Mr. Sweeney's testimony already quoted, attempts have been made to restrain the men but, as appears, entirely without success.

In view of these considerations, I would recommend that at as early a date as practicable the present State Mining Law be amended in such a way as to make it a misdemeanor, punishable by fine or imprisonment to blast out the coal in headings and narrow work without undercutting or side cutting; to place and fire blast-holes set in the solid coal at an angle over 70 degrees with the face in cases where there is but one free face to the mass of coal, or to light and fire more than one blast at a time in any heading less than 15 feet wide, unless fired simultaneously by electricity. Such provisions would make "blown-out" or "cyclone" shots of rare occurrence, and remove almost entirely the danger due to the presence of coal dust in case they did occur.

An amendment should also be introduced, providing for the appointment of at least two assistant mine inspectors. With so many important mining operations scattered over so large a territory as in this State, it is quite improbable that any thorough or useful inspection can be secured with a smaller force.

There is one provision of the present law which appears very unfavorable, and should in my judgment be carefully reconsidered. It is that requiring that all the coal shall be weighed and accounted for to the men before screening. The result of this is that the miners are only interested in securing large weights and not

in the proportion of "round" or lump coal. They are, therefore, led to obtain the coal in the easiest and quickest way, irrespective of condition, and that is by blasting out the coal from the solid without cutting it. It would be a wiser measure as regards safety and economy to allow payment only for marketable grades produced after screening, and in such ratio as would make it to the interest of the men to produce as little small coal as possible.

In conclusion, I would say, that after a careful examination of Mine No. 6 and consideration of all the evidence in the case, I find nothing calling for censure of the Keith & Perry Coal Company, or its officers, or the State Mine Inspector. The mine is well equipped with the proper machinery and appliances for the safe working of the property, and these were undoubtedly in good working order at the time of the disaster; and furthermore all the precautions provided by the present Mining Law of this State seem to have been fully complied with. The disaster was in my judgment due to criminal carelessness on the part of the miners and a persistent use on their part of methods of getting the coal which can not be too severely condemned, and which from the evidence submitted, seem to have been contrary to the rules and regulations of the officers of the company.

Respectfully submitted,

WILLIAM B. POTTER,
Mining Engineer.

Partial list of victims of the Rich Hill, Missouri Disaster
Taken from newspaper accounts
March 29, 1888

CHARLES SMITH, colored;
GEORGE MAY, white;
G. McPHERSON, white;
FRANK LAWLER, white;
JORDAN SMITH, colored;
JOSHUA TRUMBE, white;
JOHN ROBERTS, white;
GEORGE BLOCK, colored;
G. BLACK, colored;
W. Black, colored;
H. SHEPPARD, colored;
J. C. NEPTUNE, white;
JOHN LEFFLER, white;
CHARLES KAY, white;
JOHN GRAY, white;
BRUCE BROWN, white;
L. R. DIXON, white;
FRED HENDERSON, colored;
W. H. HILL, colored;
ALEX WHITE, colored;
GIBSON McFERRON, white.