

considerable and often a constant motive column is obtained from the waterfall. The motive column in artificial ventilation is produced in three distinct ways:

First, by rarefaction in furnace ventilation, when it may be said that a difference in pressure is the result of a difference in weight in the ventilation columns.

Second, by exhaustion, as in fan ventilation, when it may be said that a difference in pressure in the ventilating columns is the result of a difference in the total pressure in the downcast and upcast columns.

Third, by pressure fan ventilation, when it may be said that a difference in pressure in the ventilating columns is the result of blowing, or slightly compressing the downcast column to such a pressure above the return column as will supply the current pressure or force required.

To find the entire weight of air in the upcast shaft, first find the weight of one cubic foot and let the mean barometer read 30.4 inches, and the temperature 70° F.,

$$\text{then } \frac{1.3253}{(459 + 70)} \times 30.4 = \frac{1.3253 \times 30.4}{529} = 0.07616$$

nearly.

Let the diameter of the upcast shaft be 12 feet, and the depth 360 feet, then  $12 \times 12 \times 0.7854 \times 360 \times 0.07616 = 3100.864$  nearly; that is, the air in this case weighs 3100.864 pounds or about  $1\frac{1}{2}$  tons.

Ques. 12.—How would you lay out a system of room and pillar working, with a view to the recovery of the pillars under the various conditions of roof and bottom, the depth of strata and texture of coal seam?

Ans.—In a bituminous seam four feet thick, with a strong sandstone roof, and a thick, soft fire-clay bottom, room and pillar would certainly be the best mode of working. The rooms should not be more than 5 yards wide, and the headings not more than 3 yards wide, and if the depth of the strata is 640 feet, the side dimension may be found as follows: Extract the square root of twice the depth in feet for a soft bottom, when the square pillars should be  $\sqrt{2} \times 640 = 36$  yards side measure, or instead of being  $36 \times 36$ , the pillars could be  $40 \times 32$  yards. If the bottom and roof were both hard, and the seam strong, and of the same thickness and supporting the same depth of strata, then the dimension of the side of a square pillar should be  $\sqrt{640} = 25$  yards on the side, or if the pillar be oblong, it should be  $22 \times 30$  yards. Should the dimensions of the cover, thickness, etc., remain the same, and roof of the seam be found to be a broken soft shale, then the long wall mode of working would be preferable.

Ques. 13.—Show by a sketch the system of ventilation which in your opinion would produce the best distribution of air in a mine, so as to do away with air doors as far as possible, in order to secure the best sanitary results, and the most economical working of the mine.

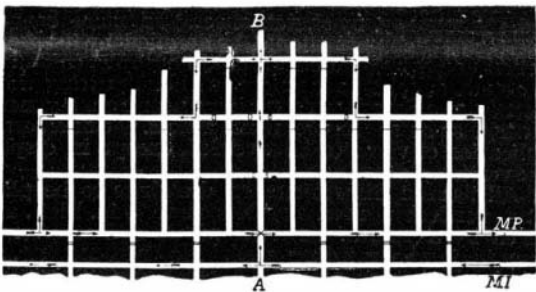


FIG. 4.

Ans.—The figure here given is a ventilated plan of room and pillar, and it will be seen that the ventilation is of the most advanced character for securing safety from accumulations of marsh gas, healthful good air for the workmen and economy in the ventilation of the mine. It will be seen that the main intake air current, MI, is split into the district as shown at A, when it is again split at the top of the panel as at B, and the main return airway from other districts is shown at MR.

Ques. 14.—What are the principal points to be kept in view in the construction of underground hauling roads, so as to insure an economical operation of a mine; and if it were necessary to have a ditch along the heading, on which side would you place this ditch?

Ans.—The principal points to be kept in view are: First, the road must be as straight as possible, and all elevations must be lowered and all depressions must be raised. Second, when curves are necessary on a rope haulage, the rail on the inside of the curve must be raised and the radius of the curve must be as large as possible. Third, the making-up and delivery stations should be sufficiently large to keep the hauling engines running full time. Fourth, the rails should be fish plated, and where the floor is wet and soft, stout battens should lie on the sleepers to support flat bottomed rails. The ditch should be on the low or rear side of the heading, out of the way of the junctions of the branch roads, and on ordinary haulage roads where curves occur, the ditch should in all cases be on the outside of the curve, otherwise the water overflows the road and loosens the sleepers, and causes the frequent derailing of the cars.

Ques. 15.—What is required by law to be kept at a mine to be used in case of accident, and what is the first duty of a mine foreman in case of a fatal or serious accident to an employe?

Ans.—The Act relating to the Bituminous Coal Mines of Pennsylvania provides, Article 18, Section 1: "It shall be the duty of operators or superintendents to keep at the mouth of the drift, shaft or slope, or at such other place about the mine as shall be designated, a stretcher properly constructed and a woolen and a waterproof blanket in good condition for use in carrying away any person who may be injured at the mine. Provided, that where more than two hundred persons are employed, two stretchers and two woolen and waterproof blankets shall be kept. And in mines generating fire damp a sufficient quantity of linseed or olive oil, bandages and linen, shall be kept in store at

the mines for use in emergencies, and bandages shall be kept at all mines."

The first duty of a mine foreman after a serious accident is to report the same to the inspector of the district, and if the case is fatal, to the coroner also of the county. Article 12, Sec. 1.

Ques. 16.—How would you set a prop in a mine under the following conditions?

- A. With a soft bottom and a hard top?
- B. With a hard bottom and a soft top?
- C. Where the seam is pitching at an angle of 10 degrees?
- D. How would you set the timber to support the roof and sides?

E. What are the smallest size props, in your opinion, that should be used in a coal mine and of what kind of wood?

Ans.—A. With a soft bottom and a hard top, the feet of the legs should be set on foot laggings or foot stringers running lengthwise with the road.

B. With a soft top and a hard bottom, if the top was very soft, I would set the heads of the legs under collars supporting cross laggings.

C. Where the seam is pitching at an angle of 10 degrees, the legs should be set at 90° with the roof and floor of the seam, or in this case 10 degrees out of plumb, or the heads of the legs should lean down the slope 10 degrees out of a vertical line.

D. The ends of the head tree or collar should be notched, and the feet of the legs set into the hard bottom stone. When, however, the top and sides are very soft, they should be secured with close lagging, and in bad cases the timber sets should be set nearly close.

E. The smallest size for mine timbers, that is the legs, should be 3 inches in diameter, and the sizes for thicker seams can be found as follows. Extract the square root of 9, multiplied by the thickness of the seam in feet, the result is the diameters in inches. Example, what should be the diameter of legs for a 6 foot seam,  $\sqrt{9} \times 6 = 7.3$ , practically  $7\frac{1}{2}$  inches.

The best kind of timber in use for mine legs, collars and lagging is hemlock.

Ques. 17.—Explain fully the principle of an exhaust fan, and also the principle of a force fan, in producing ventilation in a mine.

Ans.—The exhaust fan, as its name indicates, reduces the pressure of the air in the fan drift below that of the external air, its action being that of a centrifugal pump. The amount of exhaustion or approximate vacuum required is equal to the resistance of the ventilating current of the mine. The force fan is somewhat opposite in its mode of action to the exhaust fan, which inhales and exhales the mine air, whereas the force fan inhales and blows into the mine the fresh air. The pressure of the force fan must be equal to the friction of the ventilating current, and in this respect the two varieties of the mechanical ventilators are alike, but a high percentage of useful effect is lost, by the exhaust fan blowing out the return air at a pressure above the atmosphere, equal to the pressure below the atmosphere, in the fan passage.

Ques. 18.—If your ventilation were inefficient, and you could not increase the power, how would you increase the ventilation, and what are the inexplusive gases met with in coal mines?

Ans.—There is only one way open to increase the ventilation without increasing the power, and that is by reducing the resistance in the path of the air current.

The resistance can be reduced in two ways: First by reducing the rubbing surface per square foot of section, and second by reducing the velocity.

If the airways are made larger in section, the rubbing surface and the velocity are both reduced. Again, the velocity can be reduced by splitting the principal currents into two or more streams of air, when an increased ventilation can be obtained without increasing the ventilating power.

The inexplusive gases found in mines are carbonic acid gas and one of the gases in the air, namely, nitrogen. Oxygen is one of the principal agents in explosive mixtures.

GAS QUESTIONS.

Ques. 1.—Describe the structure of the safety lamp, and state upon what principle its safety depends. What lamps are condemned by law?

Ans.—The structure of the best safety lamps may be considered from five different points of view. First, the bottom or the body of the lamp, or the oil vessel in which is found the tube for supporting the wick, and in connection with which is the adjusting pricker to correct the light. Second, the frame and rods to support the glass and gauze cylinders, and to which are attached the tile and hand ring. Third, the glass cylinder to screen the flame from the outside air, and to allow for the free passage of light. Fourth, the gauze cylinder to prevent the outward passage of flame. Fifth, the bonnet, or metallic shield, or cover to prevent the passage of flame out of the lamp, by strong currents of wind.

The principle on which the safety of the safety lamp depends is the power of the gauze cylinder to prevent the passage of flame by chilling it. As flame is only white hot gas, and when the temperature of the gas falls below a white heat, it ceases to be flame, it therefore cannot ignite other inflammable gases. As flame can be passed at a high velocity through the meshes of wire gauze, such a high velocity is prevented by the use of the metallic shield. The Bituminous Mine Law, Article 5, Section 6 forbids the use of the common Davy lamp and Clanny lamps without shields, excepting by the mine officials for testing for gas.

Ques. 2.—What is the first duty of a fire boss on entering a mine?

Ans.—Bituminous Mine Act, Pennsylvania, Article 20, General Rule 9. Duties of fire boss. "He shall enter the mine before the men have entered it, and before proceeding to examine the same, he shall see that the air current is traveling in its proper course, and if all seems right, he shall proceed to examine the workings."

Ques. 3.—Describe the instruments that are most useful in aiding the fire boss, in determining the condition of the mine.

Ans.—The fire boss must have access to a barometer and a thermometer to inform his judgment, and he should carry with him an anemometer or wind meter, and by law a safety lamp.

Ques. 4.—What are the explosive gases found in coal mines? Describe their properties, composition, specific gravity; how and where are they produced in mines, and under what conditions do they become explosive?

Ans.—There are two explosive gases found in coal mines; namely, marsh gas and sulphureted hydrogen. Marsh gas has no color or smell, is very inflammable and very explosive when mixed with certain proportions of air, such as one of the gas mixed with nine and a half parts of air. Its composition is  $C_2H_4$ , or one volume of carbon combined with four volumes of hydrogen; and air having a weight of 1, marsh gas is 0.55; that is, it is little more than half the weight of air. Sulphureted hydrogen stinks and smells like rotten eggs; it has no color; it is very inflammable and explosive, and has a low point of ignition; its composition is  $H_2S$ , or two volumes of hydrogen combined with one of sulphur, its specific gravity is 1.179, air being taken at one, it is thus a little heavier than air.

The marsh gas is given off by the coal, being the result of slow chemical change; and sulphureted hydrogen is the result of the chemical action set up by acidulated water acting on the coal, and is therefore found most abundant in old workings flooded with water, or is given off by the water that is met with in the neighborhood of faults.

Large volumes of fire damp in holes in the roof or in goaves, when disturbed by mechanical action, such as a blow out or false shot, or by the expansion that takes place when the barometer falls, are common causes of this gas mixing with air and becoming explosive. Sulphureted hydrogen is more to be feared for its power to transmit flame, and thus to ignite explosive mixtures of fire damp.

Ques. 5.—How would you proceed to look for and detect explosive gases in mines?

Ans.—For detecting fire damp, after having reached a point in the workings where the gas may collect, I would lower the light of my safety lamp with the pricker, and then slowly raise the lamp with one hand and screen the light from my eyes with the other, to see the characteristic blue cap of fire damp on the flame, which can only be seen in a very subdued light. Sulphureted hydrogen can be detected in small quantities by its smell.

Ques. 6.—In what stage of mining operations does the greatest number of accidents occur from explosions of fire damp?

Ans.—In deep seams when the first headings and entries are driven into the coal on opening out new mines, much fire damp is met with, and explosions frequently occur. Old mines are subject to explosions, as the result of accumulations of fire damp in the goaves, so that explosions of fire damp characterize new and old mines, mines of middle age being less subject to accidents of that kind. The period of the day when explosions are most frequent depends on the practices of the district in relation to shot firing.

Ques. 7.—Should any workmen receive injuries from an explosion of gas, what would you do for them until the arrival of a physician?

Ans.—Besmear the burnt portions of their bodies with linseed oil and screen them from the air with linen bandages until the physician arrives.

Ques. 8.—How does the fall of the barometer affect the flow of gas from falls in the mines?

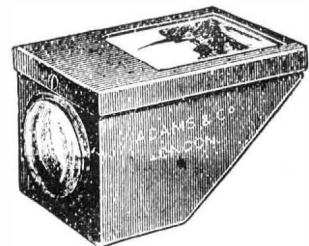
Ans.—Air in common with other gases expands and contracts in the order of the operation of Boyle and Mariotte's law, hence as the pressure of air reduces, the volume increases. The barometer, as its name indicates, is an instrument for measuring the weight or pressure of the atmosphere; consequently, as the barometer falls, the volume of the air and gas in the goaves, passages, broken roof, and fissures of the mine expands; and by this means we find the cause of gas or fire damp fouling the ventilating currents during the period of the falling of the barometer.

Ques. 9.—What are the lawful duties of a fire boss?

Ans.—The lawful duties of a fire boss are set forth in the Bituminous Coal Mines Act, Pennsylvania, Article 5, Sec. 2, as follows: "In all mines wherein explosive gas has been generated within the period of six months next preceding the passage of this act, and also in all mines where fire damp shall be generated, after the passage of this act, in sufficient quantities to be detected with the ordinary safety lamp, every working place without exception and all roadways shall be carefully examined immediately before each shift by a competent person or persons appointed by the superintendent and mine foreman for that purpose. The person or persons making such examination shall have received a fire boss' certificate of competency required by this act."

A DOUBLE REFRACTING FINDER.

NOT double refracting in the sense understood in the polarization of light, but rather a finder having two refracting lenses. This finder is different in its op-



A DOUBLE REFRACTING FINDER.

tical construction from any other. There is no ground glass about it. An image is formed by a convex lens, and this is directed at a right angle by a mirror, covered by another and somewhat powerful convex lens, which forms an eyepiece. The result of this arrangement gives a finder having an exceeding degree of luminosity. In fact, it need not be shaded from the direct beams of the sun at all. Some idea of its exterior may be had from the cut.—British Jour.