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Coal mine safety engineering

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I L L U S T R A T I O N S

C H A P T E R I

HISTORY OF COAL MINE SAFETY

The progress of coal mine safety may be compared to the development in mining through the years. When coal was first discovered centuries ago, it was taken from river or creek beds and from the outcroppings on the sides of hills. After removing the most accessible coal from the surface, it was necessary to mine the coal by quarrying or stripping the overburden from the coal seams. It is reasonable to assume that when such operations began, accidents of a serious nature also began to occur. Such accidents were no doubt due to rolling rocks or stones, falling material, and by falls of persons.

As the need for coal increased and the availability of coal near to the surface diminished, underground operations began, first by driving drifts into the coal seams and later by shafts. Simultaneously the hazards of mining increased. Accidents from falls of roof occurred because proper support was not afforded to the structure over the coal. It was natural that the miners in the early days did not have the advantage of education or experiences of the past to demonstrate what precautions should be observed, and consequently, accidents occurred due to ignorance of the hazards.

Mine floodings were not uncommon, together with falls of persons into shafts, accidents from hand tools, and vitiated air. Like all happenings of note, the history of mining records only the most noteworthy incidents. Much has been written in the past about the

legends of the evil spirits accountable for the loss of life in the underground workings. The legends related how the spirits would strangle the miners, making them sick, and in instances taking their lives. With such incidents unexplained, superstitions soon became quite prevalent about the evils of the miners.

Mines in the early days were very poorly ventilated, and in fact, no thought had been given to affording a means of circulating air through the underground workings; hence, many men were overcome, and some fatally, due to the vitiated condition of the mine atmospheres. At about the same time explosions of the atmosphere in the mines occurred, resulting in the burning of the miners and in some occasions damaging the property and causing the loss of life.

With such apparently supernatural occurrences, men of science such as chemists were called in to make a study of the conditions in the mines, and it was learned that different gases occurred such as carbon dioxide, carbon monoxide, and methane or in the miners' vocabulary, black damp, white damp, and fire damp, respectively.

Realizing that some means of air circulation was essential, it was discovered that a fire located in the bottom of the shaft would create sufficient movement of air to ventilate the mine. Mine explosions, however, continued to occur, and as a consequence, the first safety lamps were brought into existance. At the same

time it was learned that a definite plan for coal extraction would have to be followed to allow proper mine ventilation. The miners learned that from their candles gas would ignite in pockets or cavities in the roof where the gas had accumulated.

The first flame safety lamp was invented by Dr. Clanny of New Castle, England in 1815, but it was not practical for mine use. At about the same time Sir Humphrey Davy developed a lamp that was more practical, and upon this principle the present day Kohler and Wolf safety lamps are based. By utilizing the flame safety lamp, explosive gas could be detected and the hazard made known or eliminated by affording better ventilation. The general use of safety lamps for all men in the mines did not come into existance due, primarily, to the opposition to their use by the miners as has always been the case when any new device is created for the betterment of conditions or practices. The management of any mine where the flame safety lamp was used had to furnish the lamps, and usually these lamps were not utilized until after an explosion had occurred, demanding such use.

By public demand, because of so many violent deaths due to mine explosions, the Parliament of England initiated an investigation of the coal mine disasters, and based upon this investigation, laws were provided for the appointment of inspectors and inspections of mines. Naturally, a material reduction of mine explosions resulted.

The development of the coal seams in the United States was al-

so progressing in a manner similar to those in Great Britain, but due to the laxity on the part of the legislative bodies, little or no cognizance was given the need for legislation in the states to prevent the loss of life in the coal mines of this country. Consequently, mine disasters continued to occur, many from gas or dust explosions while others occurred from drownings or mine fires. During this same period the usual run of mine accidents involving only one or two men, continued to occur from falls of roof, face or sides, haulage, machinery, etc.

The development of newer methods of mining introduced additional hazards in the mines. Coal, instead of being mined by hand with picks, sledges, and wedges with the subsequent use of explosives, was mined by the use of mining machines, first by the compressed air puncher type and later with the chain type cutter. By using mining machines more rapid extraction of coal resulted, and consequently, more tonnage per individual was produced; yet, accidents occurred due to allowing greater areas of roof, unsupported, to manipulate the machines. Electrocutions occurred from the use of electricity, especially in wet mines. Occasionally men would be injured, sometimes fatally, by falling into the cutter chains on the machines.

Because of the more rapid extraction of coal, it was necessary to improve the system of haulage and, thus, electric and compressed air locomotives came into general use, both for gathering coal at the face and in hauling to the shaft or drift mouth. In

view of the flexibility of the electric locomotive, all other types were gradually supplanted. The use of mechanical haulages resulted in accidents due to individuals being run over by cars or motors, or being caught between cars or between cars and props or ribs, mashed hands during coupling of cars, run-a-way cars, and collisions between haulage motors as well as electrocutions from trolley wires.

Because of the fact that accidents in mines from the usual causes of roof falls, haulage, explosives, hand tools, handling of materials, and others were taken for granted, very little effort was directed toward improving the working conditions or practices governing the safety of the mines or miners; consequently, accidents continued to occur.

It was not until after the turn of the twentieth century when, due to the frequency of mine disasters* throughout the United States, did legislatures of states and members of the congress demand that efforts be made to arrive at the cause and prevention of such disasters. The various coal producing states established laws pertaining to mining, and the congress of the United States enacted, in 1910, laws establishing the Bureau of Mines to investigate the health and safety of the men engaged in the mineral industries.

The Bureau of Mines at the present time is considered the authority on coal mine and metal mine safety throughout the nation. Investigations of coal mine disasters and other mine accidents are made by the Bureau of Mines engineers to determine the causes. Recommendations are made for the purpose of eliminating recurrence of

*See Table I

such accidents so that the efficiency of the mine may be improved.

A number of safety educational programs have been developed. The various courses of training given are first aid to the injured, mine rescue, advanced mine rescue, and recovery operations, together with the accident prevention course.

An experimental mine is maintained at Bruceton, near Pittsburgh, Pennsylvania where experiments on explosives, rock dusting, mine gases, and other features of mine safety measures are tested and approved for safety of the mining industry. A laboratory is located in the experimental station at Pittsburgh where various mining equipment are inspected for safety features, principally for permissibility for use in coal mines. Many devices for respiratory protection for the coal mining industry and other industries, as well, are tested for approval in the laboratory. Gas, air, and dust samples are analyzed and the information utilized by the industry to understand the conditions prevalent in the mines.

Much credit must be given to the work of the United States Bureau of Mines engineers in the early days of its existance in assisting in mine rescue activities at mine fires and explosions. A number of the men lost their own lives in helping to rescue others or during the restoration of order to a mining property. In recent years the studies concerning dust conditions which effect the health hazard of miners has engaged considerable time and effort.

C H A P T E R II

ENGINEERING

One phase of coal mine safety is that of engineering, and it deals with surveys of mines, investigations of accidents, and the design or planning of coal mine operations. There are many features connected with the engineering aspect effecting coal mine safety.

The fact that the coal mining industry has been in existance for hundreds of years and the concerted efforts concerning safety are of recent thought and expression necessarily demands that the efforts in engineering must deal with existing operations and practices. It is with this thought in mind that the subject will be discussed.

The history of the mine and the district in which the mine is located is quite often important in determining what may be expected, especially so from coal mine explosions, fires, or from water. If explosions have occurred in a mine, it may have been due to several sources. The geological structure may be such that considerable quantities of methane gas are liberated and if allowed to accumulate, may be ignited. The coal seam may be dry and dusty, and for this reason, dust explosions had occurred from blown out shots or by ignitions of small quantities of methane gas which propogated the dust so that the dust was ignited, resulting in destruction to the property and loss of life. In some areas mines have been worked out and because of the water bearing formations

or flooding from the surface, were filled with water. If mining coal adjacent to such flooded mines, adequate protection should be observed and considered at all times.

Surface Operations--The surface plant and equipment of mines vary according to the type of operation. Some are of the most crude type and they may offer very few hazards, yet in the modern up-to-date operations where thousands of tons of coal are prepared daily, many hazards exist. Fire protection in the form of suitable fire extinguishers of soda acid, carbon tetrachloride, or other types should be available at strategic locations in the event of fire to buildings or equipment. Water systems are usually available at most mines for use in fighting fires.

Electrical installations should be made in accordance with the accepted code for the state or locality in which the mine is located. Too often changes are made in the average electrical installation and safety features of the original installations are destroyed. Wires are not properly strung on insulators, switches are of the open knife type, extension cords are allowed to become badly worn and shorted, electrical equipment improperly grounded, and motors of insufficient size or capacity allowed to operate at an overload. Quite often fuses are displaced with ordinary wire. Switch boards are not properly protected to prevent unauthorized persons having access to them, and properly insulated mats are not used in front of switch boards.

In preparation plants there are quantities of dust produced

by the handling or movement of coal. There should be careful consideration given to the elimination of dust by installing dust collecting systems at the source of dust production. If the plant is not large enough to justify elaborate dust collecting units, wetting the coal with water spray at dumping point will reduce materially the production of dust. Frequent and regular cleaning of the plant will remove accumulations of dust. It is important that the dust problem in preparation plants be considered since explosions have occurred due to dust accumulations being propagated and ignited.

Stairways should be erected to allow access to various parts of structures. They should be equipped with hand rails and properly illuminated.

Moving machinery having exposed belt drives or gears must be properly protected to keep men from being caught and injured. This is particularly true in the new preparation plants where there is usually a great amount of machinery and greater numbers of men employed.

Accidents in manipulating railroad cars through the preparation plant and in the yards account for serious surface plant losses. Car retarding devices should be utilized wherever possible, and where not available, properly constructed blocks to fit the rail and car wheel should be used. Many men have been injured in attempting to ride run-a-way cars in hope of trying to brake them with defective braking mechanisms. It is far better to get

away from run-a-way cars and let them travel until they come to a stop by hitting other cars or by derailing.

The disposal of refuse about some mines presents quite a problem, especially so if longwall mining is utilized. When the refuse is disposed of on the surface, the weathering of the refuse results in firing of the dump and many times the intake air of the mine draws the smoke from the pile and circulates the smoke through the mine, thus contaminating the air. After refuse piles or dumps have been allowed to burn for a number of years, a distinct hazard exists to individuals, usually children or persons engaged in recovering pieces of coal, by their falling through the crust of the dump into the fire below. The premises of mining companies should be posted prohibiting trespassing and recovering of coal from waste disposal dumps.

Hoisting equipment about a mine should be properly designed to take care of the requirements placed upon it by the tonnage produced. There are still many steam units in use at mines, yet many units now in use are powered by electricity. In many of the small operations, the gasoline automobile engine has been converted for use in hoisting both in shafts and slopes.

At the large modern mines using either steam or electricity, overwind and speed control devices are in use to govern the overhoisting or speed of hoisting to prevent accidents from this source. Physical examinations of the hoisting engineers should be the rule, yet, there are very few coal companies following this practice.

Regular daily inspections of hoisting equipment is practiced at larger and more modern properties, still, little or no thought is given such equipment at small mines. This accounts for the failure of hoisting equipment in the smaller mines whereas such failures seldom occur at well managed properties.

Cages in the modern operations are self-dumping types, and in some instances skips are used, especially in the larger mines. The small mines, employing ten or fifteen men, very seldom have anything except fixed bottoms on cages necessitating removing cars at tipple landing for dumping. Covers should be installed on all cages and equipped with bars or chains across ends and hand-holds. A lining or rail and toe board should be installed on guide sides to prevent men slipping and falling off cages. It is also worth while to have the open ends of cages protected with suitable gates to make hoisting or lowering of men safer.

All cages should be equipped with safety catches as the majority are, but the design on so many catches make them almost useless. Most catches are designed to grip into the guides by pressing against the guides when the tension on the hoisting rope is released. This action does not give sufficient braking effect to stop the ordinary loaded cage. The type of safety catch that should be utilized is similar to the ones used on elevators. This type is actuated by the release of the tension on the hoisting rope allowing two notched eccentric cams on each upper guide shoe to rotate toward the guide and apply the braking action, allowing the

thrust on the guides to be parallel to the guide rather than perpendicular as in the other type. Drop tests should be made at frequent intervals on days when the mine is idle to determine if catches function properly. This is seldom, if ever, practiced. Cages, guides, and shaft lining should be inspected regularly and at least weekly.

All shafts should be fully enclosed to a height of at least six feet at all landings, and suitable gates installed. Care should be exercised when hoisting or lowering men and the cagers should have complete charge. Adequate signal systems should be utilized with code of signals posted at all locations where signals are given or received. At no time should materials or tools be carried on a cage with men. Hoisting speeds for men should be reasonable so that the engineer will have the hoist and cage under control at all times. If steam plants are utilized, the safety codes for such installations should be followed.

In most mines of any size the fan and fan house are located in proximity to the hoisting shaft at an auxiliary shaft which may be known as the air shaft or escapement shaft. The fan selected for ventilation of the mine may be one that will operate exhausting or blowing. In the newer fan installations the airplane propeller type is now used to develop greater velocities and quantities of air. All fan houses should be equipped with explosion doors or weak walls so that in the event there is a disturbance in the ventilating circuit due to a huge fall or

because of an explosion, the fan, itself, will not be destroyed, and the pressure exerted by the unusual condition will open the explosion doors or break the weak walls. A signal device should be maintained on the fan to enable the engineer or others whose duty it is to watch the operations of the fan to know that the fan is operating at the proper speed. The fan house should be constructed, if possible, of incombustible material. This, however, is not the case in many of the smaller operating companies at the present time. There should also be two sources of power for the operation of the fan so that in the event of one power failure, the other may be utilized. The fan operation should be inspected regularly by some person in authority at least once during each operating shift.

In every mine there should be maintained suitable water supply and quarters for employees wherein they may have the opportunity of changing their clothes. Sanitation about any mine property is very essential to the health of the men engaged in the work. A system of checking the men into and out of the mine should be utilized.

Underground Mine Methods and Conditions

In the United States there are several systems of mining utilized at the present time. These systems vary with the district in which the mining is done and according to the type of coal being mined. Since many of the larger mine properties have introduced mechanized mine equipment, the system of mining has also changed. At the present time the following systems are in use: Long wall, room and pillar, butt entries, panels, and long faces.

In most of the smaller mines and particularly in the older ones a two entry system is utilized. Yet, in the larger properties and particularly so since mechanized mining has come into existance, multiple entries are used both to allow greater quantities of air to be circulated and to facilitate haulage as well as give sufficient work for loading machine units in the advanced work.

When planning mine operations it is very important that surveys be considered so that rooms, entries, and pillars between rooms and entries will be maintained at proper widths to eliminate squeezes which quite often occur when properties are driven on a "hit or miss" plan. Many accidents have resulted from poor engineering surveys of underground properties. Mines have been flooded, bodies of gases encountered, and in some instances the problem of drainage has caused considerable expense due to improper location of pumps and sumps. It is possible, if rooms and entries

are driven on sights, to maintain much better haulage systems and better ventilation. When removing pillars, serious consideration should be given to squeezes or bumps which sometimes occur in seams of coal having much overburden. Bumps have occurred in eastern Kentucky where huge blocks of coal pillar have suddenly burst, injuring anyone in proximity to them. These bursts can, without much difficulty, cause a mine explosion because of the propagation of coal dust and with the proper ignition.

Roof and Floor--The quality of the roof of any coal mine is a very important feature governing coal mine accidents because the type of mining pursued is governed in many instances by the type and quality of roof encountered, and in some coal seams draw slate may be very heavy or thick, necessitating the recovery of the coal with conveyors loaded by hand rather than with coal loading machines. In other coal seams many slips, rolls, pots, horsebacks, faults, and clay seams exist, causing considerable difficulty in maintaining proper roof control. In some mines it has been necessary to devise methods of timbering by using steel H or I beams supported with temporary jacks and good, round timbers.

In any mine a definite method of timbering must be followed, and if necessary, supplementary safety posts or props utilized. The accident experience in coal mines in the United States for the period 1906 through 1939 indicates that approximately 55% of the fatal accidents have been caused by falls of roof and sides. When

considering the number of men that have been injured by this means, certainly there is a definite plausible reason why effective timbering should be utilized in all underground coal mines. Timbers of sufficient numbers and sizes should be supplied to working places at all times together with an adequate supply of cap pieces to enable the men to be able to set the necessary timbers for their protection. In some seams of coal it is necessary, because of the height or system such as in long wall, to properly sprag the coal faces to prevent men being injured by falling coal from the face. One of the most important features about roof control is proper sounding of the roof in each working place where men have occasion to be to complete any particular job. It is only by close attention to sounding of roof and removing of loose material or proper timbering that accidents from falls of roof will be greatly diminished. Because of the fact that most men are want to neglect proper timbering, it is necessary that very close supervision and a definite plan be utilized so that sufficient timbers will be set.

It would be worth while for a study to be made by mining men and scientists to devise a roof testing device that would give an accurate indication of whether or not a dangerous roof condition exists. Much thought has been given to this particular idea and it was expressed at the National Safety Congress in Chicago, Illinois during the month of October, 1940. No doubt an instrument of this type will be developed.

Explosives and Blasting--Explosives should always be considered dangerous elements to handle and extreme care should be used by all persons coming in contact with them. A proper storage magazine should be maintained on the surface remote from all inhabited buildings. Detonators should be stored in a separate magazine from regular explosives. All boxes or containers of explosives should be opened in the manner prescribed by the manufacturer. In the present day scheme of mining, black grain powder, black pellet powder, permissible explosives, dynamite, cardox, airmite, airdox, and L.O.X. are utilized in and about coal mines. All explosives should be transported upon the surface and underground in a safe manner. Too often men in charge of explosives about the mine become oblivious to the hazards and often allow unsafe practices to exist. In some mines explosives are delivered to central locations within the mine from which they are distributed to the individual places where they are prepared and fired. In other properties men carry the explosives to the face in sacks or especially constructed explosive carrying cases sufficient to hold one day's supply. Explosives should be stored underground in strong wooden boxes remote from electric circuits and out of line of shots being fired. The methods of firing the various explosives vary with the type of explosive being used, and the principle explosive used in mines of this country is black powder in either grain or pellet form. Some are fired by fuse and some by electricity. In gaseous mines permissible explosives have been introduced and par-

ticularly so in mines that have been mechanized where on-shift shooting is permitted.

When preparing any explosives such as black powder or permissibles, extreme care should be utilized in keeping lights or other sources of ignition away from the explosives, and when being tamped into the hole, care should be exercised not to use metal bars which may cause a spark. Only wooden bars should be used in tamping shots. Too often holes are not properly stemmed with incombustible material, and as a result, there is the occasion for windy shots which in some cases have caused dust explosions.

Due to the advancement in mechanized mining, because of the fact that it is necessary to use mechanical equipment as much as possible to have a just return on the investment involved, on-shift shooting is allowed in many coal producing states. To off set the hazards from the use of black powder or permissible explosives, there has been developed in recent years a new type of blasting device known as cardox which when fired causes a rapid expansion of gas within a steel shell, rupturing the disc in the shell, and allowing the gas to escape into the drill hole, causing the coal to be broken down.

The hazard from this type of blasting unit is increased by occasionally having the shell ejected from the hole much as a bullet is fired from a gun. A number of men have been seriously injured and killed when hit by these flying shells.

Another unit that has come into prominence for the same reason

as cardox and which is manufactured by the same organization is known as airdox. This is also a shell which is placed in the drill hole and into which is forced air from a compressor unit through a flexible tube. The air is compressed to approximately 25,000 pounds per square inch which is then suddenly released, forcing the coal to be broken down in much the same manner as by utilized explosives. This type of unit is not used universally due to its initial cost and upkeep, and can only be afforded by the larger mechanical operations.

There is being tried at a number of mines a new hydraulic method of preparing coal, the method being developed by the Du Pont organization, Wilmington, Delaware. This device consists of a rubber shell protected by laced metal which will expand with the expansion of the rubber shell. Pressures of several thousand pounds are built up by a compressor unit to which the shell is attached. Coal is broken down by reason of the expansion of the shell. It is with this type of unit that the Du Pont people contemplate allowing the mechanized mining operations to prepare coal during working shifts, and to supersede the use of regular explosives in localities where the shooting of explosives is prohibited by state laws.

With the advent of more mechanized mining, it will be necessary to do more on-shift shooting; consequently, in order that the hazards inherent to such shooting be taken care of, all safety requirements as far as allaying dust, rock dusting, testing for gas

before and after firing shots, and very close supervision over the distribution and handling of explosives must be considered. It will also be necessary to afford very good ventilation at all times in all working places.

Ventilation--Perhaps the most important consideration about any coal mine besides the men that work therein should be given to the ventilation of the underground work. An adequate quantity of air should be delivered by the fan to allow sufficient air to be circulated through all working places in the mine. In most states the quantity of air required for the men is 100 cubic feet per minute; for animals it is 500 cubic feet per minute, this amount to be increased with the increase of methane content in the atmosphere. One per cent of methane, if indicated on the return, should have double the amount of air as required for mines producing no methane.

In order that the greatest efficiency may be obtained from the mine fan, careful consideration should be given to maintaining the air courses at all times to eliminate obstructions, abrupt turns, and to allow a free passage of air. At no time should more than 100 men be allowed on any one split or air circuit. In mines where large quantities of methane are produced, line brattices should be utilized from the last open crosscut to the working face to allow the air to sweep the face and dilute and render harmless the explosive gas being produced. Too often line brattices in use are not substantially constructed and their efficiency is destroyed for this

reason. When constructing a line brattice, a board should be used at the top and bottom to which the curtain should be nailed or secured so that the likelihood of leakage at the bottom and top will be minimized.

Crosscuts or breakthroughs should be made in accordance with the mining law of the state in which the mine is located. When a new crosscut is opened, the ones outby should be properly closed with well constructed stoppings to allow the passage of air through the last open crosscut and to give better circulation of air closer to the face. Too often in the average coal mine operation waste material such as slate or bone coal is used to build stoppings. Stoppings of this sort must be very carefully watched inasmuch as the material decrepitates, allowing the stoppings to settle or subside, reducing their effectiveness by allowing the air to be shorted through them. Experience has demonstrated that in mines where dirt seals are utilized, the cost for maintaining an adequately ventilated mine is much higher than in mines where stoppings of permanent nature constructed of brick or stone on the main entries and wood covered with fibre on panels or room entries are utilized. Since the ventilation of any mine is important throughout the life of the mine, very careful consideration of the system utilized should be given. Many of the larger operating companies have saved thousands of dollars in power consumption each year by maintaining their ventilating system at a high standard. There has been much discussion concerning the sealing or

ventilating of old workings. Practice in different mines varies with the attitude of the management. If worked out areas are to be sealed, well constructed seals should be used. Seals should be constructed of reinforced concrete, concrete blocks, or brick. Seals should be hitched into the rib several feet into the solid coal and into both top and bottom until a solid surface is reached, or at least 30 inches. Through each seal there should be placed a two-inch pipe equipped with suitable gate valve. The purpose of the pipe valve is to allow samples of atmosphere from behind the seals to be taken for analysis purposes. Cribs should be constructed inside and outside the seal so that in the event there is a possibility of pressure, a masonry seal will be protected by the cribs bearing most of the weight. At no time should the opening through which persons have access to the seal be closed, because the seals or sealed areas should be observed as closely as the working places in the mines. This is particularly true if the mine or sealed area produces methane gas.

When areas are left open, the requirements of the ventilating system are increased as the areas underground are worked out. It is necessary to maintain sufficient ventilation in such properties so that the working areas will be adequately ventilated. Too often obstructions are allowed to exist which hinder or disrupt the air circulation, and in some instances where mines are producing methane, large bodies of gas may accumulate and are apt to be forced out of the old workings and ignited, resulting in a mine disaster.

It is very essential that a map of mine workings be maintained upon which the direction of the air travel throughout the mine is indicated so that in the event of an emergency, the person assisting with recovery work would know the manner in which the mine had been ventilated previous to the emergency.

In many of the mechanized properties and in some of the older, more poorly ventilated mines, booster or blower fans are utilized. Too often proper maintenance of the main ventilating current is neglected because many men working in the mines believe that because the fan is delivering large amounts of air, that the air is good. Many times due to leaks the air is recirculated, and in gaseous properties methane in the atmosphere rises to the explosive range of 5 to 15 per cent. With open-type electrical circuits or open lights explosions have occurred. If the booster or blower fans are to be utilized, extreme care should be exercised in having the intakes for the fans in fresh air so that there is no recirculation. Tubing and boxing through which the air passes should be maintained in good condition. It should be directed as near to the face as possible. Overcasts and undercasts in any mine should be constructed in a streamline effect for the easy flow of air to eliminate resistance to the passage of air.

Mine doors are a very important part of mechanical ventilation for the proper circulation of air throughout the mine workings. Doors should be constructed of good, sound material and be made to close so that there will be no openings or leaks that will

allow short circuiting of the air. It is also important that wherever possible, doors should be constructed in pairs so that when one door is open, the other door will remain closed, and when constructing doors in pairs, it must be considered that the length of empty or loaded trips will determine the distance between doors. In many mines on main line haulage, trapper boys are utilized, but in the newer mine door installations, automatic doors are used. These doors are actuated by the passage of motors and cars over push down rails that cause the door to open. As soon as the trip has passed, the doors automatically close. It is important that the vicinity of the doors be kept clean to eliminate having them left open by pieces of coal which quite often fall from the cars as they pass through the doors.

All underground coal mines should be thoroughly inspected by a competent mine examiner or fireboss before each working shift starts. It should be the duty of the examiner or fireboss to test the various working places with an approved flame safety lamp or a methane detecting device to determine whether or not methane gas exists in the working places. A careful check should be made of the ventilating current to see that it is functioning properly. At the same time the unsafe condition with reference to poor roof may be marked and the conditions noted in the report made to the mine superintendent before the men are allowed to commence work. It is very essential, particularly in mechanized mines where coal is being extracted very rapidly on

two or three working shifts, that qualified men be placed in charge of each unit whose duty should be to test for gas at frequent intervals and to examine the places for other unsafe features. In mines that produce methane, the rule prohibiting smoking should be in effect.

As new installations of mine equipment are made, they should be made of the permissible type as approved by the United States Bureau of Mines. This takes into consideration locomotives, mining machines, loading machines, pumps, coal loading devices, and all motors. This will eliminate the possibility of ignition of accumulations of methane. All permissible explosives should be fired in a permissible manner.

Dust--During the past 20 years it has been recognized that coal dust accumulations in mines other than anthracite enter into coal mine explosions. There have been several coal mine explosions in which dust, only, was involved. There are relatively few coal mines in the United States, or 491 out of 6,016 in 1938, compared to the total number of mines that are operating, in which any rock dusting is done. This is a very deplorable state of affairs because every coal mine other than anthracite is apt to have conditions present in which a coal dust explosion could be propagated, resulting in loss of life. Regular tests should be made of road, rib, and roof dust to determine whether or not it would enter into a dust explosion. Samples from various sections of the mine should be taken and analyzed by the volumeter test method. This apparatus

was perfected by the United States Bureau of Mines engineers. It is in general use in properties interested in effective rock dusting in the mines. The incombustible content in the dust should be at least 65% in most mines where no methane occurs. The incombustible content should be increased according to the percentage of methane encountered, and for each one per cent of methane in the air, about ten per cent additional incombustible matter is required. In some of the Utah coal mines where the dust is more dangerous than in the mines in the midwest and eastern part of the country, rock dusting is utilized to a great extent.

Rock dusting should be applied in all entries and rooms in working territories. Rock dust barriers should be located at strategic points underground so that they may be tripped in the event of an air disturbance so that the dust may prevent the passage of flame. In the past two years experiments have been made with bags of rock dust in the mines of the Old Ben Coal Company in southern Illinois by John E. Jones, safety engineer. These tests have proved quite satisfactory in confining dust explosions. The bags are fastened to timbers near the roof and in the event of an air disturbance, the bags are broken open by the force of the air and the contents spilled into the atmosphere. The object of rock dusting in mines is to place in suspension a sufficient quantity of incombustible material to prevent the passage of flame from one particle of dust to another and to extinguish the fire.

Haulage--Haulage in coal mines operating in the United States today varies from the use of wheelbarrows to heavy locomotives with exceptionally large cars of ten-ton capacity. Different types of conveyors are in use in conjunction with locomotive haulage or with belt conveyor. Wheelbarrows are utilized in very small mining operations, and little or no hazard exists from the haulage standpoint. In many of the mines animal haulage is utilized with poines, mules, and horses. The cars vary in size from one ton to three tons. In some mines there is a combination of animal and mechanical haulage. Usually the animals are used in gathering the coal from the face and delivering it to a parting where the trips are made up and cars are transported from the parting to shaft bottom. There are, however, mines in existance that use animal haulage from the face working to the shaft bottom. In a few of the small mines manual haulage is still in use where men push the cars from the face to the shaft bottom or drift mouth. In the larger mines in the country, because of the mechanization progress that has been made during the past few years, the haulage problem has become quite important because of the necessity of speeding up transportation of coal from the face to the preparation plant. In operations where locomotives and cars are used, closer attention is being given to installing heavy steel on well ballasted road beds with grades eliminated as much as possible. In some mines the locomotive trips are directed by dispatchers who control the movement of the trips between the face and the shaft bottom or drift mouth. Many of the switches are made to operate automatically. In a few mines where the coal is

loaded at the face by mechanical means, it is conveyed to the mine preparation plant on series of conveyors. From the loading point coal is placed on the shaker or chain conveyor and transported to the junction point where it is distributed onto a belt conveyor and from there to the outside or to the main belt conveyor that leads to the outside. It is possible in this type of haulage to maintain better control over the roof conditions and eliminate the use of a large number of employees that must be used under other forms of haulage. In order that haulage systems be maintained in an efficient manner, a close inspection must be made of all equipment and repairs made promptly to avoid disruption of service through accidents. Proper clearance must be maintained and road beds kept clean. Trolley wires must be properly hung, trips must be brought to a stop when coupling or uncoupling cars, or when switching. Curves should be gradual and not abrupt. Locomotives should travel at a reasonable rate of speed. Shelter holes should be maintained along haulage roads to allow persons to get into clear when trips are passing. Lights or markers should be carried on the rear of all trips to indicate that no cars have been lost in transit. In hilly mines drags should be carried on the rear end of trips to prevent run-a-way cars and wrecks. All locomotives should be equipped with suitable lights and warning bells.

In some of the mines where seams are on a pitch, rope hoists are used. Where such a system is used care must be observed in

maintaining hoisting equipment and ropes in good condition at all times. If men are hoisted, safety chains should be used from the hoisting rope through the string of cars and fastened to the rear car of the trip because occasionally couplings between cars part, and if such occurred without safety chains, cars would run away down the slope. It is also worth while to utilize drags on the rear of trips being hoisted up the slopes so that in the event cars are lost, a derail will prevent the car from running back down the slope. All mine cars should be maintained in good operating condition. Too often in smaller properties cars are allowed to get in bad order, resulting in much spillage of coal which contributes to poor housekeeping, produces dust, and increases the cost of haulage because of the increase in power to operate locomotives. All mine cars should be properly blocked when allowed to stand either at the face or while in transit when not coupled to a motor. Many men have been killed by cars running back into working places where the men are engaged in work either on mining machines or loading coal, crushing them against the face or against the machine on which they were working.

If man trips are utilized to transport men from the face workings to the outside, extreme care should be exercised by the supervisors to see that the trips are handled in a safe manner and operated at moderate speeds. When loading or unloading man trips, the current should be shut off the trolley wires at the stations to eliminate the possibility of men being electrocuted

when getting into or out of the cars. At no time should tools be carried with the men while riding in a man trip. There should be sufficient cars in the trips to allow men to ride in cars on the side opposite the trolley wires. Lights should be maintained at loading stations.

Electricity--During the past 40 years the use of electricity in and about coal mines has come into considerable prominence, and in practically all the newer mine installations electricity is used more than any other type of power. Many of the mine properties buy power direct from power companies rather than develop power in their own plants. Ordinarily the power is received through transmission lines at high voltages from 2300 to 33,000 volts alternating current and delivered to the premises where the transformer banks are usually located to reduce the voltage to 440 or less depending upon the size of the operation and type of machinery used. The usual surface lighting is powered either by 110 volts or 220 volts. Machinery operating in the tipple and preparation plant usually runs on 200 volts alternating current or 440 volts alternating current. In underground operations usually all the motors except those driving haulage locomotives are operated on alternating current and are of 220 volt alternating current capacity. It is necessary, therefore, that converters or motor generator sets be utilized in transforming alternating current to direct current for haulage motors. Transmission lines to the underground operations are usually placed in armored cables ex-

tending down the main shaft or the auxiliary shaft. The armored cables should be frequently grounded to dissipate any possibility of charged cables.

All power wires should be properly strung on insulators with additional protection when cables are passed through doors or any other combustible material. Quite often in medium sized operations trolley wires serve as both feeder wire for machine operation and locomotive operation. Too often the wire is overloaded and there are continuous interruptions resulting in much lost time through power failures. To eliminate the possibility of such power failures sufficient feeders should be utilized in addition to the regular trolley wires to enable the passage of current through the wire in order to take care of the demands of the various machines in operation. In some of the larger mines drill holes are utilized to complete the circuit from the surface by allowing the cables to pass down through the drill hole at a point near the working face which eliminates much voltage drop. Sectional switches should be installed on all power circuits so that the power may be shut off any time when necessary. All contact hazards where men or animals are apt to get into contact with the wires such as at crossovers, at room necks, and on entries turned off the main entries should be properly protected. This is also true of trolley wires. They should be properly hung with necessary protection where they pass through doors or curtains. All rails should be properly bonded to enable a good return. Insulated

turn buckles should be used on trolley wires. Trolley frogs and cut-out switches should be provided at branch roads and at no time should trolley wires be hung on wire attached to props as is sometimes the case, for this affords a distinct fire hazard.

A telephone system should be maintained in any coal mine of average size having more than 50 men employed. Telephones should be located on the surface either in the engine room or office, on the shaft bottom, and on each parting or section of the mine. In gaseous mines telephones should be of a permissible type to prevent ignition of gas. Telephone wires should be strung on the side of the entry away from the power wires and in such a manner that they will not be easily torn down. If it is necessary that the telephone wires cross the power circuits, additional precaution should be made to eliminate the possibility of contacting the power circuit by proper insulation. In some mines a signal system is used, particularly on slopes, by making contact with wires strung along the entry and shorting these wires with a piece of metal. This is not a desirable method of signaling, especially so in gaseous mines where it is sometimes used.

All underground transformer stations and motor generator stations should be of fireproof construction and properly ventilated. Fire protection in the form of suitable extinguishers such as carbon tetrachloride, sand, or rock dust may be kept in proximity to such stations. These stations should be locked to prevent unauthorized persons from entering them. Switch boards should be properly guarded to prevent access behind the board to

anyone except an authorized person. Rubber mats should be utilized on floor in front of switches to remove the possibility of electrocutions. Circuit breakers should be installed on all circuits, and if possible, they should be of the automatic type. In many mines the hand operated circuit breakers are tied in and do not allow proper functioning, contributing to fires. Proper fuses should be utilized on all operating units such as mining machines, pump motors, and loading machines. Cables extending the source of power from power line or trolley wire should be carefully inspected at regular intervals. Whenever there appears to be a break in the cable where temporary splices are used, cables should be removed from the machine and splices properly repaired in the shop on the surface or in the underground shop.

Pumps--The number of pumps used in any mine will naturally depend upon the amount of water being produced in the mine. Switches and wires to the pump units should be properly protected and of an approved type. Pumps should be properly grounded to eliminate electrocutions. Gears between the power and the pump should be adequately covered to eliminate accidents from this source. Adequate protection should be afforded to prevent roof falls and consideration should be given to the location of the pump with reference to being placed on the intake or return airways, especially if the mine is known to generate methane gas. If the installation is of the open type or non-permissible type, the arcing of the motor or opening or closing switch may cause a gas ignition if an accumu-

lation exists in the vicinity of the pump, especially if it is on the return airway.

Loading--Loading of coal in mines of the United States varies from manual to mechanical with a number of different methods utilized. In some of the smaller properties coal is shot off the solid with black powder and loaded onto cars by hand. In other mines coal is undercut by mining machines and shot with black powder or permissible explosives and loaded into cars by hand. In the larger, more efficient operations, coal is prepared by undercutting or shearing, shot with explosives, either black powder, permissible explosives, cardox, airdox, or by hydraulic means, and loaded mechanically. Mechanical loaders that are in use vary from loading heads on shaker conveyors or pit car loaders to the use of Joy, Jeffrey, or Goodman loaders. In some properties scraper loaders are utilized that drag the coal from the face to the loading unit where coal is dumped into the pit car at that point. Many of the loading machines are track mounted while others operate on caterpillar tread. Consideration should be given to the type of equipment to be utilized according to the natural conditions encountered in the mine. Where soft bottoms occur it would not be advisable to use caterpillar units because of the difficulty in moving the unit from one place to another. The same is true in type of equipment used for undercutting. In extremely low seams of coal it is difficult to operate Joy, Jeffrey, or Goodman loading machines, and many of the operations are re-

sorting to conveyor type loading by men loading the coal onto the conveyors at the face. In certain seams of coal it is not practical to use a large loader because of the condition of the top inasmuch as it is difficult to support the roof so that it will be safe to operate the machine and yet allow the machine to operate efficiently. Occasionally in larger mines very poor roof conditions are encountered and the cost per ton of coal loaded is much greater because of the additional effort that must be utilized in roof control than producing the same amount of coal by hand onto conveyors or ordinary manual loading where such roof control may be effective. In the operation of modern mechanized equipment at the face in preparing and loading coal, serious consideration should be given to allaying coal dust produced at this source. This may be done by the use of water under pressure being directed into the chain on the cutting machines as the chain enters or leaves the kerf or cut, after shooting, and during loading operations. This is particularly important where more than one shift is operating and gang work is being accomplished.

Fire Protection--The state laws of many coal producing states require fire protection in underground operations. In most properties fire protection efforts are directed to the vicinity of the shaft bottoms and around stables if animal haulage is utilized. In mines that have machine shops underground, suitable fire extinguishers such as the carbon tetrachloride type or soda acid type are used.

It is also very important that additional supplies of brattice cloth be kept on hand for use in fighting fires. In many properties where water lines are not in general use, a fire truck consisting of a tank of several hundred gallons capacity, mounted on a regular mine car truck, and equipped with a pressure pump may be used to force the water onto any fire that might occur. Quite often in properties having water supplies available at or near the face along the haulage road, water taps are placed at frequent intervals to enable the water to be secured from the pipe line and directed toward the fire.

Protective Clothing— Protective clothing in and about mine properties is very essential in reducing coal mine accidents. Goggles of the spectacle type should be worn by all men engaged in underground operations, especially so in mines where considerable pick work is done such as in the long wall system of mining. Timber men should be required to wear goggles. When any welding or cutting operations are being done, those individuals doing the work should be required to wear special welding goggles. Safety hats have come into prominence during the past 10 years, and the more progressive mining companies are requiring their employees to wear this type of protection. Yet, there are many mines operating in the United States that do not have this protection for their men. It is indeed a difficult task to obtain cooperation in securing this type of protection. Safety hats have eliminated many injuries to the head that

would otherwise have proved serious, resulting in time loss to the injured individual. Safety shoes are worn in many mines, yet, it is also difficult to get this type of protection into general use because of the opposition that miners usually offer when changing methods or practices. This type of shoe has prevented many foot injuries.

Flood Hazard--In any underground coal mine serious consideration should be given to the possibility of flood hazards either from surface water or adjoining mines that may be encountered. If there is any possibility of flooding from surface water, proper dikes should be erected about the surface operations to prevent the water getting into the shafts. Such an accident occurred in northern Illinois at the Diamond Coal Mine in which 69 men lost their lives from flooding by surface water. A number of miners have lost their lives and mines have been flooded due to encountering adjoining mine workings where large bodies of water have been impounded. It is written into most state mining laws that when known to be approaching abandoned sections of mines that may contain water, drill holes should be made at least 20 feet in advance of the working face in the center of the place with flanking holes at 45 degrees in each corner of the place. If water is encountered in the drill holes, it is usually an easy matter to plug the hole with a suitable wooden plug which should be available for that purpose. One large mine property was lost in the state of Illinois during the past few years due to underground

water from abandoned adjoining mines. Seals had been erected of reinforced concrete between the two mines of the same company, but due to the softening action of water on fire clay below the concrete seals, and due to the increase in pressure developed by the increasing water head, the clay was pushed from underneath the concrete seals or dams and the water was allowed to enter the live workings of the mine. Consequently, it is important, when mining in the vicinity of large bodies of water in underground works, to leave sufficient barrier pillars to eliminate the possibility of flooding. At least 100 feet of solid coal pillar should be left where there is a possibility of encountering a large head of water in excess of 100 feet.

Mine Safety Board Decisions--The United States Bureau of Mines, through its mine safety board, issues decisions on safety methods and practices. Such decisions govern the safety of mine operations. There are some thirty decisions that have been published by the board. Listed below are a number of these which demonstrate just what recommendations are made for the safe operation of coal mines in the United States.

Decision I. (a) In all coal mines the portable lamps for illumination be permissible, portable, electric mine lamps; and also

(b) In places where fire damp or black damp is liable to be encountered, a permissible magnetically locked flame safety lamp for gas detection, or equivalent permissible device, be supplied to at least one experienced employee in each such place; and

(c) Any employee before being supplied with a permissible flame safety lamp be examined by a competent official of the mine to assure the man's ability to detect gas; and

(d) All coal mines whether classed as nongassy or gassy in any part, be supplied with magnetically locked permissible flame safety lamps, properly maintained and in sufficient number for all inspection purposes.

Decision II. In the interests of safety the Bureau of Mines recommends that for blasting in coal mines, permissible explosives, fired electrically, be exclusively used; and that as an aid to blasting, all coal which is feasible to cut, should be cut or sheared.

Decision IV. In the interest of safety the Bureau of Mines, Department of Commerce, recommends that auxiliary fans or blowers should not be used in coal mines as a substitute for methods of regular and continuous coursing of the air to every face of the mine.

Decision V. To prevent the propagation of mine explosion, the Bureau of Mines, Department of Commerce, recommends rock-dusting all coal mines, except anthracite mines, in every part, whether in damp or dry condition. It also recommends that rock-dust barriers be used to sectionalize the mine as additional defense; but these should not be regarded as a substitute for generalized rock-dusting.

Decision VI. In the interest of safety, the Bureau of Mines, De-

partment of Commerce, recommends that in coal mines all entries, rooms, panels, or sections that cannot be kept well ventilated throughout or cannot be inspected regularly and thoroughly, or that are not being used for coursing the air, travel, haulage, or the extraction of coal, be sealed by strong fireproof stoppings.

Decision VII. In the interest of safety, the Bureau of Mines, Department of Commerce, recommends:

1. That the main intake and main return air currents be in separate shafts, slopes, or drifts.

2. That the main intake shaft lining be of fireproof construction, and there be a minimum amount of inflammable material in or adjacent to the shaft.

Decision XI. In the interest of safety, the Bureau of Mines, Department of Commerce, recommends that in coal mines, haulage and (or) hoisting be kept in intake air as far as possible.

Decision XV. In the interest of safety in coal mining, the Bureau of Mines, Department of Commerce, recommends that, to lessen the coal dust explosion hazard:

(a) Machine coal cuttings be wet as the cutting is being done.

(b) The coal face and the working place 40 feet, therefrom, shall be kept free of coal dust by the use of water.

(c) The top of loaded cars in the working place shall be wet.

Decision XX. In the interest of safety in underground mining, the United States Bureau of Mines recommends that while driving tunnels or drifts and sinking or raising shafts or slopes, and also in their operation, there should be an adequate ventilating current wherever men work or travel.

Decision XXX. That all active underground coal mines, whether working or idle, have one or more fans in continuous operation. The capacity and installation shall be such that the entire mine workings are adequately ventilated at all times. Main fans shall be located on the surface in fireproof housing offset from the line of any mine opening. The housing shall be provided with ample pressure-relief doors or other devices easily opened by the force of an explosion. The installation shall permit prompt reversal of air flow. For mines that liberate gas, the fan shall have at least two independent sources of power immediately applicable.

C H A P T E R III
EDUCATION

The educational program of mine safety work is perhaps the most important phase of mine accident prevention activities. It has been clearly demonstrated that men who have availed themselves to various educational programs are, by far, the best workmen. For the most part the men take cognizance of the hazards that exist and prevent accidents that usually occur from them.

Accident Analysis--Closely associated with the educational program is a careful accident analysis by which safety engineers and mine operating officials are able to determine just what is causing the accidents in the mines and, thus, institute programs to eliminate recurrence of such accidents. For instance, if there is a large number of accidents from falls of roof, then it is easy to determine that proper timbering methods are not being followed by the men at the face. If accidents are occurring in haulage wherein men are being run over by moving trips, then it is reasonable to assume that men are jumping on or off of moving trips or are stumbling or falling in front of such trips, and being run over by them. It is very easy to determine many of the practices that are being followed that contribute to mine accidents by reviewing the accidents that are occurring in the mines, and this serves to remind or bring to the attention of the operating officials just what precautions should be followed in eliminating accidents in the future.

Safety Training

The safety training program to bring to the miners and operating officials the important features of coal mine safety deals very much with courses of training prepared and taught by the representatives of the United States Bureau of Mines. The courses being used at the present time are as follows:

I First Aid to the Injured

II Mine Rescue

III Advanced Mine Rescue and Recovery Operations

IV Accident Prevention Course for Miners and Operating Officials

First Aid--The first aid course was the first phase of instruction started by the Bureau of Mines, and it deals with training men in caring for injured persons in and about coal mine properties. Perhaps the most important reason for starting a first aid training program was because of the fact that in former days coal mines were located remote from settlements where prompt medical attention could be obtained. There no doubt entered into the establishment of this program the fact that most mines had extensive workings which in many cases were quite a distance from hoisting shaft or drift mouth, necessitating transportation of injured persons over long distances underground before medical attention could be administered.

So many of the coal mine accidents were of a serious nature such as broken backs, fractured skulls, broken legs, electrocutions, etc., to which prompt attention was necessary at the scene of the accident to revive a patient or to apply proper splints in order

to eliminate the possibility of the injury becoming worse.

First-aid courses taught by the Bureau of Mines and many of the state mining departments as well as other organizations interested in mine safety work follow the first-aid manual published by the United States Bureau of Mines. From time to time there have been changes made in the first-aid manual to simplify the work and to improve it, wherever possible, keeping in tune with the times. The subjects taught in the first aid program are those of:

I Physical Shock

II Artificial Respiration

A-Schaefer method
B-Sylvester method

III Control of Bleeding

A-Dressings for open wounds
B-Dangers of infections

IV Dislocations

A-How they are recognized
B-How they are treated

V Fractures

A-Recognition
B-Treatment
C-Subsequent application of splints where necessary

VI Treatment of Burns

VII Transportation of Injured Persons

A-Lifts
B-Carries

The Bureau of Mines requires that 15 hours of instruction be given before an individual is eligible for a certificate. Certificates are awarded by the Bureau of Mines and also by various state mining departments as well as some coal mining companies.

Several years ago when the interest in first-aid training became very great, it was necessary to develop a cooperative training program whereby the requests for such instruction might be taken care of. This program was developed principally in southern Illinois and was done by training key men to act as instructors of classes. Ordinarily there were 25 men in a class. Various cooperative classes were under the direction of the United States Bureau of Mines representatives who visited the classes several times during each period of instruction. Usually the classes lasted five nights, three hours each night during a week. Upon completion of the instruction, classes were examined by the Bureau of Mines or state department representatives to determine whether or not they were sufficiently proficient to be qualified for a certificate. In this manner many thousands of men were trained in a period of a few years.

In many coal mining communities first-aid contests are still held at regular intervals in which first-aid teams compete for prizes. The United States Bureau of Mines did at one time hold an annual first-aid contest in various sections of the country where teams affiliated with the organizations in mineral industry were allowed to participate. Since 1930 no international contests

have been held due to the restrictions in finances for such work by the Bureau of Mines. This action has, of course, been somewhat detrimental in the general program because many of the team members looked forward to making the trips to the international contest. Nearly two million men associated with the mineral industry have had the advantage of taking first-aid training under the direction of the Bureau of Mines representatives or their associates of various mining departments of coal producing states.

Mine Rescue--The next most popular course with the Bureau of Mines, because of the fact that qualified men in the industry are needed to assist in mine rescue work, is a course known as Mine Rescue. This training course deals with the use and wearing of gas masks and mine rescue apparatus. The gas mask used is the all service cannister mask which may be used in any atmosphere containing sufficient oxygen to support life or about 16½ per cent. The other type of apparatus is known as self-contained oxygen breathing apparatus. Several different makes of these machines are on the market. Following is a list of those machines that are most popular and are approved for mine rescue work by the United States Bureau of Mines:

1. Gibbs
2. McCaa
3. Paul
4. Fleuss-Davis

These machines are designed to allow the air breathed by the wearer

to be entirely independent of the outside atmosphere, and for that reason they are called self-contained oxygen breathing apparatus. These types are built to serve and wear for periods of two hours at a time after which they must be recharged with fresh oxygen and fresh chemical absorbant for expired carbon dioxide.

It is necessary that the men taking this course be of sound physical condition and mentally alert, because many times the work is carried on under very trying circumstances in recovering mine properties after fires or explosions, and consequently, men in good physical condition are necessary. It is important that crews of five men work together in any mine rescue activities. Constant training is important although the Bureau of Mines issues a certificate for ten hours of training. In order that the men will be entirely familiar with the apparatus, training should be undertaken by the individuals at least once each year, and more often if possible.

One of the important things to consider in rescue work is the fact that a team should not traverse the mine workings too far from the fresh air base. It is recommended that men should not advance more than 1000 feet where conditions are normal and coal is at least six feet high. If the conditions are below normal and the coal is somewhat less in height, and there are smoke and obstructions in the travelways, the distance should be greatly lessened. Occasionally something may disrupt the circulation

of air in the breathing apparatus and make it necessary for the men to return to the fresh air immediately. If the men have progressed too far, the loss of life may be the result to the wearer, due to the improper functioning of the machine.

In many of the larger mining companies where fires and explosions are apt to occur, rescue teams are maintained together with the necessary apparatus. Many of the state mining departments maintain mine rescue stations in which men train and are subject to call to assist in mine rescue activities. The state of Illinois at the present time maintains eight mine rescue stations. The men engaged in this work are mine officials and miners living in the vicinity of the station. They are compensated for their work by the mining companies.

Advanced Mine Rescue--The advanced mine rescue training course taught by the representatives of the United States Bureau of Mines deals in the first part with the study of the mine gases and the various methods for their detection. The gases studied are air, oxygen, carbon dioxide, methane, carbon monoxide, hydrogen sulphide, and other rarer gases found in mines. The use of the flame safety lamp is explained very thoroughly together with proper procedure in testing for methane. Other methane testing devices such as the Burrell Indicator, the Martinson Methane Detector, and the Union Carbide Company Methane Detector are studied. The use of small animals and birds is

discussed in the detection of carbon monoxide together with the use of the Iodine Pentoxide Detector sometimes known as the Hoolamite Detector. The Pyrotannic acid method for quantitative determination of carbon monoxide in blood and air mixtures is also discussed quite thoroughly.

Part two deals with the instruction in methods of sampling and in the use of the Bureau of Mines portable Orsat apparatus for analysing mine gases. The various methods of sampling discussed are those such as use of the vacuum bottle, aspiration, and by water displacement. Training is given in the operation of the Orsat to each of the members of the class so that they will understand how the device is operated.

Part three deals with the methods of protection against mine gases including the erection of barricades after mine fires or explosions, the use of the approved self rescuer, the approved all service gas mask, and the approved oxygen breathing apparatus together with the use of artificial respiration such as the Schaefer and Sylvester methods and the use of the oxygen inhaler.

Part four deals with the organization, equipment and protection for recovery operations such as the surface organization, the equipment necessary for conducting the work including oxygen breathing apparatus and gas masks, and the instruments and materials needed to carry on the activities.

Stoppings are discussed with reference to the erection of temporary stoppings of canvas and lumber and permanent stoppings of brick, concrete block, poured cement, plaster, and pack wall. There is a discussion of mine fires dealing with fighting mine fires, when and how to seal mine fires, when and how to unseal mine fires, the precautions to be followed after mine explosions, establishing fresh air locks, and exploring underground works.

The underground practice work in the advanced mine rescue training deals with operations before going underground, after going underground by working a problem in recovery or rescue work. Various rules and precautions in use of life line signals, the action of the leader of the group before leaving fresh air and after leaving fresh air base are discussed.

By giving this course the Bureau of Mines is able to train certain qualified men in various mining districts to enable them to handle situations in the event of an emergency, especially so since it is impossible to have the Bureau of Mines representatives or rescue crews from state or federal organizations available in every mining community, and the local group could handle the situation satisfactorily until outside help is called.

Accident Prevention--During the past few years accident prevention courses have been given for miners and operating officials to explain to the members of the classes the various hazards that exist in the mines of their particular districts so that the questions on supervision, mine haulage, accidents from falls of roof, venti-

lation, mine fires and explosions, the use of explosives, and miscellaneous accidents may be discussed thoroughly and steps taken to eliminate the hazards that exist.

The course of training deals with the study of the accidents that occur in the mines or groups of mines represented. In the course questions concerning the various practices utilized in mines are asked of the class personnel, who in turn, discuss the questions verbally or write articles pertaining to the subjects. These questions are discussed by the class personnel so that a definite decision is reached as to the manner in which the various practices are to be followed in the mine.

This course has done very much in eliminating accidents by bringing to the attention of the operating officials the importance of establishing certain definite procedures which must be followed in producing coal so that it may be done in a safe and efficient manner.

Safety Bulletin Boards--At most coal mine operating companies safety bulletin boards, upon which are posted various safety bulletins, are maintained. These bulletins are furnished by the National Safety Council and insurance companies to afford a means of visual education. These posters depict the right and wrong ways of doing a job or the hazards inherent to that job or condition.

Moving Pictures--In recent years the Bureau of Mines has prepared silent and sound moving pictures of various coal mine safety sub-

jects, demonstrating the manner in which certain jobs about the mine should be done safely and efficiently. These pictures are available for showing by a representative of the Bureau of Mines. Many coal operating companies and insurance companies have taken pictures of underground mines to describe many of the safety features existing in the mines so that they may be brought to the attention of the miners in various localities not familiar with such conditions, and by this means demonstrate to these miners the correct manner of doing the job.

Safety Contests--In many of the large coal mine operating communities where several mines are operated by the same company, safety contests are held to stimulate the interest in accident prevention. These contests may be in the form of first aid and mine rescue demonstrations. Many times bonuses are given to individuals for records established in operating for certain periods of time without lost time accidents. Banquets and meetings are held for operating officials and miners to further stimulate interest in accident prevention activities. Safety meetings are held at frequent intervals to discuss the operating problems and safety features of mining in the hope that by exchanging views or opinions and explaining the hazards that contribute to accidents, that a reduction will be made in the accidents occurring in and about the mines by eliminating such hazards that are responsible for these accidents.

C H A P T E R IV

ENFORCEMENT

In all of the coal producing states mine inspection departments have been established by the legislatures of the states. The efficiency of these departments bears a direct relation to the tonnage produced in the various states. The coal producing states that produce very little tonnage have only a few mine inspectors and little other activity regarding mine safety; yet, in the larger coal producing states such as Pennsylvania, West Virginia, and Illinois, very elaborate organizations under the mine departments of these states are maintained and are under the head of a Director of Mines.

The procedure followed in the state of Illinois will be discussed inasmuch as Illinois is one of the leading coal producing states in the Union and the efforts are comparable to those in other states.

The authority to govern the health and safety of the mines in the various states rests with the individual state departments rather than with any federal department or other authority. Consequently, the state departments have complete jurisdiction over mines operating in any particular state.

The mining law in the state of Illinois was first approved on June 6, 1911, and from time to time has been amended according to the changes deemed necessary to further enhance the safety of the mines.

State Mining Board--The State Mining Board is appointed by the governor of the state by the advice and consent of the senate. It is the duty of this board to make formal inquiry into and pass upon the practical and technological qualifications and personal fitness of men seeking appointment as State inspectors of mines, and economic investigator and of those seeking certificates of competency as mine managers, as hoisting engineers, and as mine examiners. The board also controls and directs the state mine inspectors in the discharge of their duties, and has the power to see that all the provisions of the state mining law are enforced. The statistics relating to coal mining in the state, especially in its relation to the vital, sanitary, commercial and industrial conditions and to the permanent prosperity of the industry to see that they are compiled, is also a duty of the board.

Qualifications--An applicant for any certificate, before being examined, must register his name with the State Mining Board and file with the board the credentials required by this act. An affidavit is required as to all matters of fact establishing his right to receive the examination, and a certificate of good character and temperate habits, signed by at least ten residents of the community in which he resides must be provided.

Inspectors. Each applicant for a certificate of competency as State Inspector of Mines and economic investigator must pro-

duce evidence satisfactory to the board that he is a citizen of this State, at least thirty years of age, that he has had a practical mining experience of ten years, of which at least two years have been in the State of Illinois, and that he is a man of good repute and temperate habits; he must pass an examination as to his practical and technological knowledge of mine surveying and mining machinery and appliances, of the proper development and operation of coal mines, of ventilation in mines, of the nature and properties of mine gases, of first aid to injured, of mine rescue methods and appliances, of the geology of coal measures in this State, and of the laws of this State relating to coal mines.

At the close of each examination for inspectors the board certifies to the Governor the names of all candidates who have received a rating above the minimum fixed by the rules of the board as being persons properly qualified for the position of inspector.

Mine Manager. Each applicant for a certificate of competency as mine manager must produce evidence satisfactory to the board that he is a citizen of the United States, at least twenty-four years of age, that he has had at least four years' practical mining experience, and that he is a man of good repute and temperate habits; he must also pass such examination as to his experience in mines and in the management of men,

his knowledge of mine machinery and appliances, the use of surveying and other instruments used in mining, the properties of mine gases, the principles of ventilation, of first aid to injured, of mine rescue methods and appliances and the legal duties and responsibilities of mine managers, as prescribed by the rules of the board.

Mine Manager, second class. Each applicant for certificate of competency as mine manager, second class, must produce evidence satisfactory to the board that he is a citizen of the United States, at least twenty-four years of age, that he has had at least four years' practical mining experience, and that he is a man of good repute and temperate habits. He must also submit to and satisfactorily pass such an examination as to his experience in mines and in the management of men, his knowledge of coal mining, mine ventilation, and the mining laws of this state and the required duties and responsibilities of second-class mine managers, as prescribed by the rules of the board, and it is unlawful to employ second class mine managers, or for them to serve in that capacity at mines employing more than ten men.

Mine Examiners. Each applicant for a certificate of competency as mine examiner must produce evidence satisfactory to the board that he is a citizen of the United States, at least twenty-one years of age and of good repute and temperate habits

and that he has had at least four years' practical mining experience. He must pass an examination as to his experience in mines generating dangerous gases, his practical and technological knowledge of the nature and properties of fire-damp, the laws of ventilation, the structure and use of safety lamps and the laws of this state relating to safeguard against fires from any source in mines. He must also possess a knowledge of first aid to injured and of mine rescue methods.

Hoisting engineers. Each applicant for a certificate of competency as hoisting engineer must produce evidence satisfactory to the board that he is a citizen of the United States, at least twenty-one years of age, that he has had at least two years' experience as fireman or engineer of hoisting plant, and is of good repute and temperate habits. He must pass an examination as to his experience in handling hoisting machinery, and as to his practical and technological knowledge of the construction, cleaning and care of steam boilers, the care and adjustment of hoisting engines, the management and efficiency of pumps, ropes and winding apparatus, and as to his knowledge of the laws of this state in relation to signals and the hoisting and lowering of men at mines.

The State Mining Board has the power to grant a permit to operate a second motion engine at any mine employing not more than ten men, to any persons recommended to the board by the

State Mine Inspector of the district providing that the applicant has filed with the State Mining Board satisfactory evidence that he is a citizen of the United States, that he has had at least one year's experience in operating a steam engine and steam boiler and understands the handling and care of the same. Such application must be accompanied by a statement from at least three persons testifying from their personal knowledge of the applicant that he is a man of good repute and personal habits and that he has, in their judgement, a knowledge of and experience in handling boilers and engines as required in this section. Such permit applies only to the mine for which it was issued.

Each applicant for a certificate of competency as electrical hoisting engineer must produce satisfactory evidence that he is a citizen of the United States, at least twenty one years of age, that he has had sufficient experience with electrical equipment satisfactory to the board to handle electrical hoisting machinery and is of good repute and temperate habits. He must pass an examination as to his practical and technical knowledge of the construction of same, the care and adjustment of electrical hoisting engines, the management and efficiency of electric pumps, ropes and winding apparatus and as to his knowledge of the laws of this State in relation to signals and the hoisting and lowering of men at

mines.

Political Influence--Unfortunately, because of the political set-up in most states, the qualifications for mine inspectors and other individuals heading the department are not always sufficient for the men in whom the authority is vested for such work. Too often the various appointments are made by reason of political affiliations, and consequently, there are not as many competent men associated with the inspection departments as the laws and regulations indicate. It would be far better to have all individuals acting as servants of the state as mine inspectors under a civil service rating determined by practical experience and technical training rather than being influenced by political appointment through associations with the different political parties. In this manner the men selected for the work would not be continually harassed by the thought that they would lose their positions if they were to acquire the disfavor of local politicians, and their sole duty would be to perform their work in the manner prescribed by the law.

Because of the existing conditions in the political organizations, too many infractions or violations of the law are ignored, and as a result, hazardous conditions are allowed to exist in the mines of the various states. Quite naturally these hazards contribute to the loss of life to the men engaged in the industry.

In recent months there has been much agitation on the part of labor groups to establish a federal mine inspection bill which would give members of the United States Bureau of Mines the authority to enter coal mines and to recommend, only, safety operating procedures. Very little could be accomplished by this type of legislation because of the fact that they would have no authority to penalize the operator if the recommendations were not carried out.

Perhaps the most thorough inspection departments in the various coal producing states are those of Pennsylvania and West Virginia. The laws pertaining to coal mining have been very carefully prepared, and mine inspectors have been thoroughly trained in the proper manner of inspection. Very close attention is given to all the hazards that may exist. There is no hesitancy on the part of the inspection departments to close mines or prohibit them from operating if they do not comply with the laws concerning the hazards.

Inspections--

Examination of Mines. State inspectors must devote their whole time and attention to the duties of their respective offices. State inspectors must make a personal examination at least once in every six months or oftener if necessary, of each mine in their district in which ten or more men are employed. The State Mining Board also may require state inspectors personally to examine any or all other

mines in their respective districts. Every mine in the State should be examined at least once in every six months by either a state or county mine inspector.

Scope of Examination. Every state inspector in the regular inspection of mines measures with an anemometer and determines the amount of air passing in the last cross-cut in each pair of entries in pillar and room mines, or in the last room of each division in long wall mines. He also measures with an anemometer and determines the amount of air passing at the inlet and outlet of the mines; and he compares all such air measurements with the last report of the mine examiner and the mine manager upon the mine examination book of the mine. He observes that the legal code of signals between the engineer and top man and bottom man is established and conspicuously posted for the information of all employees.

State inspectors also require that every necessary precaution be taken to insure the health and safety of the workmen employed in the mines and that the provisions and requirements of all the mining laws are obeyed.

State inspectors render written reports of mine inspections made by them to the State Mining Board in such form and manner as required by the board. State inspectors take prompt action for the enforcement of the penalties provided for violation of the mining laws.

Authority to Enter Mines. It is lawful for state inspec-

tors to enter, examine and inspect any and all coal mines and the machinery belonging thereto, at all reasonable times, by day or by night, but so as not to unreasonably obstruct or hinder the working of such coal mine, and the operator of every such coal mine is required to furnish all necessary facilities for making such examination and inspection.

Procedure in Case of Objection. If any operator shall refuse to permit such inspection or to furnish the necessary facilities for making such examination and inspection, the inspector files his affidavit, setting forth such refusal, with the judge of the Circuit Court in said county in which said mine is situated, either in term time or vacation, or, in the absence of said judge, with the master in chancery in said county in which said mine is situated, and obtain an order on such owner, agent or operator so refusing as aforesaid, commanding him to permit and furnish such necessary facilities for the inspection of such coal mine, or be adjudged to stand in contempt of court and punished accordingly.

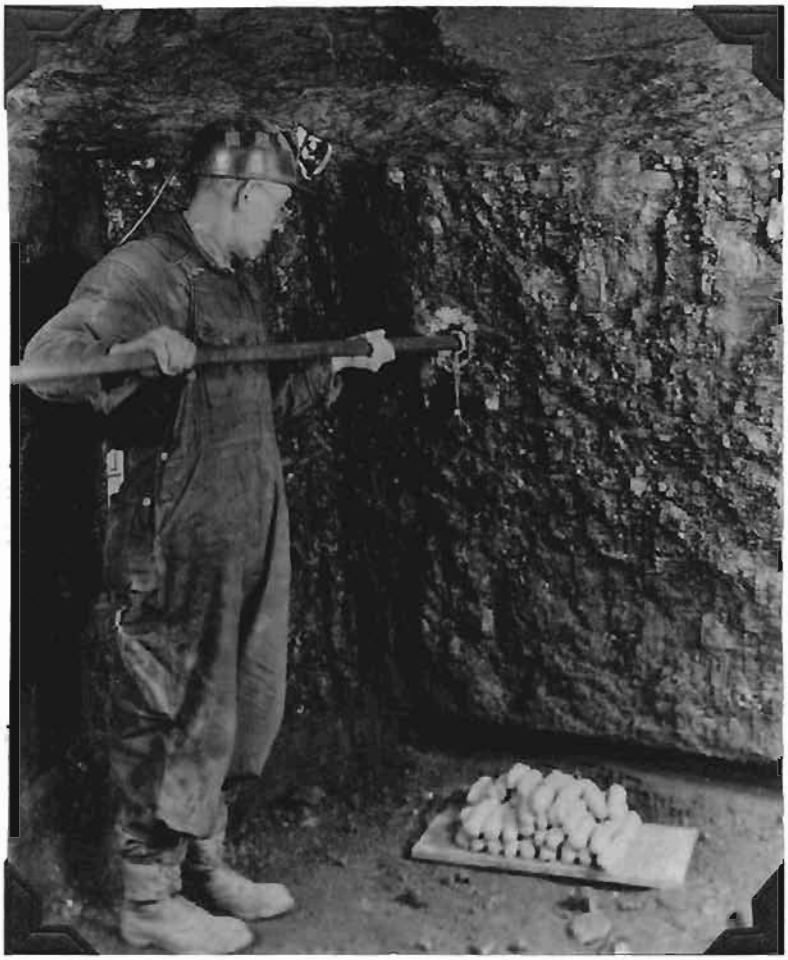
The state inspector posts in some conspicuous place at the top of each mine inspected by him a plain statement showing what in his judgement is necessary for the better protection of the lives and health of persons employed in such mine; such statement gives the date of inspection and is signed by the inspector. He posts a notice at the landing used by the men, stating what number of men is permitted to ride on the cage at one time and the rate

of speed at which men may be hoisted and lowered on the cages.

Coal Mine Disasters in the United States in which Fifty or More Men Were Killed

DATE	NAME OF MINE	LOCATION OF MINE	NATURE OF ACCIDENT	KILLED
1855	Midlothian	Coalfield, Virginia	Explosion	55
1867 April 3	Bright Hope,Clover Hill	Winterpock, Virginia	do	69
1869 September 6	Avondale	Plymouth, Pennsylvania	Mine Fire	179
1883 February 16	Diamond	Braidwood, Illinois	Inrush of surface water	69
1884 January 24	Crested Butte	Crested Butte, Colorado	Explosion	59
1884 March 13	Laurel	Pocohontas, Virginia	do	112
1891 January 27	Mammouth	Mount Pleasant, Pennsylvania	do	109
1892 January 7	No. 11	Krebs, Oklahoma	do	100
1895 March 20	Red Canyon	Red Canyon, Wyoming	do	60
1896 June 28	Twin	Pittston, Pennsylvania	Fall of Roof	58
1900 May 1	Winter Quarters 1 and 4	Scofield, Utah	Explosion	200
1902 May 19	Fraterville	Coal Creek, Tennessee	do	184
1902 July 10	Rolling Mill	Johnstown, Pennsylvania	do	112
1903 June 30	Hanna No. 1	Hanna, Wyoming	Explosion and Fire	169
1904 January 25	Harwick	Cheswick, Pennsylvania	Explosion	179
1905 February 20	Virginia City	Virginia City, Alabama	do	108
1907 January 29	Stuart	Stuart, West Virginia	do	84
1907 December 6	Monongah Nos. 6 and 8	Monongah, West Virginia	do	361
1907 December 16	Yolande	Yolande, Alabama	do	56
1907 December 19	Darr	Jacobs Creek, Pennsylvania	do	239
1908 March 28	Hanna No. 1	Hanna, Wyoming	do	59
1908 November 28	Rachel and Agnes	Marianna, Pennsylvania	do	154
1908 December 29	Lick Branch	Switchback, West Virginia	do	50
1909 January 12	Lick Branch	Switchback, West Virginia	do	67
1909 November 13	St. Paul No.2	Cherry, Illinois	Mine Fire	259
1910 January 31	Primero	Primero, Colorado	Explosion	75
1910 May 5	Palos No.3	Palos, Alabama	do	83
1910 October 8	Starkville	Starkville, Colorado	do	56
1910 November 8	Victor American No.3	Delagua, Colorado	Mine Fire and Explosion	79
1911 April 7	Price-Pancoast	Throop, Pennsylvania	Mine Fire	72
1911 April 8	Banner	Littleton, Alabama	Explosion	128
1911 December 9	Cross Mountain	Briceville, Tennessee	do	84
1912 March 20	San Bois No.2	McCurtain, Oklahoma	do	73

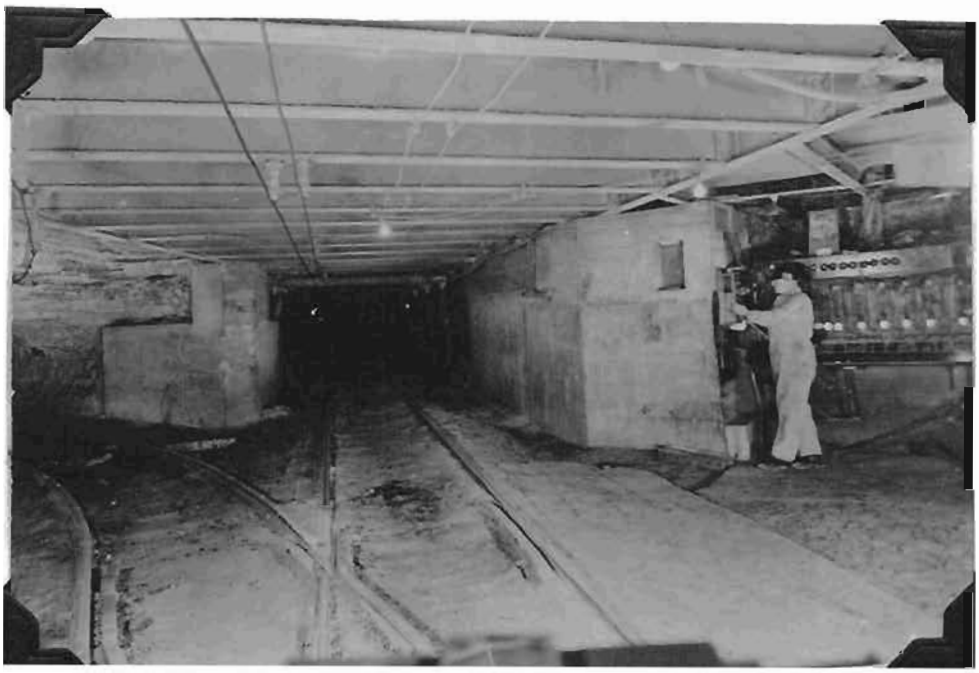
DATE			NAME OF MINE	LOCATION OF MINE	NATURE OF ACCIDENT	KILLED
1912	March	26	Jed	Jed, West Virginia	Explosion	81
1913	April	23	Cincinnati	Finleyville, Pennsylvania	do	96
1913	October	22	Stag Canon No.2	Dawson, New Mexico	do	263
1914	April	28	Eccles Nos. 5 and 6	Eccles, West Virginia	do	181
1914	October	27	North or No. 1	Royalton, Illinois	do	52
1915	March	2	Layland No.3	Layland, West Virginia	do	112
1917	April	27	Hastings	Hastings, Colorado	do	121
1917	August	4	West Kentucky No.7	Clay, Kentucky	do	62
1919	June	5	Baltimore Tunnel No.2	Wilkes-Barre, Pa.	Powder Explosion	92
1922	November	6	Reilly No.1	Spangler, Pennsylvania	Explosion	77
1922	November	22	Dolomite No.3	Dolomite, Alabama	do	90
1923	February	8	Stag Canon No.1	Dawson, New Mexico	do	120
1923	August	14	Frontier No.1	Kemmerer, Wyoming	do	99
1924	March	8	No.2	Castle Gate, Utah	do	171
1924	April	28	Benwood	Benwood, West Virginia	do	119
1925	February	20	City	Sullivan, Indiana	do	52
1925	May	27	Farmville	Coal Glen, North Carolina	do	53
1925	December	10	Overton No.2	Acmar, Alabama	do	52
1926	January	13	No.21	Wilburton, Oklahoma	do	91
1927	April	30	Federal No.3	Everettville, West Virginia	do	97
1928	May	19	Mather No.1	Mather, Pennsylvania	do	195
1929	December	17	Old Town	McAlester, Oklahoma	do	61
1930	November	5	No.6	Millfield, Ohio	do	79
1932	December	23	Shafer	Moweaqua, Illinois	do	54
1940	January	10	Bartley Mine,Pine Creek Pocahontas Co.,McDowell	County, West Virginia	do	91
1940	March	16	Willow Grove Mine	Neffs, Ohio	do	72
1940	July	15	Sonman Mine	Cambria County, Pa.	do	63



TAMPING HOLE PREPARATORY TO SHOOTING

Note the incombustible clay dummies
and wooden tamping bar.

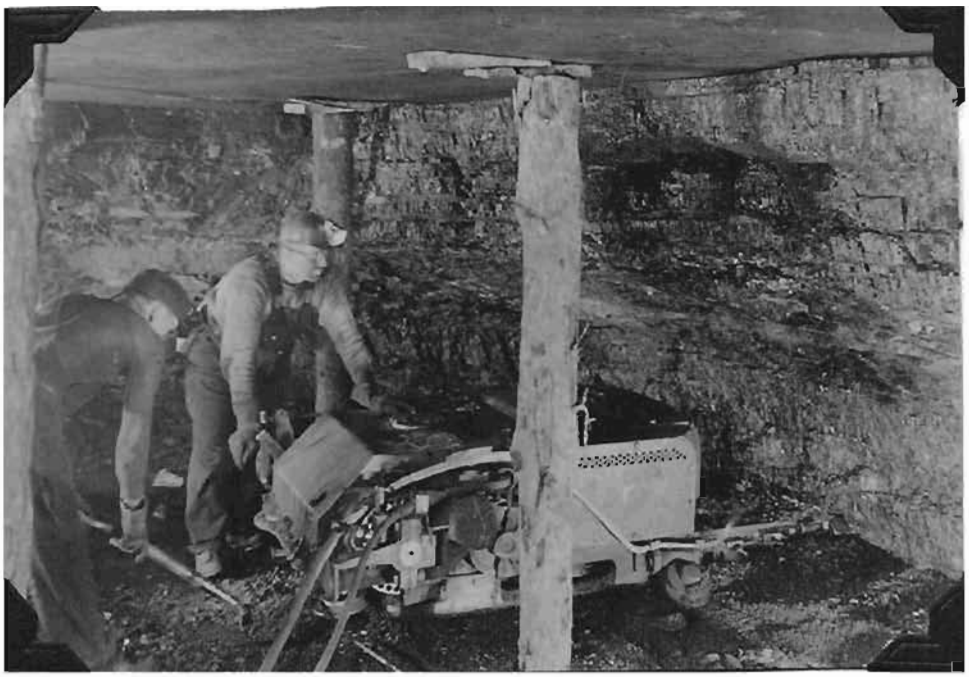
WELL TIMBERED PLACE
Note proper clearance maintained on each side of track
and safety posts at face.



Note timbering of steel I beams
and lagging at junction on main haulage road.
Note concrete retaining walls for pillar
to prevent rashing of coal.

CAREFUL EXAMINATION OF ROOF NECESSARY
Note mine foreman carries flame safety lamp,
sounding rod, and wears electric cap lamp.
Note also block used for blocking mine cars at the face.

SOUNDING ROOF
Necessary at frequent and regular intervals
with mechanical loading units.



PROPER TIMBERING AT FACE DURING CUTTING OPERATIONS
Note water spray on cutterbar used to allay the dust.

B I B L I O G R A P H Y

Information Circulars Book No.5.....
Published January, 1939 by United States Bureau of Mines
United States Department of the Interior.
Page 6986

Information Circulars Book No.2.....
Published April, 1933 by United States Bureau of Mines
United States Department of the Interior.
Pages 23-28

A Compilation of the Coal Reports of Illinois 1882-1930
Published by the Department of Mines and Minerals in 1930.
Page 68

Coal Mine Accidents in the United States 1930 .....
By---W. W. Adams, L. E. Geyer and L. Chenowith
Published by United States Department of Commerce, Bureau of Mines in 1932.
Pages 94-100

Coal Mine Accidents in the United States 1936.....
By--W. W. Adams, L. E. Geyer and M. G. Parry
Published by United States Department of Commerce, Bureau of Mines in 1939.
Pages 117

General Mining Laws.....
Published July, 1937 by the Department of Mines and Minerals, Illinois.
Pages 8-19

Report of Investigations....1930-1938.....W. W. Adams
Published December, 1940 by the United States Bureau of Mines
Page 1

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