Report of Investigation
Underground Coal Mine Explosions

U.S. Department of Labor
Mine Safety and Health Administration
1993

Scotia Mine
I.D. No. 15-02055
Scotia Coal Company
Ovenfork,
Letcher County,
Kentucky

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UNITED STATES
DEPARTMENT OF LABOR
MINE SAFETY AND HEALTH ADMINISTRATION
OFFICE OF THE ADMINISTRATOR
COAL MINE SAFETY AND HEALTH

REPORT OF INVESTIGATION
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Scotia Mine - ID. No. 15-02055
Scotia Coal Company
Ovenfork, Letcher County, Kentucky

March 9 and 11, 1976

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Release Date: August 11, 1993

INFORMATIONAL NOTICE

In September 1977, the Mining Enforcement and Safety Administration (MESA), Department of the Interior, was prepared to release its Accident Report concerning the March 9-11, 1976 twin explosions at the Scotia Coal Company's Scotia Mine which killed 26 people. Scotia and its parent company, Blue Diamond Coal Company, filed suit in federal district court to enjoin release of the Report based on a claim of prejudicial harm to its defense of pending tort litigation. After a preliminary order enjoining release of the Report to consider the legal challenge, Federal District Court Judge H. David Hermansdorfer issued a December 17, 1977 order that the Report could not be released unless an explanatory paragraph or caveat was added to it. On January 24, 1978, the Judge affirmed his December 17, 1977 decision. These events occurred when mine safety and health jurisdiction resided with the Department of the Interior.

After transfer of the mine safety and health program to the Department of Labor in March 1978, the Labor Department reviewed the Report and determined that the caveat to the Report was inappropriate and renewed legal action to have the January 1978 ruling reversed. However, because of other priority litigation relating to the explosion the effort to remove the caveat was informally stayed and the Report sealed (except for <u>in camera</u> use by certain attorneys) pending resolution of administrative civil penalty cases and criminal indictments pending against Blue Diamond and Scotia. The civil penalty action and criminal indictments against Scotia have been resolved as well as the various federal tort suits. The Report litigation, which was inactive during this period, was then reactivated. After further proceedings, the District Court for the Eastern District of Kentucky ruled on June 14, 1985, that the Report could be released after all explosion-related litigation was concluded (at this time, two state court actions remained pending). However, the court further ruled that any release must contain the caveat, which the court found to be informational rather than restrictive. At this point it was decided that no further appeals would be taken. The matter lay in this posture while the last of the pending state tort suits were being litigated to conclusion. The Department was notified in August 1992 that all pending tort litigation had been concluded. Therefore, the Report may now be publicly released.

Because the Department believes that the Report is an accurate account of what facts could be determined by the accident investigation, and is of historical and current value, the Report is being released to the public. While disagreeing with the District Court orders of December 1977, January 1978 and June 1985, but for the purpose of compliance with those orders, we have included the caveat in the Report. This informational statement is provided to fully explain the circumstances of its inclusion and the 15 year delay in the release of this Report.

August 11, 1993

COURT ORDER CAVEAT

NOTICE: This Report is the subject of a pending legal action in the United States District Court for the Eastern District of Kentucky in the case of Blue Diamond Coal Co. v. Secretary of the Interior, et al. It has been adjudged in that action that there exist the appearances of agency impropriety which arguably affect the trustworthiness of this Report. The Report has been remanded to the Secretary for reconsideration.

January 24, 1978

Abstract

This report is based on an investigation made pursuant to the Federal Coal Mine Health and Safety Act of 1969 (83 Stat. 742).[1]

Two gas and coal dust explosions, the first at approximately 11:45 a.m., March 9, 1976, and the second at approximately 11:30 p.m., March 11, 1976, occurred in the 2 Southeast Main area of the Scotia Mine, Scotia Coal Company, Ovenfork, Letcher County, Kentucky. All 15 Men working in the 2 Southeast Main area at the time of the first explosion died as a result of the explosion. Ninety-one men in other parts of the mine at that time reached the surface without mishap. At the time of the second explosion, 13 men were underground near the entrance of 2 Southeast Main; 11 died as the result of the explosion and 2 repairmen working a short distance outby escaped without injury.

The names of the victims, their ages, occupations, training, and experience are listed in Appendix A.

MESA investigators believe that the first explosion originated near No. 31 crosscut in 2 Southeast Main when a mixture of methane and air was ignited by an electric arc or spark from a battery-powered locomotive. Forces of the explosion spread to all five 2 Southeast Main entries, extended into 2 Left Section off 2 Southeast Main and dissipated as they reached the Northeast Main junction. See mine map in Appendix D.

MESA investigators believe that the second explosion originated near the entrance of or in 2 Left Section off 2 Southeast Main when a methane-air mixture was ignited by one of five possible sources: an electric arc or spark from a battery-equipped deluge system; three battery-equipped telephones; scoop batteries; residual fires; or a frictional spark from a fall of mine roof on a roof-bolting machine. The forces of the explosion extended throughout 2 Left Section and all five entries of 2 Southeast Main, spread north and south in all entries in both panels of Northeast Main, and dissipated near the junction of 3 Southeast Main in the northern direction and near the junction of Southeast Main in the southern direction. See mine map in Appendix E.

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[1]In May 1973, the enforcement agency was removed from the Bureau of Mines and became the Mining Enforcement and Safety Administration (MESA), Department of the Interior. The Federal Mine Safety and Health Amendments Act of 1977, effective March 9, 1978, redesignated the enforcement agency as the Mine Safety and Health Administration (MSHA) and placed the agency under the Department of Labor.

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PART I

GENERAL INFORMATION

The Scotia Mine, Scotia Coal Company, is located near Ovenfork in Letcher County, Kentucky, on the Poor Fork of the Cumberland River, approximately 14 miles northeast of Cumberland, Harlan County, Kentucky.

The Scotia Coal Company is a wholly-owned subsidiary of the Blue Diamond Coal Company, Knoxville, Tennessee.

Following is a list of Blue Diamond corporate officials:

Gordon Bonnyman	President
Dr. Frank C. Thomas	Executive Vice President
Jasper K. Cornett	Vice President, Operations
R. D. Cornwell	General Manager of Mines

Following is a list of management officials of the Scotia Mine at the time of the occurrences:

Freddie Maggard	General Superintendent
Richard Carter	Assistant Superintendent
Richard Combs	General Mine Foreman
Garland Couch	Chief Electrician
Charles Kirk	Safety Inspector

The Scotia Mine was started in July, 1962. It was originally opened by nine slope entries into the Imboden coalbed which averages 72 inches in thickness locally. The slope entries were developed into the coalbed and inclined due to the pitching characteristic of the coalbed from its outcrop. The outcrop slope entries, South Main, dip approximately 5 percent for a distance of about 1,400 feet from the surface. The entries then dip about 1.5 percent for an additional 4,000 feet to the 1 West Main. Inby this point for a distance of approximately 8,500 feet, the coalbed is relatively even with occasional dips and rises. The coalbed south of Northeast Main rises on a 2 percent grade.

In 1975, an additional opening in the form of a concrete-lined 13.5-foot diameter shaft, 376 feet deep, was raise-bored near the face areas of Northeast Main. The lining of the shaft was completed July 21, 1975, and work was begun to install an automatic elevator. On March 9, 1976, such work had not been completed and the shaft was being used only as an intake air opening.

Of 310 employees, 275 worked underground on two coal-producing shifts and one maintenance shift per day, 5 days a week. Approximately 2,500 tons of coal were produced daily on six active sections, consisting of five continuous mining sections and one conventional mining section.

A standard channel sample of coal taken in 2 Southeast Main by MESA personnel was analyzed by the Bureau of Mines Laboratory in Pittsburgh, Pennsylvania, as follows:

	Percent
Moisture	1.9
Volatile Matter	29.3
Fixed Carbon	44.9
Ash	23.9

Numerous tests by the Bureau of Mines have established that coal dust having a volatile ratio of 0.12 and higher is explosive. The volatile ratio of the coal in 2 Southeast Main is 0.395.

The last Federal inspection of the entire mine was completed on February 27, 1976. When the 2 Southeast Main area was examined during that inspection, the main entries were being developed. Sometime in February they were stopped and the mining equipment was moved out and utilized to start the 2 Left Section off 2 Southeast Main. A list of the number of MESA inspection mandays and the number of Notices of Violation and Orders of Withdrawal issued from May 13, 1970, to March 9, 1976, is in Appendix P.

On March 8, 1976, on the evening shift, a Federal Coal Mine Inspector conducted a Health and Safety Technical Inspection on 2 Left Section off 2 Southeast Main.

MINING METHODS, CONDITIONS AND EQUIPMENT

Mining Methods

Coal was being extracted by the room-and-pillar system of mining. Pillar extraction was conducted as part of the mining sequence. Entries, rooms and crosscuts were driven approximately 18 feet wide on 64- to 96-foot centers. The sections being worked were: 1 West Main, 1-1/2 Right 2 East, Southeast Main, Left Panel Southeast Main, 2 Left off 2 Southeast Main and Right Panel Northeast Main.

The immediate roof was generally weak shale. Roof bolts had been installed on a full pattern throughout the mine and posts, cribs and crossbars supplemented the roof bolts in many locations. For approximately 2 years preceding the accident, resin-grouted roof bolt rods were installed on a full pattern throughout.

Ventilation

Mine ventilation was induced by a Jeffrey-8 HU-96 Aerodyne fan exhausting in the 4B-4S blade position. The fan was installed on the surface and was exhausting approximately 225,000 cubic feet of air a minute at 6.2 inches water gauge pressure. Approximately 175,000 cubic feet of air a minute was intaking at the main slope openings and 50,000 cubic feet of air a minute was intaking at the 13.5-foot diameter air shaft in the

Northeast Main area. The fan was V-belt driven by a 500-horsepower electric motor which rotated at approximately 900 rpm.

The Nos. 1 and 2 entries of the main slope entries were return aircourses. A belt conveyor was installed in the No. 3 entry and Nos. 4, 5 and 6 entries were intake aircourses. The Nos. 1 and 2 entries were badly restricted by falls of roof. In order to provide additional escapeways and return aircourses for the mine, three entries had been driven from the surface adjacent to and parallel with the slope return aircourses from a distance of approximately 2,000 feet to intersect the old left panel entries of the South Main. Stoppings had been erected in these left panel entries to isolate the new returns from the remainder of the mine until such time as the necessary work was completed to connect them to the mine return system. This area was isolated at the time of the explosions. Ventilation for the new returns during development and at the time of the explosions was induced with a Jeffrey 48-inch fixed blade fan exhausting approximately 46,000 cubic feet of air a minute.

Each of the six working sections was ventilated with a separate split of air. Overcasts and permanent stoppings were constructed of incombustible material. Line brattice was used to direct ventilation to the working faces. According to Federal inspection reports of 1975, the total mine methane liberation was 568,000 cubic feet in a 24-hour period. An air sample collected during the last Federal inspection completed February 27, 1976, showed that the 2 Southeast Main area was liberating 69,000 cubic feet of methane in a 24-hour period.

Preshift examinations were reportedly made and were recorded. The mine was operating two coal-producing and one maintenance shift per day. One fire boss was assigned to examine the mine prior to the first coal-producing shift each day and the first shift following an idle period. The preshift examinations for succeeding shifts were made by certified persons during their regular tour of duty. On-shift and weekly examinations were made by certified on-shift examiners. The results of examinations for methane and other hazards were recorded in books on the surface.

Testimony presented during the public hearings conducted at Whitesburg, Kentucky, before a special panel appointed by the Secretary of the Interior to determine the causes of the explosions indicated that the recording of preshift examinations on the non-coal producing shifts was highly irregular and that the examinations themselves were perfunctory and incomplete.

The mine was operating pursuant to a Ventilation System and Methane and Dust Control Plan which had been most recently approved on June 25, 1975. Subsequently, supplemental dust control plans were submitted by the operator and approved by the MESA District Manager. As required by law, the ventilation plan was submitted by the operator for review during January, 1976.

This plan contained discrepancies in the location of some of the ventilation controls and was returned to the operator for revision. A revised plan was submitted and received by the District Manager on March 1, 1976. It was being evaluated at the time of the first explosion. The approved plan of June 25, 1975, required that a minimum of 9,000 cubic feet of air a minute pass through the last open crosscuts and at the intake end of the pillar lines. A minimum of 3,000 cubic feet of air a minute was required to be delivered within 10 feet of the deepest point of penetration of the working faces where mining operations were in progress. Plastic brattice material was used to provide face ventilation on all sections, with an exhaust system used on the continuous mining sections and a blowing system used on the conventional mining section. A bleeder system was provided for second mining areas.

The 2 Southeast Main entries rose on a 2 percent grade and had been advanced approximately 3,700 feet inby the Northeast Main. The ventilation system utilized the Nos. 1 and 2 entries as return aircourses, No. 3 as the belt entry, and Nos. 4 and 5 entries as intake aircourses. The mining height (8 feet plus) encountered in the face areas made for difficult mining with the available equipment so the operator decided to move the equipment back and start the 2 Left Section. In early February, 1976, the 2 Left Section was started off the return entries of 2 Southeast Main before permanent ventilation was established. Access to the 2 Left Section was gained by removing two permanent stoppings, one betw the track (No. 4 entry) and belt entry (No. 3 entry) and one between the belt entry and the No. 2 return entry at No. 23 crosscut, 2 Southeast Main. A check curtain was installed between the Nos. 3 and 4 entries to course ventilation up through the 2 Southeast Main entries and back to the 2 Left Section. During the public hearings, there was abundant testimony that the check curtain was maintained only intermittently and in a haphazard manner and that little effort had been made to maintain it at all after the track was laid into 2 Left Section. Miners who worked on 2 Left Section testified that on the evening prior to the first explosion they were sent by the section foreman to install check curtains across the two intake entries of 2 Southeast Main inby 2 Left when the Federal Coal Mine Inspector issued a Notice of Violation for insufficient air in the last open crosscut. They stated that the check curtains were taken down at the end of the shift. Construction of overcasts at the entrance of 2 Left Section was in progress at the time of the March 9 explosion.

During the last Federal inspection of the entire mine, completed February 2 1976, Notices of Violation were issued when a Federal Coal Mine Inspector found less than 9,000 cubic feet of air a minute reaching the last open crosscut in three of the active working sections. The air was promptly increased to more than 9,000 cubic feet a minute and the Notices of Violation were terminated.

On the evening shift of March 8, 1976 (the evening before the first explosion), a Federal Coal Mine Inspector made a Health and Safety Technical Inspection on 2 Left Section off 2 Southeast Main. During the course of this inspection three Notices of Violation were issued pursuant to Section 104(b) of the Act, two of which were for noncompliance with ventilation regulations. One was for failure to maintain the line brattice to within

10 feet of the face, the other for failure to maintain 9,000 cubic feet of air a minute passing through the last open crosscut. The line brattice was extended to within 10 feet of the face and the air passing through the last open crosscut was increased to 10,472 cubic feet a minute. The Notices of Violations were terminated.

The track haulage entries, separated from belt conveyor entries and return entries, were designated intake escapeways. The belt conveyor entries, except for portions driven prior to December 31, 1969, were separated from intake and return air entries and ventilated by separate splits of air. There were no bare trolley or trolley feeder wires in the mine.

There were no oil or gas wells on the mine property.

Coal Dust

During a Health and Safety Inspection conducted January 5, 1976, through February 27, 1976, the surfaces of the Scotia Mine ranged from damp to wet. Nine 104(b) Notices of Violations were issued during this inspection for accumulations of loose coal, coal dust and float coal dust on previously rock-dusted surfaces. Dust samples collected on surveys of the 2 Southeast Main area during previous inspections had revealed the rock dust to be adequate. During the Health and Safety Technical Inspection conducted on the evening shift prior to the first explosion, the inspector found rock dust to be adequate in 2 Left Section.

Water was used to allay dust during cutting and loading operations. The cleanup was accomplished by shoveling the loose coal and coal dust from the ribs by hand and loading it with battery-powered scoops. Rock dust was initially applied to the mine surfaces by hand. This initial application was followed by rock dusting utilizing battery-powered pneumatic rock-dusting machines.

Electricity

Three-phase power at 69,000 volts was purchased from Kentucky Power Company, reduced to 12,470 volts and transmitted to a surface substation near the mine portal. At the surface substation, electric power was reduced to 7,200 volts by a bank of three 1,250-kVA single-phase transformers for underground distribution. The transformers were connected delta-wye and the secondary neutral was grounded through a 25-ampere current-limiting resistor. A grounding circuit originating at the grounded side of the resistor was used to ground metallic frames of all high-voltage equipment served from the circuit.

A 600-ampere oil circuit breaker in the surface substation was equipped with a ground check monitor circuit and relaying designed to provide overload, short-circuit, grounded-phase and undervoltage protection for the high-voltage underground circuit.

The three-phase high-voltage circuit entered the mine by means of shielded No. 4/0 AWG, three-conductor cable installed in a borehole located within the surface substation.

An air-break disconnecting switch was installed in the high-voltage circuit at the bottom of the borehole. Portions of the underground high-voltage circuit consisted of Nos. 4/0, 2/0, and No. 2 AWG, three-conductor, high-voltage cable, all of which were equipped with metallic shielding around each power conductor. A one-line diagram of the high-voltage power system from the surface substation to 2 Left Section off 2 Southeast Main power center is contained in Figure 1 of Appendix J.

A "Y"-box was installed at the beginning of the high-voltage branch circuits extending to the coal-producing sections. One of the "Y"-boxes contained two oil circuit breakers with an oil circuit breaker connected in the branch circuit and an oil circuit breaker connected in the main circuit. Each circuit breaker was equipped with devices to provide short-circuit, overload and grounded-phase protection for the high-voltage circuits extending inby the "Y"-box. Two ground check devices were provided to monitor the continuity of the grounding circuit for the high-voltage circuits extending inby from the "Y"-box. These ground check devices also provided undervoltage protection for the inby high-voltage circuits. High-voltage cable couplers installed on the "Y"-box provided visual evidence of circuit deenergization for the inby high-voltage circuits.

Each of the remaining four "Y"-boxes contained two three-pole fused disconnect switches. These switches provided visible evidence of circuit deenergization and were equipped with devices to provide grounded-phase and undervoltage protection. Current-limiting fuses (rated at 160 or 200 amperes) in conjunction with the switches provided overload and short-circuit protection for the inby circuits. Each "Y"-box was also equipped with ground check circuits to provide ground check monitoring for the circuits extending inby.

The 23 portable power centers in the mine ranged in size from 112.5-kVA to 500-kVA. These power centers reduced the 7,200-volt alternating current to 480-volt alternating current for the operation of 18 belt conveyor drive units, 29 pumping stations, five battery-charging stations and the electric equipment of the six coal-producing sections.

The portable power centers which supplied power to the belt conveyor drive units, drainage pumps and battery chargers were equipped with molded-case circuit breakers which had devices that provided short-circuit, grounded-phase and undervoltage protection for the 480-volt circuits originating at the power centers. In most cases, the overload protection was provided in the controllers for the loads served by the power centers.

The section power centers supplied three-phase, 480-volt power to section distribution boxes which in turn supplied three-phase, 480-volt power to the electric equipment on the sections. The section power centers were equipped with molded-case circuit breakers which had devices that provided short-circuit, grounded-phase and undervoltage protection for the circuits originating at the power centers. The section distribution boxes were equipped with molded-case circuit breakers which had devices that provided short-circuit and grounded-phase protection for the trailing cables extending to the electric face equipment and other electric equipment on the sections.

Transportation

Coal was transported from the face areas in shuttle cars and transferred to belt conveyors on which the coal was transported to the preparation plant located on the surface near the mine portal. Mine supplies were transported in open mine cars pulled by battery-powered, track-mounted locomotives. Trolley wire was not utilized in the mine.

Men were transported underground in closed self-propelled, battery-powered, track-mounted personnel carriers and/or open cars pulled by battery-powered, track-mounted locomotives.

Communication

Communication between various points in the mine and the surface was accomplished by the use of permissible-type Mine Safety Appliances telephones, Approval 9B-8, installed at necessary locations throughout the mine and at surface facilities and interconnected by means of two-conductor telephone line.

Fire Protection

The company's program of instruction, location and use of firefighting equipment; location of escapeways, exits and routes of travel; and evacuation procedures and fire drills was received by the District Manager on July 17, 1974, and approved September 5, 1974. Evacuation maps showing escape routes were posted on each working section.

Adequate firefighting facilities were provided at the mine. Suitable fire extinguishers were kept on each working section and at each electrical installation. Water for dust-allaying and firefighting purposes was to be provided from a 200,000-gallon tank located on the hill approximately 225 feet above the mine portal. Four-inch pipe was used to transport water underground and two-inch pipe was used on each active section. In addition, all belt drives were provided with automatic deluge systems designed to activate in the event of a belt drive fire. These units normally operated from a 110-volt a.c. power line. A standby power source, consisting of two 6-volt Globe GC680 Gel/Cell 7.5 ampere-hour rechargeable batteries connected in series, was enclosed in the control box. Firefighting facilities were not needed during the recovery operations.

Explosives

Supplies of permissible explosives and electric detonators were stored in separate magazines located on the surface. Explosives and detonators were transported into the mine in a specially constructed track-mounted car pulled by a battery-powered locomotive. Underground explosives-storage magazines were provided in 1 West Main Section and at the intersection of Northeast Main and 2 Southeast Main. The car for transporting explosives had exposed metal inside. Explosives and detonators were stored in their original containers at several locations underground.

Coal was mined in 1 West Main Section with conventional equipment using permissible explosives for blasting coal. Shots were fired with a permissible-type shot-firing unit. Explosives were used on construction projects throughout the mine.

Training Program - Medical Assistance Program

The proposed training plan for 1976 was received by the District Manager on December 23, 1975, and approved January 26, 1976. The approved program provided that all required training be completed using approved materials and techniques, qualified instructors and properly maintained records. Many miners stated that they had received little or no training, particularly in the use of self-rescue devices, nor had they participated in a program of instruction relative to firefighting and evacuation plans. Scheduled training classes were poorly attended; some were unattended. The operator's Safety Inspector had nonetheless certified in the operator's plan for evacuation and firefighting that the employees of the Scotia Mine had participated in such a program prior to submittal of the plan.

Arrangements were made for 24-hour ambulance service. Also, an ambulance was available on the mine property. Arrangements were made with physicians to treat injured personnel. Patients requiring hospitalization were taken to the Whitesburg Appalachian Regional Hospital, Whitesburg, Kentucky, or the Valley View Community Hospital, Benham, Kentucky.

Illumination and Smoking

Permissible-type electric cap lamps were used for portable illumination in the mine. The operator's program to prevent smoking in the mine and smoking materials from entering the mine was submitted to the District Manager on April 6, 1970. The program provided for a notice to be posted on the bulletin board notifying all employees that they were not allowed to carry smoking materials, matches or lighters into the mine. In addition, each employee was to be advised by his immediate supervisor that violation of this order would subject him to a personal fine. Searches were to be made weekly or more often if necessary to assure compliance. Records of these searches were to be kept and made available to interested persons.

Mine Rescue

The Scotia Coal Company did not maintain a mine rescue team. Prior to the first explosion, self-contained breathing equipment had been ordered by the operator and plans had been made to train a mine rescue team as soon as the equipment was received.

Employees were to carry one-hour Drager or MSA self-rescuers.

According to the last Federal inspection of the entire mine, completed February 27, 1976, adequate escapeways were available from the working sections to the surface. The check-in and check-out system consisted of placing a metal check corresponding to the miner's lamp number on a check-in board. An examination of the lamp racks provided a double check.

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PART II

EXPLOSION AND RECOVERY OPERATIONS, MARCH 9, 1976

Participating Organizations

Officials of the several organizations who assisted in directing the recovery operations include: Jasper K. Cornett, Vice President, Operations, and R. D. Cornwell, General Manager of Mines, Blue Diamond Coal Company; Freddie Maggard, General Superintendent, Scotia Coal Company; Harreld N. Kirkpatrick, Commissioner, Kentucky Department of Mines and Minerals; Robert E. Barrett, Administrator, and John W. Crawford, Assistant Administrator, Coal Mine Health and Safety, Mining Enforcement and Safety Administration.

Ten mine rescue teams from the following organizations participated in the recovery operations:

Westmoreland Coal Company, Big Stone Gap, Virginia (2 teams)
Beth Elkhorn Corporation, Jenkins, Kentucky (2 teams)
International Harvester, Benham, Kentucky
U. S. Steel Corporation, Lynch, Kentucky
Clinchfield Coal Company, Dante, Virginia
National Mines Corporation, Wayland, Kentucky
Mining Enforcement and Safety Administration (2 teams)
Morgantown, West Virginia, and Pittsburgh, Pennsylvania

Names of the mine rescue team members and other persons who participated in the recovery operations are listed in Appendix B.

Activities of MESA Personnel

At 12:26 p.m., March 9, 1976, Charles Kirk, the Scotia Safety Inspector, reported the occurrence of an ignition in the mine to the Whitesburg, Kentucky, MESA Field office. Federal Coal Mine Inspector Cecil Davis was dispatched to the mine and the District Manager, Coal Mine Health and Safety District 6, Pikeville, Ky., was notified. Minutes later, Kirk reported the occurrence to be an explosion with 15 of the 106 men underground unaccounted for. Herman Lucas, Federal Coal Mine Inspection Supervisor; Rick Keene, Mining Engineer; Jack Collins and John South, Federal Coal Mine Inspectors, left immediately for the mine, and the District Manager was informed of the situation at 12:45 p.m. The District Manager notified the headquarters office of MESA in Arlington, Va., at 12:50 p.m. He then called for the assistance of mine rescue teams from nearby coal mining companies and dispatched other District personnel to the mine.

MESA headquarters office ordered the MESA mine rescue teams in Morgantown, West Virginia, and Pittsburgh, Pennsylvania, to be airlifted to the area and the Mine Emergency Operations Plan was initiated. The Arlington office notified the District Manager of Coal Mine Health and Safety District 5 in Norton, Virginia, of the emergency and instructed him to contact mine rescue teams in southwestern Virginia for their assistance, and to then proceed to the mine with key personnel.

Federal Inspector Davis arrived at the mine approximately 1:10 p.m., March 9, 1976. Davis was the first MESA official to arrive at the mine following the explosion. He verbally issued an Order of Withdrawal for the entire mine and posted a MESA "red tag" at the mine portal. Davis immediately checked the fan and found it to be operating normally. He checked the fan discharge for smoke, methane and carbon monoxide content. Smoke was not observed, the methane content was 0.2 percent and the carbon monoxide content was 80 parts per million. A written Order of Withdrawal pursuant to Section 103(f) of the Act was issued by B. A. Taylor, Federal Coal Mine Inspection Supervisor, at approximately 3:00 p.m.

MESA officials Lucas, Keene, Collins and South arrived at the mine at approximately 1:15 p.m. Federal Inspectors began monitoring the fan continuously. A short time later Everett Bartlett, Hazard District Supervisor, Kentucky Department of Mines and Minerals, arrived at the mine. A surface control center was established in the mine office and Lucas assumed direction of MESA activities. A system to record all recovery operation activities was established.

Approximately 3:15 p.m., Bill W. Clemons, Assistant District Manager, District 6; and W. R. Compton, District Manager, Monroe West, Subdistrict Manager, and James V. Bowman, Coal Mine Technical Specialist (Ventilation), District 5, Norton, Virginia, arrived at the mine. A short time later Charles Sample, Coal Mine Inspection Supervisor, District 7, arrived at the mine. Clemons assumed direction of MESA activities being conducted from the surface control center.

The approximate time each mine rescue team arrived at the mine was as follows:

International Harvester Team, Benham, Ky. - 3:00 p.m.
Westmoreland Coal Company, No. 1 Team, Big Stone Gap, Va. - 3:00 p.m.
U. S. Steel Corporation Team, Lynch, Ky. - 3:19 p.m.
Westmoreland Coal Company, No. 2 Team, Big Stone Gap, Va. - 3:30 p.m.
Beth Elkhorn Corporation, Nos. 26 and 29 Mine Teams, Jenkins, Ky. - 6:00 p.m.
Clinchfield Coal Company Team, Dante, Va. - 6:30 p.m.
National Mines Corporation Team, Wayland, Ky. - 6:00 p.m.
MESA (2 teams), Morgantown, W.Va.; Pittsburgh, Pa. - 10:00 p.m.

Approximately 5:20 p.m., Harreld N. Kirkpatrick, Commissioner, and Sam Johnson, Assistant to the Commissioner, Kentucky Department of Mines and Minerals, arrived at the mine.

Approximately 8:30 p.m., Robert E. Barrett, Administrator, MESA, John W. Crawford, Assistant Administrator, Coal Mine Health and Safety, and Robert G. Peluso, Assistant Administrator, Technical Support, arrived at the mine.

Mining Conditions Immediately Prior to the Explosion

The weather on March 8, 9 and 10, 1976, was cold and cloudy. By late evening on March 11, it was clear and the temperature had increased from 32° to 50° Fahrenheit. The temperatures and barometric pressures for this period of time recorded at the U. S. Department of Commerce National Weather Service, F.A.A. Station, London, Ky., which is about 70 air miles from the Scotia mine, were as follows:

Date	Time	Temperature (°F)	Barometric Pressure
March 8	7:55 a.m.	32°	28.84
March 9	11:55 a.m.	41°	28.36
March 10	7:55 a.m.	37°	28.74
March 11	11:58 p.m.	50°	28.79

MESA investigators believe that the slight change in atmospheric pressure did not contribute materially to the explosion.

The 2 Southeast Main entries were developed about 3,700 feet from the Northeast Main junction. The height of the entries in the faces, including coal and impurities, had increased from a normal height of 6 feet to about 8 feet. According to statements from company officials the working height and the size of the mining equipment were not compatible so the company decided to stop development of 2 Southeast Main and move the equipment into 2 Left Section. The mining equipment was moved back and 2 Left Section was activated in early February, 1976. It was worked for a period of about one month without installing permanent ventilation controls (overcasts or airlock doors) which would have provided positive ventilation in 2 Southeast Main inby 2 Left Section. Overcasts were under construction when the explosion of March 9 occurred. Concrete-block stoppings were removed at No. 23 crosscut between the Nos. 2 and 3, and 3 and 4 entries to permit entry into the Section. Reportedly, a plastic check curtain was installed across the latter opening to control the air current.

According to his testimony given at the official hearings, James Bentley, Assistant Mine Foreman in charge of ventilation, made a weekly inspection of 2 Southeast Main and the 2 Left Section on the day shift of March 8, 1976. He stated that he made tests for methane with a "gas meter" at several locations in 2 Southeast Main inby 2 Left and at the faces of each of the five entries. He also made tests for methane in each of the five faces in 2 Left Section. The highest methane content detected in these areas was 0.3 percent. He stated that he did not take air quantity measurements in either of these areas, but an air measurement of 17,820 cubic feet a minute was taken at the 2 Southeast Main regulator located in No. 1 entry near the Northeast Main junction. Bentley stated initially that there was no check curtain in the No. 23 crosscut between Nos. 3 and 4 entries, 2 Southeast Main, across the track going into 2 Left Section. Later in his testimony, he stated that there was a partially erected check curtain at this location. He instructed the brattice men who were working nearby to repair the check curtain and to make sure it was kept up. This check curtain controlled the air current that ventilated 2 Southeast Main inby 2 Left Section.

On March 8, 1976, at approximately 2:00 p.m., Cecil Davis, Federal Inspector, arrived at the mine to conduct a Health and Safety Technical Inspection of the 2 Southeast Main Section. His primary assignment and purpose for this inspection was to observe respirable dust control practices during mining operations and to collect respirable dust samples. After talking to company officials he learned that the mining equipment had been moved out of the 2 Southeast Main Section and moved into the 2 Left Section. He entered the mine and arrived on 2 Left Section about 3:30 p.m. Davis stated that he rode into the section on a covered porta-bus and therefore did not notice whether any ventilation controls were installed across the track entry going into 2 Left Section. He did not inspect 2 Southeast Main inby 2 Left during his inspection of March 8, 1976.

During his inspection of 2 Left Section Davis issued three 104(b) Notices of Violation of the mandatory safety regulations, as follows:

A Notice of Violation of Section 75.301, Title 30, CFR, for failure to maintain at least 9,000 (8,092) cubic feet of air a minute in the last open crosscut.

A Notice of Violation of Section 75.301.1 for line brattice being 25 feet from the face of No. 5 entry.

A Notice of Violation of Section 75.316 for inoperative water sprays on the continuous mining machine.

The amount of air reaching the last open crosscut was increased to 10,472 cubic feet a minute within the required time of 30 minutes by repairing the check curtains (ventilation controls). The line brattice was extended to within 10 feet of the face of No. 5 entry within the required time of 10 minutes. The operator was given until 4 p.m., March 9, 1976, to repair the water sprays on the continuous miner. The inspector returned to the surface at approximately 9:20 p.m.

According to testimony by Gary W. Smith, second shift utility man on 2 Left Section, he was instructed by James Williams, Section Foreman, 2 Left Section, in the presence of James H. Maggard, Maintenance Foreman, on March 8, 1976, about 5:30 p.m., to install check curtains across the Nos. 4 and 5 entries of 2 Southeast Main inby 2 Left Section. These instructions were given shortly after Williams had been issued the Notice of Violation by Inspector Davis for failure to maintain at least 9,000 cubic feet of air a minute in the last open crosscut. Smith stated that Williams and Maggard helped him install the check curtains across Nos. 4 and 5 entries at a location about three crosscuts inby 2 Left Section. The Nos. 4 and 5 entries were the only intake airways for 2 Southeast Main.

Carlos Smith, second shift continuous mining machine operator on 2 Left Section, stated that at the end of the second shift, as the crew was lea[ving] the section on March 8, 1976, James Williams stopped the porta-bus at th[e] mouth of 2 Left and instructed Gary Smith to remove the two check curtains that he had installed a few hours prior. Carlos Smith and Roy McKnight were sitting closest to the exit of the porta-bus. Carlos Smith told James Williams that he and Roy McKnight would take the check curtains down. Carlos Smith removed the check curtain across No. 5 entry and Roy McKnight removed the curtain across No. 4 entry.

Records of the preshift examinations made by Charles Fields, fire boss, and Arvil Cornett, third shift Mine Foreman, on March 9, 1976, indicated no unsafe conditions. The presence of methane in an amount of one percent or more was not recorded. According to these records Fields made the preshift examination of what is noted as "2 SEM" and reported that more than 14,000 cubic feet of air a minute was passing through the last open crosscut. However, according to testimony by Cornett at the official hearings, he made the preshift examination of 2 Left Section. He stated that only 10,120 cubic feet of air a minute was passing through the last open crosscut. Additional testimony revealed that even though Cornett frequently assisted Fields in making the preshift examinations, Fields signed the reports. Fields stated that he could not make the preshift examinations of the entire mine by himself in the time permitted by the Act to complete preshift examinations because of the extent of the mine workings.

Even though the 2 Southeast Main Section became inactive in early February, 1976, and the mining equipment had been moved into 2 Left Section which was approximately 1,700 feet outby, the fire boss records continued to designate what was noted as "2 SEM" and did not record the active section in 2 Left off 2 Southeast Main. Testimony of Fields and Cornett revealed that preshift examinations were made, nonetheless, in the active section, 2 Left off Southeast Main, but were not made in 2 Southeast Main inby 2 Left on March 9, 1976.

The Explosion

On the morning of the explosion, March 9, 1976, the day shift (7:00 a.m. - 3:00 p.m.) crew of 106 men entered the mine and were transported to their working areas by battery-powered porta-buses and locomotives. Of the 106 men underground, 13 were in 2 Southeast Main and 2 Left Section off 2 Southeast Main (explosion area). Of those 13 men, nine men under the supervision of Virgil Coots, Section Foreman, were producing coal in 2 Left Section; two men were building overcasts at the mouth of 2 Left; and one man was tending the 2 Left belthead located at the mouth of 2 Left in No. 22 crosscut between Nos. 2 and 3 entries of 2 Southeast Main.

According to his testimony at the official hearings, on the morning of the explosion J. P. Feltner, Underground Construction Foreman, called Richard Combs, General Mine Foreman, about 7:30 a.m., after all the mantrips and men had entered the mine and told Combs that he would have a load of steel rails delivered from 1 Right off 2 East to 2 Southeast Main.

Combs and Feltner had discussed delivery of the load of rails to 2 Southeast Main several days prior when Combs had expressed a need to extend the track in 2 Southeast Main preparatory to reactivating the section. After Feltner arranged to have a motor crew pick up the rails and deliver them to 2 Southeast Main, he traveled to 2 Left Section in search of a rail bender and oxygen-acetylene tanks. He stated that James Bentley was with him while he was in 2 Left Section. Feltner did not make tests for methane or take air measurements while he was in this area of the mine, nor did he go inby 2 Left Section. Feltner stated that there was no check curtain across the track going into 2 Left, but he observed a piece of plastic along the track on the mine floor between Nos. 2 and 3 entries, near where the check curtain was supposed to have been hung. He stated that he was aware at that time that the absence of a check curtain at this location caused a short circuit of the air current which was ventilating 2 Southeast Main inby 2 Left.

Feltner testified that in his opinion this check curtain had been recently torn down because it was difficult for vehicles to pass through the check curtain without damaging it or tearing it down.

Feltner left the 2 Southeast Main area and traveled to the mouth of Northeast Main where he met the motor crew with the load of rails. The motor crew, operating the Nos. 6 and 8 battery-powered locomotives, had stopped at the charging station at the mouth of Northeast Main to charge the batteries on the No. 6 locomotive. Feltner stated that two locomotives were used to transport the load of rails because the batteries on the No. 6 locomotive were discharged and only one set of trucks was operating on the No. 8 locomotive. The No. 6 locomotive, a 7-ton Goodman, equipped with an air compressor for the pneumatic braking system, was operated by Roy McKnight. The No. 8 locomotive, an 8-ton Westinghouse equipped with a mechanical braking system, was operated by Lawrence Peavey. The two locomotives were coupled and the truck load of rails was in front coupled to the No. 8 locomotive. Feltner stated that the motor crew left the mouth of Northeast Main pushing the truck load of rails toward 2 Southeast Main about 11:35 a.m. He stated that it would have taken the motor crew about 10 minutes to reach 2 Southeast Main inby 2 Left Section. He stated that the motor crew did not have gas-detecting equipment, and that he had not at any time instructed them to make any tests or examinations of 2 Southeast Main inby 2 Left before entering the area. He thought that the area inby 2 Left had been preshift examined because it was on intake air.

Feltner stated that he left the mouth of Northeast Main at the same time as the motor crew and traveled to Southeast Main where some of his crew were setting timbers along the track haulage road approximately 800 feet inby the Southeast Main belt drive. Shortly after he arrived at this location, at approximately 11:45 a.m., he felt a gust of air moving outby opposite to the ventilating current's normal direction and observed rock dust in suspension. He thought that the gust might have been caused by a crushed-out stopping outby and he took his crew to investigate. They had traveled outby about 600 feet when the ventilating current reversed to its normal direction. After Feltner learned that an explosion had occurred he contacted all active sections of the mine except 2 Left off 2 Southeast Main.

According to his testimony given at the official hearings, James Bentley made an inspection of the abandoned 2 Left Section off Northeast Main on the morning of the explosion. He found that a regulator was open approximately four feet wider than he had originally set it after the section was abandoned. After completing his inspection of this section he returned to the regulator and closed it to the original position. He took an air measurement and then walked to the No. 3 belt drive in Northeast Main near the entrance of 3 Southeast Main where a telephone was located. He called Lawrence Cohen, Section Foreman in the Left Panel Sout east Main, and advised Cohen of his location. Bentley asked Cohen to take an air measurement on the Left Panel and call back. Bentley then called Virgil Coots, Section Foreman in the 2 Left Section off 2 Southeast Main, and told Coots that he had inspected 3 Southeast, Right Panel Northeast Main, Northeast Main and 2 Left Section off Northeast Main. Bentley told Coots that he found the regulator in 2 Left Section off Northeast Main open about four feet wider than it was supposed to be and that his closing of the regulator to its original position should increase the ventilation on 2 Left Section off 2 Southeast Main. Bentley asked Coots how much air did he have and Coots replied that he had just lost his air. Coots told Bentley that he would go out to the mouth of 2 Left Section where two men were building overcasts, and determine if the men had remove a stopping which could have short-circuited the ventilation. Approximatel two minutes later, about 11:45 a.m., the explosion occurred.

The motor crew delivering the truck load of rails had reached their destin tion at the end of the track in 2 Southeast Main when the explosion occurr Including the two locomotive operators, there were 15 men in the 2 Southea Main area when the explosion occurred. All died as a result of the explos

Electrical Equipment in the Explosion Area

Electric circuits and equipment that were installed and/or operated in the explosion area.

The energized electric equipment located at the intersection of 2 Southeast Main and Northeast Main.

1. One EMCO, 300-KVA belt power center, Serial No. 503-300-P-1, located in No. 180 crosscut.
2. One Ensign Electric, 7,200-volt "Y"-box, Serial No. M-1157, located in No. 182 crosscut.
3. One 480-volt, 150-horsepower belt conveyor drive unit for the Northeast Main No. 2 belt.
4. One Ensign Electric, 480-volt, 150-horsepower belt controller with external control circuitry, Serial No. 44WR7-150-20, located at the Northeast Main No. 2 belt drive.

5. One Wise Industries, Incorporated, (120-volt a.c./12-volt) battery-powered deluge water spray system for the Northeast Main No. 2 belt drive.
6. One 480-volt, 75-horsepower belt conveyor drive unit for the 2 Southeast Main belt.
7. One Long-Airdox, 480-volt, 75-horsepower belt controller with external control circuitry, located at the 2 Southeast Main belt drive.
8. One Wise Industries, Incorporated,-(120-volt a.c./12-volt) battery-powered deluge water spray system for the 2 Southeast Main belt drive.
9. One 480-volt, 1-horsepower portable pump, located in No. 167 crosscut Northeast Main.
10. One Mine Safety Appliances, 24-volt, battery-powered telephone, located at the intersection of 2 Southeast Main and Northeast Main.
11. A Pyott-Boone, Incorporated, fire detection system.

The energized electric equipment located at the intersection of 2 Left Section and 2 Southeast Main.

1. One Ensign Electric, 112.5-kVA belt power center, Serial No. 240, located in No. 20 crosscut.
2. One 480-volt, 75-horsepower belt conveyor drive unit for 2 Left Section.
3. One Long-Airdox, 480-volt, 75-horsepower belt controller with external control circuitry, located at the 2 Left Section belt drive.
4. One Wise Industries, Incorporated, (120-volt a.c./12-volt) battery-equipped, deluge water spray system for the 2 Left Section belt drive.
5. One Mine Safety Appliances, 24-volt, battery-equipped telephone, located at the 2 Left Section belt drive.

The energized electric equipment located in 2 Left Section.

1. One Ensign Electric, 500-kVA section power center, located in No. 1 crosscut between Nos. 3 and 4 entries.
2. One section distribution box, located in No. 4 crosscut between Nos. 3 and 4 entries.
3. One permissible-type Lee-Norse continuous mining machine, Model No. CM38Y-3E/60, Approval No. 2F-1604A, Serial No. 3669, located in the face of No. 4 entry.
4. One permissible-type National Mine Service Company shuttle car, Model No. 48, Approval No. 2F-1490A, Serial No. 130, located directly behind the continuous mining machine in No. 4 entry.
5. One permissible-type National Mine Service Company shuttle car, Model No. 48, Approval No. 2F-1490A, Serial No. 702, located in No. 3 entry between Nos. 3 and 4 crosscuts.

6. One permissible-type Galis roof-bolting machine, Model No. 320, Approval No. 2G-2631A-1, located in the face of No. 2 entry.
7. One permissible-type Galis roof-bolting machine, Model No. 320, Approval No. 2G-2631A-1, Serial No. 3253360, located in No. 1 entry between Nos. 4 and 5 crosscuts. It could not be determined whether or not this roof-bolting machine was energized at the time of the March 9 explosion.
8. One Long-Airdox belt feeder, type FBM-56, Serial No. 54-110, located in No. 3 entry between Nos. 2 and 3 crosscuts.
9. One Porter Electric battery charger, located in No. 3 crosscut between Nos. 3 and 4 entries. This battery charger was connected to the two 64-volt battery trays on the Elkhorn scoop.
10. One permissible-type Elkhorn battery-powered scoop, Model No. AR4, Approval No. 2G-2271-13, Serial No. 4753608, located in No. 3 crosscut between Nos. 3 and 4 entries. The two 64-volt battery trays on the scoop were connected to the battery charger.
11. One permissible-type Mine Safety Appliances, 24-volt, battery-equipped telephone, Approval 9B-8, located in No. 4 crosscut between Nos. 3 and 4 entries.

The energized electric equipment located in 2 Southeast Main inby 2 Left Section.

1. One permissible-type Westinghouse-Whitcomb battery-powered locomotive, Serial No. 80218, Approval No. 1537, Company No. 8, located in the track entry at No. 31 crosscut in 2 Southeast Main.
2. One permissible-type Goodman battery-powered locomotive, Serial No. 5480, Approval No. 1532, Company No. 6, located in the track entry at No. 31 crosscut in 2 Southeast Main.

The high-voltage circuit breaker located on the surface, protecting the underground high-voltage circuits, opened at the time of the explosion and automatically removed all electric power from the mine with the exception of:

1. The Mine Safety Appliances battery-equipped telephones.
2. The Wise Industries, Incorporated, battery-equipped deluge water spray systems.
3. The Pyott-Boone, Incorporated, belt fire detection system.
4. The various battery-powered vehicles located throughout the mine.

Figure 2, Appendix J, shows the location of all energized electrical circuits and equipment in the explosion area at the time of the March 9, explosion. Immediately after the explosion, the Pyott-Boone, Incorporated, fire detection system was deenergized from the surface.

A pumping station had been installed at 1 East Main for the purpose of preventing flooding of the main line track. To prevent flooding after the explosion, it was necessary to restore electric power to the pump. Therefore, at 2:20 p.m., March 9, 1976, power was restored to the power center at 1 West Main which supplied power for operation of the pump at 1 East Main.

Recovery Operations

According to available evidence, when the explosion occurred, John Hackworth, belthead attendant, was at the 2 Southeast Main belt drive, located in No. 3 entry Left Panel Northeast Main. He was rolled a short distance by the forces of the explosion from 2 Southeast Main but was not seriously injured. He immediately called the surface and reported what had happened. Failing to establish communications with anyone in 2 Southeast Main, Hackworth donned his self-rescuer and proceeded into 2 Southeast Main to investigate. Reportedly, he traveled approximately 2,200 feet without making contact with anyone before he was forced to retreat.

Ventilation controls in 2 Southeast Main inby the Northeast Main Right Panel were destroyed by the forces of the explosion. The 2 Southeast Main and 2 Left Section were the only areas of the mine affected by the forces of the explosion except for the disruption of electric power throughout the mine. All persons underground at the time of the explosion came to the surface, except the 15 men in the explosion area and a number of miners who gathered at the entrance of 2 Southeast Main to attempt a rescue effort.

MESA officials Keene and Collins, accompanied by Kentucky official Everett Barlett, entered the mine at approximately 2:05 p.m., March 9, and made contact with company employees who were attempting rescue efforts. The employees had partially repaired a damaged overcast in the Right Panel of Northeast Main near the entrance to 2 Southeast Main, and had installed five temporary stoppings inby the overcast. After examination and evaluation of conditions in the immediate area near the entrance of 2 Southeast Main, the group decided to retreat to the entrance of Northeast Main, approximately 2,800 feet outby. They established a fresh air base at this location at approximately 3:00 p.m.

Federal Inspectors West, Sample and Bowman entered the mine with two rescue teams equipped with self-contained breathing equipment at approximately 4:30 p.m., reaching the fresh air base at the entrance of Northeast Main approximately 20 minutes later. All company personnel except Bentley, Hargus Maggard, Maintenance Foreman, and Hackworth were withdrawn to the surface at this time. After checking the returns on each side of the Northeast Main entries, the party advanced open face to the entrance of 2 Southeast Main. After exploring this area the party established a fresh air base in the track entry, one crosscut outby the Northeast Main Right Panel overcast at approximately 6:30 p.m. After the fresh air base had been established, recovery and rescue efforts inby the fresh air base were accomplished by mine rescue teams under oxygen. During debriefing, only one team reported that they had observed smoke during their explorations. Later during the recovery operations, they stated that they had probably observed haze instead of smoke.

The recovery operations were continuously hampered by insufficient ventilation. However, the entries were slowly cleared and the fresh air base advanced in steps. At approximately 9:49 p.m., the fresh air base was advanced to No. 15 crosscut in 2 Southeast Main.

After having been briefed, Administrator Barrett, Assistant Administrator Crawford and Assistant Administrator Peluso entered the mine accompanied by Sam Johnson, Assistant to the Commissioner, Kentucky Department of Mines and Minerals. They arrived at the fresh air base at approximately 10:00 p.m.

The first body was discovered by a mine rescue team at 10:18 p.m., at No. 22 crosscut in No. 2 entry of 2 Southeast Main, approximately 50 feet inby the 2 Left belt drive.

The fresh air base was advanced to No. 20 crosscut at approximately 10:50 p.m. By 1:00 a.m., March 10, the fresh air base was moved up for the last time to No. 22 crosscut in the track entry directly across from the 2 Left belt drive. At this point all available fresh air was expended and all efforts to obtain additional quantities of air were unsuccessful.

The Nos. 2, 3 and 4 bodies were found in the Nos. 1 and 2 entries of 2 Southeast Main near the entrance of 2 Left Section. The Nos. 5, 6 and 7 bodies were found along the No. 4 entry of 2 Left Section. The Nos. 8, 9, 10, 11, 12 and 13 bodies were found all together along the right rib of the No. 5 entry in 2 Left Section, behind a partially constructed barricade. Evidence indicated that some effort had been made to construct a barricade by hanging a plastic check across the mouth of No. 5 entry. However, the left side of the check was not fastened to the rib when discovered by the rescue team. About 1:20 a.m., March 10, the last two bodies were found in No. 4 entry of 2 Southeast Main near the battery locomotives located between Nos. 31 and 32 crosscuts. Appendix D shows the locations of the bodies.

The rescue teams reported that each of the men behind the partially constructed barricade had removed his self-rescuer from his belt and container. One victim had fastened his self-rescuer around his neck, the normal position when wearing the apparatus, which indicates that some of these victims may have worn their self-rescuers for a period of time. The self-rescuers belonging to victims other than those behind the barricade were found either on their belts or near their bodies. Self-rescuers for two of the victims were not found.

The mine rescue teams that recovered the two bodies at the locomotives in 2 Southeast Main reported that the controller on each locomotive was in the off position, the lights were not lit and the battery covers were blown from one locomotive as a result of the explosion. The teams did not report any sound in the vicinity of the locomotives. When questioned later, after the existence of the air compressor on the Goodman locomotive became known, they stated that at no time did they hear the compressor in operation.

MESA and industry mine rescue teams wearing self-contained breathing equipment recovered the 15 bodies. The bodies were brought to the surface at 4:46 a.m., March 10. Bentley, Maggard and Hackworth remained underground and assisted with the recovery operation until all bodies were brought to the surface. Several miners entered the mine during the recovery to tighten the temporary ventilation controls installed by mine rescue teams to increase air quantity. Other miners operated transportation and haulage equipment, loaded supplies and equipment, and assisted in other ways.

Information collected from the rescue teams indicated that the bodies of the victims found in 2 Left Section showed no visible signs of burns or evidence of physical harm from the forces of the explosion, whereas the victims found in 2 Southeast Main were severely burned and showed visible signs of physical harm.

The rescue teams reported that 17,000 cubic feet of air a minute was measured at the first fresh air base at the mouth of 2 Southeast Main. This quantity of air progressively decreased each time the fresh air base was advanced. When the fresh air base was advanced to No. 22 crosscut, the quantity of air available for recovery operations was too small to be measured with an anemometer, and the atmosphere in No. 2 entry at No. 22 crosscut contained 2.6 percent methane and 0.1 percent carbon monoxide. Methane ranging from 2 to 3 percent and carbon monoxide ranging from 0.1 to 0.25 percent were detected by the rescue teams along the belt line and in the faces of the 2 Left entries.

Methane ranging from 3.5 to 5 plus percent and 0.2 percent carbon monoxide were detected in Nos. 1 through 5 entries in 2 Southeast Main at No. 27 crosscut.

Recovery operations temporarily ceased when the last two bodies were recovered. Nos. 1, 2, 3, 4 and 5 entries of 2 Southeast Main from No. 32 crosscut inby, a distance of 800 feet, were not explored by the rescue teams because of the lack of sufficient ventilation to dilute and carry away the methane and carbon monoxide, and otherwise clear the entries.

Flame and Forces

The official investigation of the March 9 explosion was not completed prior to the second explosion. Therefore, the extent of the flame and forces of the first explosion has been primarily determined from statements of witnesses during the official hearings who were in the mine when the explosion occurred, and from observations reported by mine rescue teams, MESA representatives, and Kentucky representatives and company personnel who took part in the recovery operations of March 9 and 10, 1976. The investigation following the unsealing of the mine confirmed this determination.

Flame: Evidence of heat or flame, in the form of coke, soot, partly burned paper, melted plastic brattice material, melted conveyor belt, and charred cable insulation was observed in all of the 2 Southeast Main entries from No. 15 crosscut inby to No. 32 crosscut where the two locomotives were located, a distance of approximately 1,600 feet, and in the 2 Left entries off 2 Southeast Main for a distance of about 150 feet. The most outby evidence of heat or flame was a piece of melted conveyor belt in No. 4 entry of 2 Southeast Main at No. 15 crosscut.

The three victims found in the No. 2 entry off 2 Southeast Main near the entrance to 2 Left and the two victims found near the locomotives located in No. 4 entry of 2 Southeast Main between Nos. 31 and 32 crosscuts were burned severely. The remaining 10 victims found near the entrance of 2 Left and in 2 Left Section were not burned.

Forces: The forces of the explosion radiated from No. 4 entry of 2 Southeast Main near No. 31 crosscut where the locomotives were located; traveled outby in all five entries; traveled in all four entries in 2 Left Section for a distance of approximately 200 feet; and continued outby in all entries to the junction of 2 Southeast Main and Northeast Main, where the forces diminished. Gusts of wind and dust clouds were detected along the haulage roads in Southeast Main outby the junction of Northeast Main and at the entrance of 2 Left Section off Northeast Main. The mine fan was unaffected by the explosion and continued to operate normally. The fan pressure recording system (chart) did not indicate any increase or decrease in fan pressure at the time the explosion occurred. All of the concrete block stoppings in 2 Southeast Main and 2 Left (approximately 70) were destroyed; and generally, the displacement was from the intake toward the return aircourses. Two partially constructed overcasts at the mouth of 2 Left Section off 2 Southeast Main were destroyed and three of the four overcasts in the Right Panel of Northeast Main at the entrance of 2 Southeast Main were damaged by the forces. These damaged overcasts were the most outby evidence of destruction from the forces of the explosion. John Hackworth, belthead attendant, located at the 2 Southeast Main belthead in the No. 3 entry Left Panel of Northeast Main, was knocked down and rolled a short distance by the forces. The 2 Southeast Main belt conveyor, approximately 2,600 feet in length, was damaged by the forces at many locations. The 2 Left belthead was moved outby a short distance and the 2 Left belt inby from the belthead was damaged for a distance of approximately 150 feet.

The diluting and quenching effect of the rock dust that had been applied in 2 Southeast Main, particularly in 2 Left Section which, according to testimony, had been rock dusted on the morning of the explosion, was a principal factor in preventing further spread of the explosion.

Appendix D shows the areas affected by the explosion, the extent of flame and forces, the location of equipment and the location of the bodies.

Probable Point of Origin

Based on all available evidence, MESA investigators conclude that the explosion of March 9, 1976, originated in the No. 4 entry of 2 Southeast Main between Nos. 31 and 32 crosscuts, where the two battery-powered locomotives were located.

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PART III

EXPLOSION, MARCH 11, 1976, AND SEALING OPERATIONS

After the bodies were removed from the mine property, at approximately 5:00 a.m., March 10, 1976, Barrett, Crawford, Peluso, Compton and Clemons held a conference in MESA's communications van, parked beside the bathhouse, to discuss when an underground investigation of the explosion could be started. During this conference they concluded that the investigation could begin after necessary work had been accomplished to provide additional ventilation to the fresh air base at the entrance of 2 Left Section off 2 Southeast Main and the exploration completed. After this conference, courses of action were discussed with Freddie Maggard and Richard Carter, Scotia Coal Company officials, David McKnight, Scotia Employees Association, and Kirkpatrick and Johnson, Kentucky Department of Mines and Minerals. All parties agreed to send the MESA mine rescue teams into the 2 Southeast Main entries at 4:00 p.m., that day, to restore ventilation and complete the exploration of the area that had not been explored during the recovery of the bodies. It was further planned to station certified company officials and Federal Inspectors at necessary regulators so that they could be repositioned under the direction of the Surface Control Center if additional quantities of air were necessary. The investigation was planned to begin on Thursday morning, March 11.

Meanwhile, MESA personnel remained on duty at the mine and monitoring of the fan continued. In order to prevent flooding of the main line track at 1 East Main, all parties agreed to restore electrical power and reactivate the pump in that area. Therefore, at 2:20 p.m., that afternoon, Henry R. Simpson, repairman, closed the high-voltage breaker restoring power only to the portable transformer at 1 West Main which supplied power for the operation of the pump at 1 East Main.

Approximately 3:10 p.m., on March 10, a briefing was held concerning plans, procedures and responsibilities. Shortly afterwards, Richard Combs, accompanied by Federal Coal Mine Inspection Supervisor B. A. Taylor, entered the mine and made a fire-boss examination of the main line to the entrance of 2 Southeast Main. Thereafter, the mine rescue teams and other assigned personnel entered the mine and the effort to obtain the needed ventilation was begun. Persons were stationed at the following locations:

Douglas Fleming and James Bentley	- Shaft bottom
Bill Riley and Ronnie Franks	- 1 West Return Regulator
James Frazier and Danis Ison	- 1 Right off 1-1/2 Right
Troy Coleman and Rexford Music	- Left Panel Regulator
Ronald Hughes and B. Barnette	- Southeast Main Regulator
Gene Dale and Gene Graham	- 3 Southeast Regulator and Bleeder

Russel Tackett and John Pyles	- Bleeder Return 1 Right
B. A. Taylor and Merle Rhodes	- Traveling Between Regulators
John Banks	- Fan

According to their testimony at the official hearing, while casually conversing during their preshift examination, Combs and Taylor discussed the battery-powered locomotives that were located in the first explosion area. Combs remarked that one of the locomotives was equipped with an air compressor that operated the brakes. Taylor stated that on the evening of March 11, he mentioned to Clemons Combs' remark concerning the air compressor on the locomotive. This conversation with Clemons was also very brief and neither placed significance on the air compressor being a possible source of ignition. Testimony indicated that other company and MESA officials were aware of the presence of the air compressor on the locomotive. No one perceived the air compressor as a possible source of ignition.

Inadequately supported, loose roof was detected by MESA mine rescue teams over the track haulage road a short distance inby the entrance of 2 Southeast Main. Considerable delay occurred while this area was being temporarily supported by center-timbering.

Several adjustments were made in the regulators in the mine ventilating system. The temporary stoppings which had been erected by the rescue teams during recovery operations were checked for leaks and made reasonably airtight. These efforts failed to produce any additional ventilation at the last fresh air base at No. 22 crosscut. When the MESA rescue teams arrived at this fresh air base, they discovered that they could not communicate with the surface control center. Considerable effort was exerted to restore communication, to no avail. At midnight, work was discontinued for the remainder of the night because the fresh air base could not be advanced without additional ventilation and the communication system was still out of order. All underground personnel were removed from the mine at approximately 12:45 a.m., March 11, 1976.

Because the agreed-upon schedule could not be kept, Company and MESA officials met at 2:05 a.m., March 11, to revise the plan for completing recovery operations. Persons attending this meeting were as follows:

<u>Scotia Coal Company</u>

Richard Carter
Bill Foutch
Merle Rhodes
James Cornett
James Bentley

Freddie Maggard
Ray Asher
Harvey Creech
Charles Kirk

Mining Enforcement and Safety Administration

Bill Clemons	Bill Riley
B. A. Taylor	Douglas Fleming
John W. Stevenson	Jack Collins
Joseph Marshalek	Rexford Music
Herschel Lough	Russel Tackett
Troy Coleman	Eugene Dale

It was concluded that before exploration of 2 Southeast Main could proceed, it would be necessary to install a new telephone line; construct concrete-block stoppings between the intake and return aircourses in 2 Southeast Main in order to reduce air leakage; and check the stopping line between intake and return aircourses from the portal to 2 Southeast Main for leakage. It was further concluded that it would be necessary to install roof bolts in the loose roof at the entrance to 2 Southeast Main so that the center posts could be removed from the trackway in order to transport the large number of concrete blocks and other material necessary to construct the permanent ventilation controls. To install the roof bolts, a roof bolting machine would have to be moved from the Northeast Main to the 2 Southeast Main area. Also, power would have to be restored to the Northeast Main entry and to the distribution center which supplied power for the bolting machine.

The plan was discussed at a meeting beginning at 7:00 a.m., March 11, attended by, but not limited to, the following persons:

Scotia Coal Company

Freddie Maggard	Richard Carter

Scotia Employees Association

David McKnight	Garland Lewis

Kentucky Department of Mines

Harreld N. Kirkpatrick	Sam Johnson

Mining Enforcement and Safety Administration

Robert E. Barrett	John W. Crawford
Robert G. Peluso	

The plan and details for its implementation were adopted. After the meeting, Barrett, Crawford and Peluso returned to Washington, D.C., to brief Department of Interior officials on recovery operations and to develop plans for the official investigation of the explosion. Kirkpatrick and Johnson also left the mine. Lawrence D. Phillips, District Manager, Coal Mine Health and Safety, District 6, assumed direction of MESA's activities.

At 8:14 a.m., Don Varner, a certified company employee, accompanied by Ron Suttles, Federal Coal Mine Inspector, entered the mine to make a preshift examination of all areas except 2 Southeast Main. Ray Caldwell, company pumper, accompanied by Joseph Tankersley, Federal Coal Mine Inspector, also entered the mine to check pumping stations.

The 103(f) Order issued by B. A. Taylor on March 9, 1976, was modified on March 11, 1976, by Rick P. Keene to change such order to a 103(e) and (f) order.

In accordance with the plan, at approximately 2:00 p.m., on March 11, Henry R. Simpson, company repairman, and James Arnold, Federal Coal Mine Inspector (Electrical), entered the mine to energize the high-voltage circuit to the section power center in Northeast Main; to ascertain that all the under-voltage release mechanisms had functioned properly; and to determine if each of the high-voltage switches had opened. All the switches were found in the open position. They apparently had opened from under-voltage when the surface high-voltage circuit breaker opened at the time of the March 9 explosion. Simpson and Arnold disconnected the high-voltage coupler on the outby end of the high-voltage cable extending into 2 Southeast Main from the "Y"-box located at the mouth of 2 Southeast Main. They then placed the dust covers on the coupler and receptacle. Simpson had intended to cut the telephone line that was extended into 2 Southeast Main during the recovery operations; however, he found that the telephone line had already been cut.

Simpson and Arnold restored the power in a step-by-step procedure. They started at 1 West Main, where power had previously been restored for pumping, and closed the appropriate switch in each "Y"-box, thus energizing the main circuit to the next "Y"-box, until the entire circuit was energized to the section power center in Northeast Main. All branch circuits were left deenergized and the switches supplying power to these circuits were tagged out. Due to the feed-through design of the belt power center at the mouth of 2 Southeast Main, the power center there was energized when the main high-voltage circuit was energized. Simpson checked the molded-case circuit breakers installed in the belt power center for the circuits to the 150- and 75-horsepower belt conveyor drives and the pump at the mouth of 2 Southeast Main to ascertain that the three circuit breakers had opened automatically when the power had been interrupted. The locations of the levers indicated that the circuit breakers were in the tripped position. The couplers on the cables supplying power to the two belt conveyor drive units and the pump were connected into the belt power center and were left connected.

Arnold and Simpson examined the Galis 320 roof-bolting machine in the Northeast Main section for permissibility and for proper operating condition. Their examination revealed that the hydraulic rotating motor was off the drill head; the brake mechanism was missing; a hydraulic tram motor was missing; a bolt was loose in the master switch; and the trailing cable contained a defective splice. Ernest Lee Collins and Rick Parker, company repairmen, made the necessary repairs to the roof-bolting machine and installed a new trailing cable. Collins, Parker and a work crew of company miners, accompanied by two Federal Coal Mine Inspectors, moved the roof-bolting machine to the entrance of 2 Southeast Main. They were unable to push the machine off the track so Parker and Collins pulled the trailing cable over to the belt power center, intending to energize it and to tram the roof-bolting machine off the track under its own power. The coupler on the roof-bolting machine trailing cable was not compatible with the receptacle on the power center. They unplugged the coupler on the pump trailing cable from the power center and proceeded to remove the coupler from the pump cable so that the coupler could be installed on the roof-bolting machine trailing cable.

In the meantime, Kenneth Kiser, Federal Coal Mine Inspector, and James Williams, Section Foreman, upon completing their assignment to check the stopping line from 1 West Main to the mouth of Northeast Main, called the surface control center and were instructed to continue checking the stopping line up to 2 Southeast Main. They arrived at the mouth of 2 Southeast Main at approximately 10:15 p.m. They met the other 11 persons that were in the area. At this time, all other persons that had been assigned to check and repair the stopping line from the portal to 1 West Main had completed their assignment and returned to the surface.

The energized electric equipment at the mouth of 2 Southeast Main at the time of the March 11 explosion consisted of:

1. One EMCO 300-kVA belt transformer, Serial No. 503-300-P-1, located in No. 180 crosscut.
2. One Ensign Electric 7,200-volt "Y"-box, Serial No. M-1157, located in No. 182 crosscut.
3. One Wise Industries, Incorporated, battery-equipped deluge water spray system, located at Northeast Main No. 2 belt drive installation.
4. One Wise Industries, Incorporated, battery-equipped deluge water spray system for 2 Southeast Main belt drive installation.
5. One Mine Safety Appliances battery-equipped telephone, located in the track entry at the intersection of 2 Southeast Main and Northeast Main.
6. Two battery-powered Westinghouse locomotives, company Nos. 7 and 9.

Energized electric equipment in 2 Southeast Main and 2 Left Section off 2 Southeast Main at the time of the March 11 explosion consisted of:

1. One battery-powered Westinghouse locomotive, Serial No. 80218, company No. 8, located in the track entry at 2 Southeast Main, No. 31 crosscut.

2. One battery-powered Goodman locomotive, Serial No. 5480, compa(No. 6, located in the track entry at 2 Southeast Main inby No. 31 crosscut.

3. One Wise Industries, Incorporated, battery-equipped deluge water spray system for the 2 Left off 2 Southeast Main belt drive unit.

4. One Mine Safety Appliances battery-equipped telephone, installed during the recovery operations at the fresh air base in the track entry at No. 22 crosscut in 2 Southeast Main.

5. One Mine Safety Appliances battery-equipped telephone, located at the 2 Left off 2 Southeast Main belt drive unit.

6. Two 64-volt battery trays on the Elkhorn battery-powered scoop, Model No. AR-4, located in 2 Left off 2 Southeast Main, at No. 3 crosscut, between Nos. 3 and 4 entries. The battery trays were connected to a deenergized battery charger located adjacent to the scoop.

7. One Mine Safety Appliances battery-equipped telephone, located in the track entry at No. 4 crosscut in 2 Left off 2 Southeast Main. (The telephone line entering 2 Southeast Main was disconnected).

Figure 3 in Appendix J shows the location of all energized electric equipment in the explosion area at the time of the March 11 explosion.

J. B. Holbrook, Don Creech, Don Polly, James Sturgill, Monroe Sturgill, James Williams, John Hackworth and Glenn Barker, Scotia employees, and Grover Tussey, Richard Sammons and Kenneth Kiser, Federal Coal Mine Inspectors, were in the vicinity of the roof-bolting machine, and Collins and Parker were in the process of removing the coupler from the pump trailing cable when another explosion occurred in the 2 Southeast Main area at approximately 11:30 p.m.

Collins and Parker heard the explosion and then felt pressure and heat. The atmosphere became so dusty that their visibility was limited to about 12 inches. They put on their self-rescuers, found a telephone line, and holding to each other, followed it to the main line track. They continued holding to each other, and followed the telephone cables out the track entry toward the surface. They arrived at the junction of Northeast and Southeast Main before visibility improved sufficiently for them to recognize their surroundings. After arriving at the Northeast Main belt head, Parker called the surface supply house, reported the explosion and asked for transportation. They then proceeded out the track entry. When they arrived at the mouth of 1 West, they heard someone paging them on the mine telephone and Parker answered. He was told that transportation was on the way and to wait at that point.

They, however, continued out the track entry to about one-half mile from the surface, where they were met by Richard Combs and Federal Coal Mine Inspector Davis who transported them to the surface.

Immediately after receiving the report of the explosion on the surface, the underground mine power circuit was deenergized and the mine fan was checked and found to be operating normally. Federal Coal Mine Inspection Supervisor Taylor, who was directing MESA's activities at this time, called Phillips and Clemons. The Administrator and Assistant Administrator, Coal Mine Health and Safety, were immediately notified. MESA's mine rescue teams were again ordered airlifted to the area and the Mine Emergency Operations Plan was again initiated. Requests were again made for rescue teams from area mines. Teams from the following coal companies responded:

International Harvester, Benham, Kentucky
U. S. Steel Corporation, Lynch, Kentucky
Beth-Elkhorn Corporation (3 teams), Jenkins, Kentucky
National Mines Corporation, Wayland, Kentucky
Island Creek Coal Company (2 teams), Keen Mountain, Virginia
Clinchfield Coal Company, Dante, Virginia
Westmoreland Coal Company (2 teams), Big Stone Gap, Virginia

Clemons arrived at the mine at approximately 1:00 a.m., March 12, and resumed direction of the MESA effort. Thereafter, other MESA personnel from Districts 5, 6 and 7; Dave Zegeer and Warnie Flint of Beth-Elkhorn Corporation; John Young and Albert Wagers of U. S. Steel Corporation; and other nearby mining officials and Scotia officials and employees arrived and assisted with the effort.

The two survivors of the explosion, Collins and Parker, were debriefed. From the information they provided, particularly regarding the extent of the forces of the explosion, it was recognized that it might be necessary to utilize the air shaft inby 2 Southeast Main in the rescue effort. Therefore, arrangements were made to have a mobile crane dispatched to the shaft from a nearby mine. Maggard, Carter and other company officials; the officials of nearby coal companies previously mentioned; and Clemons, Compton and other MESA officials met to discuss possible rescue approaches. It was decided that rescue efforts would be attempted from both the portal and shaft. While the crane was being moved into place at the shaft, James Bowman, Federal Coal Mine Technical Specialist (Ventilation), and Donnie Short, Federal Coal Mine Inspector, entered the portal slope on foot, followed by Don Disney and Allen Evans of the International Harvester mine rescue team with self-contained breathing equipment in a porta-bus. The U. S. Steel Corporation mine rescue team stood by on the surface. Bowman, Short, Disney and Evans, who were in frequent telephone communication with the surface control center, reached near to the junction of 2 East before observing any evidence of disturbance. They continued about nine crosscuts inby 2 East where they found that the ventilation was reversed. This party was withdrawn from the mine.

The U. S. Steel Corporation team and the International Harvester team were instructed to proceed underground to establish a fresh air base at the entrance of 2 East Main, and to determine the extent of damage to the ventilation controls in the area.

Barrett, Crawford, Peluso and Joseph O. Cook, Deputy Assistant Administrator, Coal Mine Health and Safety, arrived at the mine about 6:00 a.m., March 12, and were briefed on the progress of the rescue effort. Kirkpatrick and Johnson arrived about the same time.

At 6:55 a.m., Monroe West, Paul Merritt, Federal Coal Mine Inspection Supervisor, and David McKnight, entered and inspected the shaft, explored around the shaft bottom and explored toward 2 Southeast Main. They maintained constant communication with the surface. In that area of their exploration, they found the ventilation controls intact and conditions suitable for a rescue effort.

Meanwhile, mine rescue teams exploring around the 2 East area found the ventilation controls disrupted to the extent that additional progress would be slow. In order to continue rescue efforts in this area it would have been necessary to make changes in the ventilation that could have endangered rescuers in the shaft area. Therefore, rescue efforts from the portal were discontinued in order to concentrate rescue efforts in the shaft. The rescue teams that had entered from the portal were withdrawn.

Approximately 9:45 a.m., West, Merritt and McKnight were withdrawn from the mine shaft. The Nos. 1 and 2 Westmoreland Coal Company and the National Mine Corporation mine rescue teams, and Clemons were lowered into the shaft. Clemons briefed the mine rescue teams at the bottom of the shaft. The Westmoreland teams were instructed to travel along the Northeast Main track entry, open face, in intake air toward 2 Southeast Main. The National Mine Corporation rescue team was instructed to stay at the bottom of the shaft as a back-up team. The Beth-Elkhorn team was standing by on the surface. One of the Westmoreland teams arrived at the mouth of 2 Southeast Main approximately 12 o'clock noon, March 12, and found 11 bodies. After determining that there were no signs of life, the teams were ordered to return to the surface without recovering the bodies because of the possibility of another explosion. All persons were returned to the surface by 1:02 p.m.

During the remainder of March 12 and 13, several conferences were held to discuss possible courses of action. Persons in attendance during all or portions of these conferences were as follows:

<u>Blue Diamond Coal Company</u>

Jasper K. Cornett
R. D. Cornwell

Scotia Coal Company

Richard C. Ward
Freddie Maggard
Richard Combs
Bill Foutch
M. P. Barret
Richard Carter
Charles Kirk

Office of the Governor of Kentucky

Hank Lindsey

U. S. Congressional Representative

Tim Lee Carter, Member of Congress, 5th District of Kentucky

Scotia Employees Association

David T. McKnight
Garland Lewis
James Powell

Kentucky Department of Mines and Minerals

Harreld N. Kirkpatrick
Sam Johnson
Everett Bartlett

Department of the Interior

Kent Frizell, Under Secretary

Mining Enforcement and Safety Administration

Robert E. Barrett
Robert G. Peluso
Dick Nellius
W. R. Compton
Joseph Marshalek
Donald Mitchell
John W. Crawford
Joseph O. Cook
Lawrence D. Phillips
M. L. West
John W. Stevenson

All parties concurred that the chance of another explosion was too great to permit anyone to reenter the mine and a consensus decision was reached to seal the mine on the surface. Preparations to seal began immediately and all openings had been closed by 2:10 p.m., March 19, 1976.

At 2:10 p.m., on March 15, 1976, a 104(a) Order was issued by Rick P. Keene to cover the entire mine.

Mine Emergency Operations

The Mine Emergency Operations Group was placed on alert at 1:25 p.m., March 9, when it became known that 15 miners were unaccounted for following the first explosion at the Scotia Mine. The MEO Operations Support Center and Staging Facility was continuously manned and the MESA mine rescue teams were airlifted to Tri-City Airport, Johnson City, Tennessee, and thence to the mine site by automobile. The communications van with two members of the MEO Group was deployed to the mine. A driller was located for possible probe hole drilling. The alert was terminated late on March 9 when it was determined that there were no miners trapped underground. The van and two members of the support team returned to the staging facility in Charleston, West Virginia, on March 11.

The MEO Group was again placed on alert at 1:10 a.m., March 12, when it became known that 11 men were unaccounted for following the second explosion. MESA mine rescue teams were again airlifted. The communications van and two members of the MEO Group proceeded to the site, followed by the seismic system, logistics van, auxiliary truck and four additional members of the MEO Group. A driller was held available. Approximately noon on March 12, when it became known that there were no miners trapped underground, all staff and equipment except two members and the communications van returned to the staging center.

PART IV

ACTIVITIES DURING PERIOD MINE WAS SEALED
(March 20 - July 14, 1976)

During construction of the mine seals, provisions were made to sample the mine atmosphere behind the seals at the Nos. 4 and 8 seals at the mine portal; at the 13.5-foot air shaft; and at the 10-inch ventilation boreholes located at the back end of the pillared areas in the 1 West, 1 East and 2 East Mains.

Precautions were taken to restrict anyone from getting near the seals for a period of 72 hours after their completion. After the waiting period, daily sampling of the mine atmosphere at these locations was started. These samples were initially analyzed at the MESA laboratory in Mount Hope, West Virginia.

MESA officials decided that an onsite gas analysis system was necessary to provide constant monitoring of the mine atmosphere while the mine was sealed. Glen Humphrey, Supervisory Chemist of the Mount Hope laboratories, was assigned to establish and maintain such a system.

MESA and company officials discussed the need for additional sampling capabilities, particularly in the 2 Southeast Main area. The company employed Ray Resources, Drilling Contractor, 630 Commerce Square, Charleston, West Virginia, to drill three boreholes. Drilling of the No. 1 borehole started April 19, and was completed April 27, 1976, to a depth of 1,121 feet. The hole penetrated the coalbed near the location of the two locomotives in 2 Southeast Main. On May 1, 1976, drilling of the No. 2 borehole was started. On May 9, the borehole was completed to a depth of 1,146 feet, penetrating the coalbed near the faces of 2 Southeast Main. The No. 3 borehole was started May 31, and completed to a depth of 1,030 feet on June 8, 1976. This borehole penetrated the coalbed in 1-1/2 Right near Northeast Main. Appendix F shows the location of these boreholes.

While these boreholes were being drilled, MESA developed plans to install an onsite gas sampling and analysis system. On July 6, 1976, work on a field laboratory began. The gas sampling van, a trailer equipped with constant monitoring and remote sampling devices, loaned by the U. S. Bureau of Mines, Bruceton, Pennsylvania, was situated on the mine property a short distance from the No. 3 borehole. The van also housed a gas chromatographic system designed and built by personnel at the Mount Hope laboratory. The van was operational by the morning of July 13, 1976.

The gas sampling van was equipped with a device capable of analyzing samples from 19 different locations. The equipment could be operated in the automatic or manual mode. The automatic mode allowed a different location to be sampled every 5 minutes until the cycle was complete. The equipment then reset and the same cycle repeated unattended. The manual mode allowed selection and sampling of any location deemed necessary as operations progressed.

The straight line distances from the Nos. 1, 2 and 3 boreholes and the 13.5-foot air shaft to the gas sampling van ranged from 3,000 to 5,800 feet.

Incorporated into the sampling system was a heavy-duty, continuously operating pump. This allowed samples from the most remote location (the No. 2 borehole) to reach the van in less than 30 minutes. Tracer gas injected into the sample lines from the No. 3 borehole would indicate changes in atmospheric conditions underground within 10 minutes.

Infrared monitoring equipment for carbon dioxide, carbon monoxide and methane, as well as paramagnetic detector for oxygen were available as back-up instrumentation should the chromatographic system fail. These instruments also served as a second method of detecting any changes in conditions underground.

The gas chromatographic system designed at the Mount Hope laboratory was equipped with one thermal conductivity and two flame ionization detectors, allowing samples to be analyzed for oxygen, nitrogen, methane, carbon dioxide and carbon monoxide. The system was capable of analyzing one sample every 10 minutes, making readily available reliable data regarding underground atmospheric conditions.

The performance and accuracy of the field laboratory was continuously verified by duplicate samples sent to the Mount Hope laboratory. Onsite gas sampling and analysis provided constant monitoring of the Scotia Mine 24 hours each day, 7 days each week, from July 14, 1976, until the No. 2 borehole area was ventilated on March 8, 1977.

The established sampling procedure was as follows:

> Each hour a sample was collected from the "critical" sample location (the sampling point behind the sealed area nearest the recovery teams). A series of samples were collected at 4:00 a.m., 10:00 a.m., 4:00 p.m. and 10:00 p.m., from Nos. 1, 2 and 3 boreholes and the 13.5-foot air shaft. Additional samples were manually collected in 250 cc bottles from the 13.5-foot air shaft and the Nos. 1, 2, 3 and 10-inch 1 West Main boreholes. Underground samples were collected behind the seals on each advance of the fresh air base using 250 cc and 10 cc sampling bottles. Spot samples were collected intermittently from the 10-inch 2 East Main borehole.

Approximately 40 to 50 samples were analyzed daily until the seal was removed from the 13.5-foot air shaft, at which time the number of samples analyzed was reduced to between 30 and 40.

The analyses of the first air samples collected from the Nos. 1, 2 and 3 boreholes on the date of their completion were as follows:

	No. 1 Borehole Percent	No. 2 Borehole Percent	No. 3 Borehole Percent
Carbon Dioxide	4.53	4.66	2.59
Oxygen	6.58	5.82	8.29
Methane	31.26	36.47	25.70
Carbon Monoxide	1.60	1.93	0.0078
Hydrogen	0.54	0.10	0.00
Ethane	0.20	0.35	0.14

During the time the mine was sealed the company obtained necessary mine rescue equipment for three mine rescue teams. With assistance from MESA and the Kentucky Department of Mines and Minerals the company trained three mine rescue teams composed of employees of the Scotia Mine. In addition, the Blue Diamond Mine at Leatherwood, Kentucky, equipped and trained two mine rescue teams to assist with the recovery operations.

During this time the company developed a plan to re-enter and recover the mine. Several meetings were held by representatives of the four parties to discuss the plan. Three primary methods were discussed, as follows:

1. Remove the seals and ventilate the entire mine.
2. Enter the 13.5-foot air shaft using the air-lock method of recovery.
3. Enter the main portals using the air-lock method of recovery.

After extensive consideration of the safety factors, advantages and disadvantages of the three methods, a consensus agreement was reached that a greater degree of safety for the recovery teams could be maintained by employing the air-lock method and entering the mine through the main portal entries.

Persons attending some or all of the meetings were as follows:

<u>Blue Diamond Coal Company</u>

Gordon Bonnyman
Jasper K. Cornett

<u>Scotia Coal Company</u>

Richard Carter
Woods G. Talman - Consultant

<u>Scotia Employees Association</u>

David McKnight
Kenneth Goins
Benny Adams

Kentucky Department of Mines and Minerals

Harreld N. Kirkpatrick
Sam Johnson

Mining Enforcement and Safety Administration

Joseph O. Cook	Ray G. Ross
Lawrence D. Phillips	William R. Park - Consultant

A final review and evaluation by representatives from the four parties of all analyses of air samples collected from the sealed area at the Nos. 4 and 8 seals located at the mine portal showed little contamination of the air. This indicated that a homogenous atmosphere in the mine would not be achieved. The air samples collected from the Nos. 1, 2 and 3 boreholes and the 13.5-foot air shaft were highly contaminated and were considered to more accurately represent the overall underground condition. Therefore a target date of July 14, 1976, was agreed upon for removal of the seals at the main portal entries and the start of recovery operations. The analyses of the air samples collected on July 14, 1976, were as follows:

	No. 1 Borehole Percent	No. 2 Borehole Percent	No. 3 Borehole Percent	13.5-ft Air Shaft Percent
Carbon Dioxide	5.22	5.04	3.16	2.69
Oxygen	1.72	1.93	3.43	4.80
Methane	53.68	55.46	40.89	40.44
Carbon Monoxide	0.43	0.45	0.00	0.0028

The continuous gas sampling capability of monitoring the atmosphere in the 2 Southeast Main area was a deciding factor in establishing a reentry target date.

U. S. Bureau of Mines

The Bureau of Mines fully cooperated with MESA when asked for assistance in several phases of the Scotia Mine recovery and investigation. The Bureau provided leadership in procuring and installing tube bundles for the gas sampling in the boreholes and round-the-clock manning of the equipment during the initial phases of gas sampling. The Bureau subsequently trained MESA personnel to perform the sampling. About 800,000 bits of information from the samples were computerized for future analyses and publication.

Immediately after the second explosion, MESA requested that the Bureau perform tests in its Experimental Coal Mine. Tests conducted in dual gas zones showed that a complete combustion reaction would not occur in a methane-rich atmosphere located adjacent to a combustible methane atmosphere, but that sufficient mixing would follow a first explosion to develop a second explosive mixture within a short time.

PART V

UNSEALING OF MINE AND RECOVERY OPERATIONS

Since the mine had been sealed for approximately four months, it was calculated that the mine could accumulate approximately 23 million gallons of water within its lower confines as of July 1, 1976. From studies of the mine elevation contours it was determined that this amount of water would block the main aircourses in the South Main entries at the lowest elevation within the mine, located approximately 1,000 feet inby the intersection of the South Main entries and 1 West Main. This blockage of the main aircourses would effectively negate any attempt to provide sufficient ventilation between the intake air shaft located in the Northeast Main area of the mine and the main fan near the mine portal.

Samples of the underground atmosphere collected on July 12, 1976, at Nos. 1, 2 and 3 boreholes and at the air shaft showed carbon monoxide concentrations ranging from 28 to 4,500 parts per million. Since the presence of carbon monoxide in a sealed area can be indicative of heat, any attempt to reventilate the mine by opening the portal seals and the seal at the air shaft could conceivably have resulted in the rekindling of a "hot spot". Should this have occurred, it would have been necessary to reseal the mine, further delaying the recovery operation.

The possibility of entering the 13.5-foot diameter air shaft and air-locking to 2 Southeast Main, a distance of approximately 4,000 feet, was considered. This method of recovery presented many problems, including installation of ventilation and hoisting facilities, handling of supplies underground and, most importantly, the fact that the shaft provided only one way of ingress and egress.

Based on the information available concerning the possible water blockage, the presence of carbon monoxide in the 2 Southeast Main area, and the hazards involved in entering the shaft, the recovery of the mine by the air-lock method, starting at the mine portal, appeared to be safest and most practical. Therefore, the re-entry plan submitted by Scotia Coal Company on July 2, 1976, which proposed incremental re-entry using controlled ventilation (air-lock method), starting at the mine portal, was approved on July 13, 1976.

Scotia Coal Company had on order the necessary equipment to install ventilating and hoisting facilities in the shaft. It was agreed that should insurmountable conditions be encountered during the air-locking of the main entries, the possibility of entering the shaft would then be reevaluated

The approved re-entry and recovery plan called for initial re-entry into the Scotia mine through the new return entries. Forces of the explosions of March 9 and 11, 1976, had caused no damage to the new returns. Prior to the anticipated re-entry date of July 14, 1976, the

48-inch fan was checked and was operational. A booster fan provided with 30-inch tubing, the opening of which was directed toward the motor and fan housing of the 48-inch fan, was installed to dilute any high concentrations of methane that could accumulate in the fan housing.

Everything was ready for re-entry on the morning of July 14, 1976. Four mine rescue teams equipped with 4-hour self-contained breathing equipment, non-sparking tools and cable-reel voice communication systems were available. Members of three of the teams were employees of Scotia Coal Company, and the fourth team was composed of personnel from the Kentucky Department of Mines and Minerals. Two mine rescue teams from Blue Diamond Coal Company, Leatherwood, Kentucky, participated in the recovery operation from August 12, 1976, through the recovery of the bodies on November 19, 1976.

At 8:00 a.m., three mine rescue teams proceeded underground to erect three temporary seals necessary to form an air lock prior to opening portal seals Nos. 1 and 3. In addition to the temporary seals, a temporary stopping provided with a door was to be erected in the crosscut between Nos. 2 and 3 entries to separate the intake aircourses from the return aircourses. The teams were a maximum distance of 250 feet underground, working in a respirable atmosphere. By 10:20 a.m., the work of erecting the seals and stopping was completed and the teams returned to the surface. Shortly thereafter two mine rescue teams proceeded underground to knock holes in portal seals Nos. 1 and 3 large enough for passage of team members and supplies. Because of the thickness of the seals work progressed slowly.

By 10:15 a.m., July 16, these openings were large enough to permit the passage of men and materials. The temporary seals erected to form an air lock were removed, the door in the temporary stopping in the crosscut between Nos. 2 and 3 entries was closed and the teams returned to the surface. The booster fan was started and at 10:40 a.m., the 48-inch fan was put in operation. Air measurements showed the fan to be exhausting 17,000 cubic feet a minute at 0.2 inch water gauge, and 15,840 cubic feet of air a minute was intaking in the No. 1 entry. The fan was constantly monitored so that positive control could be maintained on the methane removal rate by opening and closing the explosion doors.

At 1:13 p.m., a mine rescue team went through the No. 1 portal seal to explore. The team advanced to the No. 11 crosscut in No. 1 entry without incident. A normal atmosphere had been found in all entries to this point and the fresh air base was moved to crosscut No. 11. The exploration continued to No. 22 crosscut in No. 1 entry. Conditions were normal and the fresh air base was moved to No. 18 crosscut, and shortly thereafter, to No. 21 crosscut.

From this fresh air base the mine rescue teams then moved inby approximate 225 feet to Survey Station No. 113 in the No. 2 entry, Left Panel South Main. An air lock was constructed just inby the fresh air base in No. entry. Rescue teams, under oxygen, traveled through the air lock and explored the Left Panel entries through the connecting slope entries and the Right Panel entries of South Main to No. 21 crosscut. Accumulations of water, roof falls and hazardous roof conditions made the exploration work slow and difficult. By the afternoon of July 20, temporary seals had been erected in the Left and Right Panel entries of South Main just inby the connecting slope entries. Part of the stoppings that had been used to isolate the new returns were removed. Two air-lock stoppings at No. 19 crosscut between Nos. 2 and 3 entries in the Right Panel South Main were also removed. For ventilation purposes, the slope entries were now connected to the new returns and the temporary seals erected by the mine rescue teams isolated this area from the remainder of the mine. Approximately 4:00 p.m., July 22, backup temporary seals had been erected in the Right and Left Panels of South Main. The area was then ventilated.

By July 24, recovery work had advanced up the Right Panel entries and a fresh air base was established at No. 26 crosscut. It was then decided to ventilate the mine with the Jeffrey-8H60 fan installed on the surface at the No. 1 slope entry. With all personnel out of the mine, the 48-inch fan was shut down, and at 3:19 p.m., July 24, the Jeffrey-8H60 fan was started. By opening the explosion doors, this fan was regulated to exhaust 31,000 cubic feet of air a minute at a water gauge of 0.3 inches. The explosion doors on the 48-inch fan were opened, thereby making the new return entries all intakes, which were then regulated to approximately 8,000 cubic feet of air a minute. Throughout the remainder of the recovery to the intersection of Northeast Main and 2 Southeast Main, as additional ventilation was required, the explosion doors on the Jeffrey-8H60 fan were closed to maintain more than 10,000 cubic feet of air a minute at the fresh air base, as well as an amount necessary for methane dilution which was by-passed into the return entries outby the fresh air base.

Exploration and recovery work resumed on the morning of July 25. By August 3, the connecting entries at 1 East Main had been sealed and a fresh air base established at No. 50 crosscut of the Right Panel entries. Mine rescue teams traveled through the seals in the connecting entries and encountered large accumulations of water at the intersection of 1 East Main and the Left Panel entries of South Main. Exploration work inby the seals in the Right Panel entries revealed three and one-half feet of water just inby No. 51 crosscut. Mine rescue teams placed suction lines into each of these areas and around-the-clock pumping operations began. While the water was being pumped, mine rescue teams were able to travel through the connecting entry at No. 51 crosscut and build seals in the Left Panel entries just inby the connecting entry. Not until August 26, 1976, had the water level been lowered enough to allow completion of the temporary seals required to seal 1 East Main.

The exploration and recovery work in South Main inby 1 East Main was hampered by accumulations of water for a distance of approximately

2,400 feet from Nos. 51 to 77 crosscuts. Work progressed slowly through this area. From just inby the intersection of 2 East Main and South Main to the intersection of South Main and Southeast Main, approximately feet, many adverse conditions were encountered that delayed progress. In this area the roof was extremely hazardous, large roof falls were encountered and many crosscuts were filled with gob. The connecting entries between the Right and Left panel entries were impassable and air-locking had to continue in the Right Panel of South Main and in Southeast Main to No. 122 crosscut before the Left Panel entries could be utilized as return aircourses.

By November 3, a fresh air base had been established at No. 169 crosscut in the Left Panel entries of Northeast Main, approximately 1,000 feet ou by the location of the bodies. Only the Left Panel entries had been ven lated to this point.

At this point, it became essential that all work inby the fresh air base at No. 169 crosscut be closely monitored to insure that nothing was disturbed except to the extent absolutely necessary to explore and recover the area. It was agreed by all interested parties that all mine rescue teams working inby the fresh air base would be accompanied by a represen tive of Scotia Coal Company, Scotia Employees Association, Kentucky Depa ment of Mines and Minerals, and MESA.

The decision to neutralize the batteries resulted from knowledge gained during recovery. It had been found that the deluge water system installe at each belt head drive in the mine was a possible ignition source. system in use was manufactured by Wise Industries, Inc., Wise, Virginia. Each unit contained two six-volt batteries in series to activate the system in the event of a fire during a power outage. During the early stages of recovery, the deluge water system on the belt head drive at No. 10 crosscut in the slope belt entry had been examined and the batteries found to be fully charged. The possibility of the batteries in the system at other belt drives being fully charged could not be ignored. Therefore, it had been decided that, as each belt drive was encountered, the batteries in the deluge water system would be removed by the mine rescue teams if the atmosphere was known to be non-explosive. If the atm phere should be at or near the explosive range the batteries would not be disturbed.

It was known that the two battery-powered locomotives in the track entry near No. 181 crosscut in the Left Panel, and the six-volt batteries in the deluge water system on the Northeast Main belt drive and on the 2 Southeast Main belt drive located in the Left Panel Northeast Main at No. 183 crosscut, were possible ignition sources. Not knowing the condition of the locomotives and batteries, and realizing that the atmosphere in that area would pass through the explosive range during the ventilation advance, it was decided to neutralize these ignition sources as quickly as possible while the atmosphere was known to be non-explosive No. 3 borehole samples showed carbon dioxide - 3.8 percent; oxygen - 3.9 percent; methane - 48.9 percent; and carbon monoxide - 3.5 ppm.

On November 3, a mine rescue team, composed of representatives of Scotia Coal Company, Scotia Employees Association, Kentucky Department of Mines and Minerals and MESA, went through the air lock in the track entry at No. 169 crosscut, crossed over to the No. 3 entry (belt entry) and traveled to the belt drives. The batteries in the deluge water system on each belt drive were removed and brought back to the fresh air base. On November 4, the Right Panel of Northeast Main was ventilated up to No. 169 crosscut by making the Left Panel entries intake aircourses and passing the air through the connecting entries into the Right Panel entries which served as return aircourses. The return air was directed over the overcasts at the intersection of the Left Panel of Northeast Main and Left Panel of Southeast Main. On November 8, 1976, the mine rescue team proceeded up the track entry to the locomotives and disconnected the batteries. No. 3 borehole samples showed carbon dioxide - 3.3 percent; oxygen - 5.9 percent; methane - 42.8 percent; and carbon monoxide - 1 ppm.

Temporary seals were erected in the Right and Left Panels of Northeast Main just outby the intersection of 2 Southeast Main and on November 11, 1976, the fresh air base was advanced to No. 179 crosscut in the Left Panel entries. The first mine rescue team inby the fresh air base roped off the area around the bodies near No. 181 crosscut to prevent anyone entering. Temporary seals were then erected in 1-1/2 Right, in Right and Left Panels of Northeast Main just inby the intersection with 2 Southeast Main and in 2 Southeast Main. Backup seals in 2 Southeast Main were erected by rescue teams to prevent contamination of the atmosphere.

At 1:00 p.m., on November 18, 1976, ventilation of this area was started. As quickly as possible after ventilation started, guards were posted at the roped off area. The ventilation was completed at 8:50 p.m., and barefaced work crews immediately started erecting backup seals. At approximately 3:00 a.m. November 19, all backup seals had been erected and the crews returned to the surface. The guards remained underground.

At 5:46 a.m., November 19, recovery teams left the surface enroute to 2 Southeast Main to view the area and prepare the 11 bodies for removal to the surface. At 6:14 a.m., the recovery teams arrived at 2 Southeast Main.

The first team to proceed into the area where the bodies were located consisted of the following persons: Charles Day, Coroner, Letcher County, Kentucky; Richard Carter and Harvey Creech, Scotia Coal Company officials; Dr. John Feegle, Scotia Coal Company medical representative; David McKnight, Kenneth Goins and Benny Adams, representatives of Scotia Employees Association; Harreld N. Kirkpatrick, Commissioner, Kentucky Department of Mines and Minerals; Dr. George Nichols, Kentucky Department of Mines and Minerals medical representative; Robert E. Barrett, Administrator, and Joseph O. Cook, Deputy Assistant Administrator, MESA; and Dr. R. L. Thompson, Captain, MC, USN, MESA medical representative. This team viewed the area and the bodies to confirm that nothing had been disturbed except to the extent absolutely necessary to protect the lives of people who were underground while the area was being explored and ventilated. When this team had completed its mission, those members who were not going to assist further in the recovery moved out of the area. Another team, which included six morticians, moved into the area. The medical examiners, physicians and morticians examined each body, made identification, removed the personal effects and prepared the bodies for removal. Appendix E shows the locations of the bodies.

The bodies arrived on the surface at 11:59 a.m., and were placed in a temporary morgue which had been established in the mine shop. Family members or their designated representatives were permitted to view the bodies. The bodies were then transported by ambulance to mortuaries or medical centers requested by the next of kin. Appendix N is a report by Dr. Robert L. Thompson, Captain, MC, USN, on the condition of the 11 bodies and the results of autopsies performed on six of the victims.

After the bodies were removed from the mine, all work was suspended during a mourning period from November 20 through November 28, 1976, except for patrolling of the mine by certified company officials and MESA personnel. Recovery work resumed on Monday, November 29, 1976. Permanent seals (concrete block) were constructed across the 2 Southeast Main entries near the junction of Northeast Main.

On November 29 and 30, 1976, a meeting to discuss recovery of the remainder of the mine was held at Knoxville, Tennessee, the headquarters of Blue Diamond Coal Company. In attendance were Jasper K. Cornett, Dr. Frank C. Thomas, W. D. Coffey and Woods Talman, company representatives; Kenneth Goins and Benny Adams, representatives of the Scotia Employees Association; Harreld N. Kirkpatrick and Sam Johnson, Kentucky Department of Mines and Minerals; and Joseph O. Cook, Lawrence D. Phillips, Ray G. Ross and William R. Park, Consultant, MESA. The company proposed a plan for recovery of the remainder of the mine by a continuation of the air-locking procedures used to date. All parties were not in agreement with this plan because of extensive gob areas which had not been ventilated and which contai high concentrations of methane. An alternate method was proposed for recover ing the 1 West, 2 East, Southeast Main, Northeast Main inby 2 Southeast Main and gob areas. Company representatives requested time to consider the alternate method.

The meeting was reconvened at the Scotia Mine on December 8, 1976. The company presented a recovery plan for systematic removal of all seals and controlled ventilation of all areas of the mine, except 2 Southeast Main. The plan was agreed to by all four parties.

On December 8, 1976, the main fan was started and adjusted to course 150,000 cubic feet of air a minute through the mine at a water gauge of 1.8 inches. Precautions were taken to prevent the hazard of static electricity from the drive belts, and the fan motor structure was ventilated with an auxiliary fan and tubing. It was decided that the methane content of the air passing through the main fan should not exceed 3 perce

Air from the mine containing a greater concentration than 3 percent was diluted with air by-passed through the explosion doors between the mine opening and fan. Personnel from the MESA Technical Support group installed methane monitoring units at the mine return and fan exhaust which provided continuous monitoring of the methane content. Communication facilities were established from the surface to each seal to be removed. Arrangements were made with the Federal Aviation Administration to prohibit air traffic over the mine area for a period of 72 hours.

On Friday, December 10, 1976, all power was removed from the mine and from structures located near the fan installation. Personnel, with communication to the fan monitoring area, were stationed at power control centers at other surface facilities to deenergize all power should it be necessary. At 8:14 a.m., two mine rescue teams, support personnel, and representatives from the four groups entered the mine in battery-powered porta-buses to begin removing seals and ventilating the area. On reaching the seal in 4 Left bleeder, communications between the area and the surface control center were established. At 9:23 a.m., the seal was removed. The seal at 1 East Main was removed at 10:30 a.m. Air was intaking into 1 East. Seals across Nos. 3 and 4 entries, Right Panel Northeast Main, No. 2 entry Left Panel Northeast Main, and Nos. 1, 3 and 4 entries 1-1/2 Right near Northeast Main were removed between 11:47 a.m. and 1:25 p.m. There was a strong air flow into 1-1/2 Right. All persons returned to the surface. At 3:55 p.m. and 4:29 p.m., the caps were removed from the two 10-inch boreholes into 2 East gob area. The holes were intaking. The seal on the 13.5-foot diameter shaft was removed at approximately 11:07 a.m., Saturday, December 11, 1976. This provided additional intake air into Northeast Main, 3 Southeast, 2 Left off Northeast Main and to areas behind the shaft. The methane content of the air exhausting from the mine increased at this time (approximately 2:00 p.m.) and peaked at 6.2 percent. The methane content of the air passing through the mine fan was 2.9 percent. In order to keep the methane concentration passing through the fan from exceeding 3 percent, the No. 3 fan explosion door was opened an additional six inches. At 3:00 p.m., the methane content started to decrease and continued decreasing thereafter. At 7:00 a.m., Sunday, December 12, the methane content of the air exhausting from the mine was 1.9 percent; the carbon dioxide and carbon monoxide contents were 0.35 and .002 percent, respectively. At 7:00 a.m., Tuesday, December 14, the predetermined quantities of 2 percent methane, 0.5 percent carbon dioxide, and .0050 percent carbon monoxide had not been exceeded for 48 hours and therefore, plans were made to re-enter the mine. At 9:57 a.m., one company, one MESA, and one Scotia Employees Association representative entered the mine. Approximately 35,300 cubic feet of air a minute, containing 4 percent methane, was passing out of 4 Left bleeder and approximately 44,000 cubic feet of air a minute was exhausting from 2 East. Seals across entries in the Left Panel 2 East, Nos. 1 and 2 entries Right Panel 2 East and across the No. 2 entry 1-1/2 Right near Northeast Main were removed.

Water approximately seven inches deep was encountered at the 1 West track switch. Workmen on the afternoon shift restored power to 1 West and started pumps to dewater the area.

The area inby the intersection of the Left Panel Southeast Main and Northeast Main, and 1-1/2 Right had not been explored. On December 15 16 men, including representatives from the four groups, entered the mine to explore these areas. Access to 1-1/2 Right was blocked by water; however, air was moving through the area. The men proceeded on foot to Northeast Main and at 2:06 p.m., the Northeast Main faces and areas behind the shaft had been traveled and found safe. The forces of the explosion had destroyed six stoppings and the ventilation controls at the mouth of 3 Southeast. Consequently, 3 Southeast Main was not being ventilated. Plastic brattice stoppings were installed to reventilate 3 Southeast. On Thursday, December 17, the seals across the Southeast Main and 1 West Main were removed to permit ventilation of these areas. The only remaining sealed area was 2 Southeast Main.

Power was removed from the mine and no one was permitted underground on December 18 and 19. During this time the maximum methane concentration in air from the mine was 0.7 percent. On December 21, the mine was preshift examined to No. 74 crosscut inby 1 West Main, and at 10:57 a.m., 12 men representing the four groups entered the mine and examined all accessible areas in 1 West Main. No additional work or exploration was done from December 21 through 26 except to patrol the mine.

From December 26 through 31, construction work was done on ventilation controls in 2 Left off Northeast Main and on overcasts at 2 Southeast Main junction to control the air intaking through the 13.5-foot diameter shaft and to provide sufficient ventilation for recovery of 2 Southeast Main. After permanent ventilation had been established in Northeast Main, the Left and Right Panels of Northeast Main inby 2 Southeast Main were re-rockdusted. By February 13, 1976, all areas of the mine had been ventilated except 2 Southeast Main.

During the period December 8 to 20, 1976, more than 31,000,000 cubic feet of methane was removed from the mine.

PART VI

UNSEALING AND RECOVERY OF 2 SOUTHEAST MAIN AND RECOVERY OF 2 EAST MAIN

On Monday, February 14, 1977, at a meeting at the mine, the company presented to the representatives of the four groups a revised plan for recovery of 2 Southeast Main and 2 Left Section. The plan, agreed to by all groups, provided that the area was to be recovered by the controlled ventilation, air-lock method, in four advances. A minimum of 60,000 cubic feet of air a minute would be available at the mouth of 2 Southeast Main intake entries. The batteries on the deluge system, telephones, scoop and locomotives were to be deenergized by the mine rescue teams during explorations from the Nos. 19 and 25 crosscuts. The explorations inby the seals were to be made by Scotia mine rescue teams accompanied by a State and a MESA representative. These rescue teams were instructed not to move or disturb any physical evidence without prior approval from the surface control center. The atmosphere in the sealed area would be sampled daily from the Nos. 1 and 2 boreholes.

The necessary overcasts and stoppings had been previously constructed and more than 60,000 cubic feet of air a minute was reaching the mouth of 2 Southeast Main. Samples of mine atmosphere collected from the No. 1 borehole (sealed area), showed 71.24 percent methane, 0.58 percent oxygen, 6.47 percent carbon dioxide and .00021 percent carbon monoxide. Following the meeting, a Scotia mine rescue team, accompanied by State and MESA representatives, entered the sealed area through the air lock from the fresh air base at No. 4 crosscut in No. 4 entry. All entries were explored to just inby No. 14 crosscut. As the team advanced, the observed conditions were reported to personnel at the fresh air base and plotted on a map. During exploration, nothing was moved without prior approval from the surface control center. The predetermined locations for seals at No. 12 crosscut were examined, cleared of loose coal and measurements made for material required to construct the seals. These materials were prepared at the fresh air base and transported to the work area on the specially built rail car. The construction of the seals was completed on February 15, and the explored area was ventilated the following day. During ventilation, all power was removed from the mine and only those persons required for the ventilation were permitted underground. The seals at the fresh air base were removed from the intake and return entries and air directed by plastic stoppings in the crosscuts between Nos. 3 and 4 entries. The ventilation was controlled to limit the methane content to less than 5 percent outby the fresh air base. When the area was ventilated and found to be safe, official investigating teams, composed of representatives from the four groups, made a thorough examination of the area and collected dust survey samples. While the investigation was being conducted, workmen constructed plastic backup seals and concrete block stoppings. The stoppings were completed to the second crosscut outby the seals. The entire area was re-rockdusted after the investigation was completed and prior to further exploration.

On Monday, February 21, mine rescue teams entered the seals inby No. 17 crosscut and explored all entries and crosscuts including No. 22 crosscut. During this exploration, the batteries on the deluge system for the 2 Left Section conveyor belt and the telephones in Nos. 3 and 4 entries at No. 22 crosscut were removed to the fresh air base. Temporary plastic seals were constructed across the entries inby No. 19 crosscut. The area was ventilated. The investigating teams examined the area and collected dust samples. Workmen constructed backup seals and permanent stoppings between Nos. 3 and 4 entries. The area was then rockdusted.

Since the entries explored to date were open and easily traveled, it was decided by the participating groups that, for the safety of persons involved, both the scoop and locomotive batteries would be deenergized during explorations from the fresh air base at No. 19 crosscut. Conditions permitting, one set of seals would be constructed inby No. 28 crosscut to permit recovery of the remaining area of 2 Southeast Main. The battery scoop was located in 2 Left Section and the two battery locomotives were located near No. 31 crosscut in No. 4 entry 2 Southeast Main. Air samples collected from the sealed area showed the atmosphere was stable.

On Monday, February 28, a mine rescue team, accompanied by State and MESA representatives, explored 2 Left Section. The scoop batteries, which were being charged at the time of the first explosion, were disconnected from the battery charger and 2 Left Section telephone was brought to the fresh air base. Another team explored 2 Southeast Main to No. 32 crosscut and disconnected the batteries on the two locomotives. Plastic seals were constructed across the entries inby No. 28 crosscut, and the explored area, including 2 Left Section, was ventilated. A thorough investigation was made and dust samples were collected. It became evident at this time that the forces of the second explosion emanated from the 2 Left Section with great force and traveled outby and inby along 2 Southeast Main entries. Backup seals were built and permanent stoppings were constructed between Nos. 2 and 3 entries in 2 Left and Nos. 3 and 4 entries in 2 Southeast Main. The 2 Southeast Main entries were re-rockdusted. However, because of the time that would be involved and problems that could develop by attempting to maintain a stable and safe atmosphere inby the temporarily sealed area, it was decided by the four participating groups to ventilate the area inby the No. 28 seal before re-rockdusting was completed in 2 Left Section.

On Tuesday, March 8, a mine rescue team explored the entries inby No. 28 crosscut and the area was ventilated on the same day. An investigation team examined the area and collected dust samples.

The 2 Southeast Main and 2 Left Section were recovered and examined by March 9, 1977.

Mining had been completed in much of 2 East area. The 1-1/2 Right Section off 2 East Main, a pillar section, was the only remaining active portion of 2 East. The 1-1/2 Right Section was surrounded by mined-out areas. It was ventilated on Tuesday, December 14, 1976, when seals across 2 East and 1-1/2 Right near Northeast Main were removed. At that time, the active area was inaccessible because of an accumulation of water outby the 1-1/2 Right Section off 2 East Main. However, air was flowing through the area from the 13.5-foot diameter shaft.

Water accumulations were removed and on Tuesday, April 14, 1977, MESA investigation teams with representatives of the company and Scotia Employees Association examined all accessible areas in 2 East Main including 1-1/2 Right Section. No evidence of flame or forces from the explosions were observed in 2 East area. Plastic checks and ventilation controls in use on March 9, 1976, were all intact. There were no falls at the faca areas. The examination of the 2 East area completed the investigation of all accessible areas of the mine.

Appendix B lists the names of persons who directed and participated in the recovery operations following the unsealing of the mine.

PART VII

INVESTIGATION, DISCUSSION AND EVALUATION

Public Hearings

The Secretary of the Interior appointed a panel to conduct an investigation to determine the causes of the explosions. The Public Hearings were held in the County Courthouse, Whitesburg, Letcher County, Kentucky, on April 5 - 9, and 27 - 30, 1976. The names and titles of the panel members were as follows:

> Robert E. Barrett, Chairman,
> Administrator, Mining Enforcement and Safety Administration.
>
> Fred G. Karem, Panel Member;
> Deputy Under Secretary, Department of the Interior.
>
> Harreld N. Kirkpatrick, Panel Member;
> Commissioner of the Department of Mines
> and Minerals, Commonwealth of Kentucky.
>
> George R. Eadie, Panel Member;
> Professor of General Engineering,
> University of Illinois.
>
> George G. McPhail, Panel Member;
> Senior Mine Rescue Officer for the
> Province of Ontario, Canada.
>
> Thomas A. Mascolino, Panel Counsel;
> Assistant Solicitor, Department of the Interior.

Transcripts of these official hearings are available at MESA headquarters, 4015 Wilson Blvd., Arlington, Va., 22203.

The mine was sealed on the surface on March 19, 1976, before an investigation of either explosion had been made. Recovery of the mine by the air-lock method began on July 14, 1976, when the seals were broken at the surface portal and continued three shifts a day, 5 to 7 days a week, until the 2 Southeast Main (explosion area) was recovered on March 9, 1977. During the period from July 14 to October 22, 1976, while the areas of the mine that were not affected by the explosions were being recovered, MESA selected and organized investigation teams and appointed a Coordinator. Together, they developed detailed plans and procedures for investigating the explosions. The team members were selected from Technical Support and Coal Mine Health and Safety personnel with expertise and experience in the fields of mine ventilation systems; high-and-low voltage mine power systems; electrical installations and equipment; explosibility of gas and coal dust; propagation of gas and coal dust explosions; mine rescue and recovery operations, and investigations following similar disasters; and underground photography. A Special Investigator was assigned to each investigation team for the purpose of observing conditions and practices which could constitute willful violations of the Act. MESA established procedures for custody of evidence. The chain of custody was maintained by marking each item of evidence, and recording the identity of the person obtaining the item, and the date, time and location where found. Each item was recorded in a master custody log and was secured in a custody van located on the mine property. The chain of custody was continually preserved for each item throughout the transporting and testing process.

A member of the Kentucky mine rescue team and a member of the MESA mine rescue team were assigned to travel with the recovery teams as observers during the recovery of 2 Southeast Main to insure that any evidence which might be used to determine the causes of the explosions was not disturbed or destroyed.

Investigation Committee

The underground investigation of the causes of the explosions was begun on July 14, 1976, and continued until May 25, 1977. The following persons participated in the investigation:

Kentucky Department of Mines and Minerals

Harreld N. Kirkpatrick	Commissioner
Sam Johnson	Assistant to the Commissioner
Albert Alexander	District Supervisor
William E. Clayton	Electrical Instructor

Scotia Coal Company

William Coffey	Director of Safety
David Adams	Chief Electrician
Henry R. Simpson	Repairman
Raymond Asher	Engineering Department

Scotia Employees Association

David McKnight	President
Benny Adams	Committeeman
Kenneth Goins	Committeeman

Mining Enforcement and Safety Administration

Lawrence D. Phillips	District Manager, District 6
Ray G. Ross	Supervisory Mining Engineer
James D. Micheal	Coal Mine Specialist Coordinator

Team No. 1 - Technical Support

J. W. Stevenson	Mining Engineer (Ventilation) Team Leader
James Banfield	Mining Engineer (mine mapping)

Team No. 2 - Technical Support
Evaluation of Flame and Forces

John Nagy	Physical Scientist Team Leader
E. N. Kawenski	Chief, Industrial Safety Branch Mining Engineer

Team No. 3
Plotting of Evidence and Dust Sampling Survey

Paul J. Componation	Supervisory Coal Mine Technical Specialist (Ventilation) Team Leader
Raymond Strahin	Federal Coal Mine Inspector
Joseph Tankersley	Federal Coal Mine Inspector
Nolan White	Federal Coal Mine Inspector Special Investigator
Earl Mazzeo	Photographer

Team No. 4
Electrical Investigation

Cecil E. Lester	Coal Mine Specialist Director of Electrical Investigation Groups

Group No. 1
Inspection and Test of Mine Power System

Ralph Rinehart	Electrical Engineer Group Leader
Aaron Jones	Electrical Engineer
Donald Osborne	Federal Coal Mine Inspector (Electrical)

Group No. 2
Inspection of Electrical Equipment and Power Cables

Richard Reynolds	Electrical Engineer Group Leader
George Fesak	Electrical Engineer
Andy Lycans	Coal Mine Technical Specialist (Electrical)
Gary Perry	Federal Coal Mine Inspector Photographer
Arthur Cross	Federal Coal Mine Inspector Special Investigator

Beginning at the mouth of Northeast Main and continuing throughout 2 Southeast Main, immediately after the fresh air base had been advanced by recovery teams, and the area outby had been secured, ventilated and otherwise made safe, the investigation teams entered the area to make comprehensive inspections and evaluations of existing conditions, and to conduct dust surveys. All observed conditions were recorded by one of the team members either on a map or on tape. Photographs were taken and sketches made of conditions and equipment when necessary. The data collected by the investigators was transferred to a large-scale map for a composite record.

Factors Affecting the Explosions

Ventilation

The 2 Southeast Main was developed approximately 3,700 feet into virgin territory by five entries, using the room and pillar system of mining. At the time of the explosion the elevation of the coalbed near the faces was approximately 70 feet higher than at the mouth of 2 Southeast Main. Intake air was coursed into the area through the No. 4 track entry and the parallel No. 5 entry. The Nos. 1 and 2 entries were return aircourses. The conveyor belt was installed in No. 3 entry and was ventilated with a separate split of air. During the Federal inspection completed in February, 1976, 25,168 cubic feet of air a minute was measured at the return regulator and 69,000 cubic feet of methane was being liberated in 24 hours. From all available evidence, it appeared that development of the 2 Southeast Main faces was discontinued in early February, 1976, and mining in 2 Left Section off 2 Southeast Main, approximately 1,700 feet outby, was started. At this time, the 2 Southeast Main faces and 2 Left Section were on one continuous split of air. On March 9 1976, work was in progress to construct overcasts at the junction of 2 Left Section and 2 Southeast Main to permit splitting of the air. To gain access into 2 Left Section, concrete block stoppings were removed at No. 23 crosscut between Nos. 2 and 3 entries and Nos. 3 and 4 entries, 2 Southeast Main. Reportedly, to prevent short-circuiting of the air ventilating 2 Southeast Main inby 2 Left, a plastic check curtain was installed between Nos. 3 and 4 entries at No. 23 crosscut. Air-lock door which would have permitted entry into the section and still provided positive ventilation in 2 Southeast Main inby 2 Left were not provided.

On the afternoon shift, Monday, March 8, Federal Coal Mine Inspector Davis, while making a Health and Safety Technical Inspection, measured the air in the last open crosscut of 2 Left between the intake and return aircourses. The quantity of air measured was 8,092 cubic feet a minute and a 104(b) Notice of Violation was issued. The quantity of air in the last open crosscut was increased to 10,472 cubic feet a minute and the Notice was terminated. According to his testimony at the official hearings, Davis stated that the check curtains were repaired to increase the quantity of air. According to other testimony, witho the knowledge of the Inspector, miners had been instructed by Section Foreman Williams to install plastic checks across Nos. 4 and 5 entries i

2 Southeast Main inby 2 Left. The Section Foreman ordered the checks inby 2 Left removed prior to leaving the Section at the end of the shift. Miners and Assistant Mine Foreman Bentley testified that they did not notice a check curtain across the 2 Left track at No. 23 crosscut when they entered the Section on March 8. According to testimony, this check curtain had been totally missing or partially down for several days prior to the first explosion. The open No. 23 crosscut and the placement of the checks in Nos. 4 and 5 entries, 2 Southeast Main inby 2 Left, short-circuited the ventilation inby 2 Left.

According to testimony at the official hearings, on March 9, while making an inspection of the abandoned 2 Left Section off Northeast Main, Bentley found that a regulator was open approximately four feet wider than he had originally set it after the Section was abandoned. According to Bentley, he closed the regulator to its original position, which decreased the quantity of air by 8,940 cubic feet a minute. Following the adjustment of the regulator, Bentley contacted Section Foreman Virgil Coots in 2 Left Section off 2 Southeast Main to inquire about Coots' ventilation. Bentley told Coots that his closing of the regulator should have increased Coots' ventilation. Coots told Bentley that he had just lost his air. A few minutes later, at approximately 11:45 a.m., the explosion occurred.

Following the explosion on March 9, approximately 17,000 cubic feet of air a minute was available to ventilate the 2 Southeast Main area. Rescue personnel were unable to obtain any appreciable movement of air inby No. 22 crosscut. Wednesday evening, March 10, company officials and employees and MESA representatives, including the MESA rescue teams, entered the mine for the purpose of making adjustments in the mine ventilation system to provide additional air in 2 Southeast Main to permit total recovery of the area so that an investigation into the cause of the explosion could be conducted. Company and MESA representatives were dispatched to underground regulators which were adjusted in an effort to increase the amount of air available for 2 Southeast Main. Approximately 19.000 cubic feet of air a minute was taken from the 1 West air split, but this amount did not increase the air quantity for 2 Southeast Main.

According to the ventilation plan submitted to the District Manager for approval on March 1, 1976, approximately 175,000 cubic feet of air a minute was intaking at the main portals and ventilating 1 West Main, 2 East Main area, Southeast Main, and the Left Panel of Southeast Main; a portion of the air ventilated 2 Southeast Main. Another 50,000 cubic feet of air a minute was intaking at the recently constructed air shaft and ventilating areas inby 2 Left off Northeast Main. A portion of this air was also used to ventilate 2 Southeast Main. The amount of intake air entering 2 Southeast Main from the two sources could possibly vary due to a change of resistance in either intake source.

During the investigation following recovery of the mine, it was found that some ventilation controls shown on the ventilation map submitted for approval on March 1, 1976, were not in place in areas of the mine that had not been affected by the forces of the explosions. Two missing regulators, one in the No. 1 entry of 2 Left off Northeast Main and one in the connecting entries from the air shaft entries, were crucial. These regulators would have controlled the quantity of air from the air shaft which was being diverted to the gob areas, and also would have significantly affected the volume of air available to ventilate 2 Southeast Main both before and after the first explosion. When the mine had been reventilated after the second explosion, it was found that these missing controls permitted approximately 47,000 cubic feet of air a minute to enter the gob area. After a regulator and stoppings were erected in 2 Left off Northeast Main to limit the quantity of air entering the gob area, approximately 65,000 cubic feet of air a minute was then available at the mouth of 2 Southeast Main. Since all efforts after the first explosion to provide additional air to 2 Southeast Main were unsuccessful, this indicates that much of the air from the intake air shaft prior to the March 9 explosion must have been diverted to the fan through 2 Left off Northeast Main. Under these circumstances, the adjustment of ventilation controls in other areas of the mine during recovery after the first explosion could not have provided any meaningful increase in air for 2 Southeast Main, as these adjustments would only have increased the volume of air in the free split (2 Left off Northeast Main) through the gob area to the fan. During recovery after the first explosion, these missing regulators were assumed to be in place, and company officials did not indicate otherwise during the morning meeting of participating groups on March 10, or at any other time. This assumption was the decisive factor in the failure to provide additional air for 2 Southeast Main. This failure resulted in the delay in exploring the remaining portion of 2 Southeast Main and in re[illegible] methane from the area. Several other discrepancies in the ventilation map submitted for approval on March 1, 1976, are shown in Appendix C.

The approved face ventilation plan for the continuous mining machine sections required that line brattice be installed to within 10 feet of the point of deepest penetration of any face from which coal was being mined, using an exhaust system of ventilation. During the official hearings, miners testified that on continuous mining machine sections, there was a practice to install line brattice as a blowing system during the shift and to change the system to exhaust prior to leaving the section at the completion of the shift. Company officials were reportedly aware of the practice During recovery operations after the first explosion, line brattice in 2 Left Section off 2 Southeast Main was observed installed on the right side of the continuous mining machine in No. 4 entry, indicating a blowing system of face ventilation had been used.

Ventilation surveys were conducted at the mine from June 5 through 9, 1972, and from June 17 through 24, 1974, by company and MESA personnel. The first survey was conducted at the request of the company. The surveys indicated numerous restrictions such as roof falls in the return slope entries. The main return was restricted to a single line of overcasts; and had double-regulated splits and small cross-sectional area overcasts. Approaches to some overcasts were not streamlined to permit an even air flow. These conditions and practices contributed to unnecessary high resistance to air flow. The survey reports recommended that the high resistance areas be eliminated; that an intake air shaft be provided in the Northeast Main area; and that additional return aircourses be provided in the slope area.

A 13.5-foot diameter air shaft was completed July 21, 1975, and new return aircourses were developed parallel to the slope entries. However, at the time of the explosion the new return entries had not been connected to the mine ventilation system.

During the recovery operations and the investigation, it was found that the air flow from four main return aircourses was restricted to one single line of overcasts at 2 East and the area over one of the overcasts was only 40 square feet. The tops of overcasts in entries, except where additional clearance was required for haulage equipment or an escapeway, were constructed to about one-half the entry height thereby restricting air flow to an area approximately one-half the entry area. Where additional height was needed at overcasts along haulageways and escapeways, roof had been taken down immediately above the overcast site and little effort had been made to streamline the entry on each side of the overcast to reduce resistance. See Appendix L, Figure 2. Gob was stored in crosscuts and entries in many areas of the mine. Main return aircourses at many locations were restricted by gob and falls of roof. Some ventilation controls installed during development had not been removed when no longer needed to control the air current, resulting in unnecessary restrictions. Proper ventilation controls were not installed when the air shaft was put into service. The bleeder system and ventilation controls in the pillared area of 1-1/2 Right off 2 East Main did not insure that return air flow from the gob area would not enter the active working places along the pillar line.

From the available evidence, MESA investigators conclude that: 1) The 2 Left Section off 2 Southeast Main was activated before permanent ventilation controls were installed and ventilation problems were encountered (low air quantity) on this section on the last coal-producing shift before the explosion, and immediately before the explosion occurred; 2) Checks were ordered installed acrcss intake aircourses in 2 Southeast Main; 3) The air current was intentionally short-circuited in 2 Southeast Main (and also in Northeast Main), which resulted in unventilated areas and methane accumulations; and 4) A regulator was changed during the coal-producing shift on March 9, 1976, shortly before the explosion occurred.

The above conditions and practices, some of which had existed for an extensive period of time, resulted in serious mine ventilation problems that were either undetected or ignored by mine management, and reflected a lack of understanding by mine officials of sound ventilation principles, a lack of appreciation of potentional hazards of methane accumulations, or a disregard for compliance with Federal law pertaining to mine ventilation.

To reconstruct the mine ventilation system as it existed immediately to the March 9 explosion is almost impossible because of the many chai that had to be made in the system to provide adequate ventilation for the recovery operations. Therefore, the investigation teams could not definitely determine whether the entire mine was adequately ventilated immediately prior to March 9. However, considering the inefficiencies in the entire ventilation system, as described in this report, it is questior able whether there was sufficient air to provide positive ventilation at all times to the six coal-producing sections and the other areas of the mine that were required to be ventilated.

From May 17 to 23, 1977, MESA personnel in cooperation with company persor conducted tests to simulate the ventilation system that was in effect on 2 Southeast Main on March 9, 1976. The tests were made to determine airflows, rates of methane liberation, the effect of short-circuiting the air through No. 23 crosscut and the effect of checks in Nos. 4 and 5 intake entries in 2 Southeast Main inby 2 Left.

The tests indicated that when the air was short-circuited at No. 23 crosscut, with approximately 11,000 cubic feet of air a minute passing through the last open crosscut in 2 Left Section, only a perceptible movement of air was detected by chemical smoke test in the last open crosscut in 2 Southeast Main. Methane was liberated from all faces in 2 Left and 2 Southeast Main sections; from the solid ribs in Nos. 1 and 5 entries; and from cracks in the floor inby 2 Left. The methane accum slowly in 2 Southeast Main inby 2 Left when the air was short-circuit No. 23 crosscut, and more rapidly when the air was totally restricted by checks installed across Nos. 4 and 5 intake entries, 2 Southeast Main inby 2 Left. Appendix M-1 is a report of the test.

Methane

Methane had been detected in the Scotia Mine on numerous occasions, by both company officials and MESA inspectors. During June 5 to 9, 1972, and June 17 to 24, 1974, MESA representatives conducted ventilation surve in the mine at which times analyses of samples of the mine return air showed a daily methane liberation of 216,000 and 411,000 cubic feet, respectively. Samples collected by MESA inspectors during 1975 showed the mine liberated as much as 568,000 cubic feet of methane in 24 hours. Mine air samples, collected in the immediate return aircourses of active sections during MESA inspections in 1975, showed that all sections were liberating methane. Methane was liberated in greater amounts in development of virgin territory.

Examinations of the mine record books showed that methane, in amounts of as much as 5 percent, was detected in Southeast Main on February 1 and 5, 1976, and in the Left Panel off Southeast Main on February 27, 1976.

Testimony of company officials and employees at the official hearings indicated that as much as 3 percent methane had been detected in No.

entry, 2 Southeast Main, 4 or 5 crosscuts inby 2 Left Section during development of that area. During December, 1975, mechanics working on equipment in the track entry about eight crosscuts outby the face area had ignited a methane feeder while using an acetylene torch. This ignition was not reported to MESA. Company officials reported detecting as much as 4 percent methane in various working places while making routine examinations and tests. According to an air sample collected by a Federal inspector on January 22, 1976, 2 Southeast Main was liberating 69,000 cubic feet of methane in 24 hours. During rescue and recovery operations in 2 Southeast Main following the March 9 explosion, rescue teams reported methane concentrations ranging from 1 percent at No. 11 crosscut to more than 5 percent at No. 27 crosscut.

After the mine was sealed on March 19, 1976, until April 27, 1976, the methane in 2 Southeast Main increased to 36.47 percent. By July 14, 1976, the methane content in this area had increased to 55.46 percent; and by February 14, 1977, the methane content in this area had increased to 71.4 percent, as determined by analyses of air samples collected through Nos. 1 and 2 boreholes. During the investigation in 2 Southeast Main methane was being liberated from the ribs of Nos. 1 and 5 entries and from cracks in the mine floor along these ribs. Air samples collected from cracks in the bottom of No. 4 entry and from bubbles in water in No. 1 entry between Nos. 25 and 26 crosscuts showed 1.74 and 6.81 percent methane, respectively. The cover over the coal in 2 Southeast Main exceeded 1,100 feet. The pressure created by this overburden caused stresses which resulted in heaving and fracturing of the mine floor as well as sloughing of the coal ribs and faces. These conditions, as they developed, caused release of methane.

Preshift examination was to be made by a certified fire boss prior to the first of the two coal-producing shifts. At the official hearings the fire boss stated that he was unable to personally examine each of the six sections because of the extent of the mine workings. Other certified officials examined some of the sections, but the fire boss signed the record book on the surface. During the investigation following the second explosion, a search was made in the mine for dates and initial marks that would indicate that required examinations and tests had been made. The last marks on a roof bolt plate in face areas were; 2 Southeast Main "2-6 CF" and "2-6 VC"; and Left Panel Northeast Main "11-8-75 CF". It was a practice in the Scotia Mine to place dates and initials on roof bolt plates. See Appendix L, Figures 3 and 4.

The records of the preshift examinations for March 9, 1976, signed by Charles Fields, fire boss, showed that he made the preshift examination of the entire mine including 2 Southeast Main. However, testimony at the official hearings indicated that Arvil Cornett, third shift Mine Foreman, made the examination in 2 Left Section, but did not examine 2 Southeast Main inby 2 Left Section. Cornett stated that 10,120 cubic feet of air a minute was measured in the last open crosscut in 2 Left Section. However, the fire boss record book showed 14,000 cubic feet of air a minute but designated the place as "2 SEM". The fire boss record book was confusing because though mining had been discontinued in 2 Southeast Main during early February, 1976, and the mining equipment moved to 2 Left Section, the fire boss book continued to show a designation for 2 Southeast Main and made no reference to the active 2 Left Section.

On the day shift, March 9, 1976, J. B. Feltner, Underground Construction Foreman, instructed the operators of the Nos. 6 and 8 battery-powered locomotives to transport a load of rails into 2 Southeast Main inby 2 Left Section. Feltner testified that he did not instruct the locomotive operators to make tests or examinations of the area before entering the area. He stated that he assumed 2 Southeast Main inby 2 Left had been preshifted because the area was on intake air. He testified that the locomotive operators did not have methane detectors.

On-shift examinations for hazardous conditions were to be made on each active coal-producing section by certified foremen. Miners whose duties required that they make tests for methane during the operation of electric equipment in face areas were provided with approved-type methane detectors but often were not trained in the use of these detectors.

The weekly examination of the entire mine for hazardous conditions, including tests for methane, was to be made by James Bentley, Assistant Mine Foreman in charge of ventilation. The weekly examination record book indicated that three mine examinations had been made during the 25 days preceding March 9. Bentley testified that recording in the book was made only upon completion of each examination of the entire mine. He stated that the last weekly examination which had been completed was not entered in the record book because of seizure of the record book by MESA following the explosion on March 9. He stated that he had examined the 2 Southeast Main inby 2 Left Section on March 8, and had not found more than 0.3 percent methane.

Testimony at the official hearings revealed that a check in No. 23 crosscut across the track leading into 2 Left Section off 2 Southeast Main was totally missing or partially down at various times preceding the first explosion. The night before the explosion, check curtains were hung across the intake entries in 2 Southeast Main inby 2 Left. These practices short-circuited the air that was to ventilate 2 Southeast Main inby 2 Left.

Testimony revealed that a methane feeder in the floor had been detected in 2 Southeast Main about eight crosscuts outby the faces in December, 1975 Measurements at this feeder made by company officials showed methane concentrations of 5 percent. In May, 1977, MESA and company personnel conducted ventilation tests in 2 Southeast Main and determined that the rate of methane liberation at that time was 5.7 cubic feet a minute.

The foregoing evidence shows that 2 Southeast Main was liberating methane prior to the first explosion; that there were practices detrimental to proper ventilation; that required examinations were not conducted; that as much as 5 percent methane was present immediately after the first explosion; and that methane was still being liberated after the explosions.

Mining of coal in 2 Left Section off 2 Southeast Main began approximately one month prior to the explosion. In this period, 2 percent methane was detected in intake air by a miner. While engaged in rescue operations following the March 9 explosion, rescue teams reported that 3 percent methane was detected in the 2 Left entries. During the investigation in March, 1977, methane was liberated in audible and detectable amounts from Nos. 2 and 3 faces in the 2 Left entries. Evidence shows that methane was liberated in 2 Left Section prior to the first explosion and between the first and second explosion, and that an explosive concentration of methane had built up in 2 Left Section at the time of the second explosion.

In May 1977, ventilation tests showed that methane was liberated in 2 Left Section off 2 Southeast Main at the rate of 1.5 cubic feet a minute. This area was not ventilated during the approximate 60-hour interval between explosions. Although 17,250 cubic feet of air a minute was entering 2 Southeast Main, after the first explosion, little if any air reached the last fresh air base at No. 22 crosscut. It was this lack of sufficient ventilation that delayed rescue and recovery efforts. Calculations indicate that during the period between explosions, methane concentration in the approximately 300,000 cubic feet of open volume in 2 Left Section would have increased to the explosion range. The presence of an explosive concentration of methane in 2 Left Section at the time of the second explosion was shown by the extension of flame to all faces of the Section. Flame will not propagate into a dead-end passageway unless an explosive methane concentration is present, as has been demonstrated in experimental tests reported in Bureau of Mines Report of Investigations No. 6344. The presence of flame at the faces was evident from the heavy coke deposits in these areas. Tests were made on a sealed dust collection box of one of the two roof-bolting machines on 2 Left Section. The boxes on both machines were partially crushed by the second explosion. Tests in which one of the boxes was subjected to explosion pressure sufficient to crush it to the same extent as occurred in the second explosion, showed that the pressure had to exceed 30 psig. For this pressure to develop in a mine explosion, a methane concentration of at least 7 percent would be required. Appendix M-10 is a report on the tests conducted on the dust collection box.

Rick Parker, one of the two survivors of the March 11 explosion, who was located at that time in the Left Panel of Northeast Main at No. 182 crosscut, near the junction of 2 Southeast Main, at the official hearings stated:

> ". . . well, we heard it . . . a large boom. And within just a matter of seconds . . . in fact, I think I had time to get my hands over my ears. I was trying to protect them from any percussion. There was just a . . . you could hear it coming at you and then, all of a sudden, just a big whoosh, right over the top of you . . ."

Tests in the Bureau of Mines Experimental Mine showed that for a "boom" to develop, the methane in the March 11 explosion area would have had to have been in a concentration of 7.5 to 12 percent. A coal dust explosion, except a high velocity explosion developing in float coal dust, develops a "whoosh" without a "boom".

At the time of the second explosion the methane in 2 Left Section was mixed rather than layered. The rescue teams, after the first explosion, reported a nearly uniform methane concentration of 3 percent throughout 2 Left Section. Fifty-eight days after the second explosion the methane concentration at No. 2 borehole showed 29.3, 29.5 and 29.7 percent methane at the mine floor, mid-height and roof, respectively.

Coal Dust

During the investigation, band dust samples were collected by MESA in South Main, 1 West Main, 2 Left off Northeast Main, Southeast Main, Northeast Main, 3 Southeast Main and 2 Southeast Main. Samples were collected 180 feet apart in each entry, except that in 2 Southeast Main and 2 Left Section off 2 Southeast Main, samples were collected 90 feet apart in each entry. The samples were analyzed for incombustible and coke content. Outside the areas affected by the explosions (in South Main, Southeast Main, 1 West Main, 3 Southeast Main and 2 Left off Northeast Main), the incombustible content averaged 80 percent in the intake aircourses and 70 percent in the return aircourses. Sixteen percent of the 226 intake samples were below the required 65 percent incombustible content and 73 percent of the 194 return samples were below the required 80 percent incombustible content. Appendix H shows the sampling locations and dust analyses.

During 1975 and 1976, prior to the explosions, 405 mine dust samples were collected in the Scotia Mine by MESA inspectors. Analyses of these samples are similar to those of the above samples. In this period the average incombustible content of the dust in the intakes was 82 percent, and 12 percent of the 280 intake samples were less than the required 65 percent incombustible content. In the return aircourses, the average incombustible content of the dust was 78 percent, and 39 percent of the 125 samples were less than 80 percent incombustible. During the period January 27, 1976, to March 9, 1976, dust surveys were conducted in four sections of the mine not affected by the explosions. In these areas, the average incombustible content of the intake aircourse samples was 88 percent, and of the return aircourse samples was 92 percent. Only one sample of the 42 collected was below the requirements of the law.

Two hundred dust samples collected in 2 Southeast Main after the explosions showed an average incombustible content of 49.6 percent; 18 dust samples from 2 Left Section off 2 Southeast Main had an average of 42.7 percent; and 184 samples from the Right Panel Northeast Main had an average of 56.6 percent. The incombustible content of these samples does not represent the conditions prior to the explosions. The 2 Left Section was rock-dusted on the shift preceding the first explosion. In the Left Panel Northeast Main, where a few sampling locations were in the area affected by the explosions, the average incombustible content of 131 samples was 78.9 percent. These data show that outside the explosion area the average incombustible content of the dust was above 65 percent but a large number of samples were below the minimum requirements of the law. The number of deficient samples was considerably greater in return aircourses than in intake aircourses. In the area affected by the explosions nearly all the samples were deficient in incombustible content.

Close examination by the investigation teams of the mine surfaces in the explosion area showed that all locations, except in the immediate face areas, had been rock-dusted prior to the first explosion. The average incombustible content of 54 mine dust samples collected in the intake aircourses of 2 Southeast Main prior to the explosions was 81.3 percent; the average in the return aircourses was 82.6 percent. Four of the 18 samples in the return aircourses contained less than 80 percent incombustible content.

Visual examination by the investigation teams of the explosion area showed deep accumulations of coal and coal dust in 2 Left Section, 2 Southeast Main and Right Panel Northeast Main. The accumulations were greater than those in the rest of the mine. The greater accumulation in the three areas above was partly due to stresses imposed on the coal by the overburden. In the three areas, the coal was visibly fractured and tended to spall from the ribs. In February, 1977, four full-depth samples of coal dust (-20 mesh) were collected from 2 Southeast Main entries by the investigation teams. Data from these samples show 66.6, 27.8, 28.8 and 20.9 pounds of coal dust per linear foot of entry width and an average incombustible content of 28.3 percent. In order of the above data the sampling locations were 2 Southeast Main, No. 5 Entry, between Nos. 22 and 23 crosscuts; 2 Southeast Main, No. 1 Entry, between Nos. 23 and 24 crosscuts; 2 Left Section, No. 4 Entry, between Nos. 1 and 2 crosscuts; and 2 Left Section, No. 1 Entry outby No. 1 crosscut.

Examination of the explosion area in 2 Southeast Main indicated that much of the coal dust on the floor had been raised into suspension during the second explosion, and in relatively large areas. The ribs at many locations were scoured clean by the air movement of the explotion. It is concluded that in the first explosion much of the rock dust in the top layer of dust in 2 Southeast Main from Nos. 15 to 34 crosscuts was mixed with a heavy sublayer of coal dust to produce a mixture that would be less than 65 percent incombustible. The second explosion then propagated through this dust having low incombustibility.

Sampling during the investigation verified that considerable mine dust was raised into suspension in 2 Southeast Main in the second explosion. At No. 20 crosscut in 2 Southeast Main, dust in a square-foot area on top of a power center was collected by the inventigation teams. The dust was equivalent to an airborne dust concentration of 0.3 ounce per cubic foot, which is six times greater than the minimum explosive concentration. The dust on the power center had settled from the mine atmosphere after the second explosion. During the explosion, the quantity of dust in the air would have been greater. The incombustible content of the dust in this sample was 28.3 percent, as compared to 23.9 percent for the coal seam itself, indicating that only a small fraction of the dust burned during the explosion. This also indicates that a considerable amount of dust was dispersed into the air by the second explosion. The above indications were confirmed by a sample collected 1,500 feet outby the power center where dust had settled on a concrete block on the floor in No. 3 crosscut. The dust on the block was equivalent to an airborne dust concentration of 0.1 ounce per cubic foot and the incombustible content was 36.3 percent.

The Explosions and Their Propagations

The evidence gathered by MESA's investigation teams indicate that the March 9 explosion was initiated by ignition of a methane accumulation near No. 31 crosscut in 2 Southeast Main. The combustible methane mixture did not extend to the faces of 2 Southeast Main. Consequently, pressure relief following ignition was attained in both inby and outby directions and neither the pressure nor the flame velocity were excessive.

The exploding methane dispersed mine dust into the air and caused flame to propagate approximately 1,600 feet. Soot deposits confirmed that coal dust entered into the explosion. The explosion developed relatively low pressure and low flame velocity as evidenced by the minimal damage outby the intersection of 2 Left Section. Flame propagation was arrested by the incombustible matter in the top layers of the mine dust. But forces of the explosion mixed the relatively deep floor and rib coal dust with the rock dust.

The evidence gathered by MESA's investigation teams indicate that the March 11 explosion was initiated by ignition of a methane accumulation in or near the entrance of 2 Left Section off 2 Southeast Main. The high-velocity methane explosion dispersed the relatively deep coal dust accumulations on the floor and ribs in 2 Left Section. Soot deposits in 2 Left Section confirmed that coal dust burned. The explosion flame propagated into the entries of 2 Southeast Main where a large amount of coal dust was dispersed with a lesser amount of rock dust that had been mixed by the previous explosion. The presence of rock dust in the top layers outby No. 15 crosscut and the pressure relief provided by the intersection of 2 Southeast Main with the Right and Left Panels of Northeast Main slowed the advancing flame. However, sufficient coal dust from the floor and ribs was dispersed in the Right Panel Northeast Main inby 2 Southeast Main to allow the explosion to continue in an inby direction in the Right Panel. Explosion flame was eventually quenched by the rock dust and the pressure relief provided near the intersection of the Right Panel and 3 Southeast Main.

Electrical Circuits and Equipment

All energized electrical circuits and equipment located in the explosion areas, or which supplied power to electric equipment in the explosion areas, were examined and some extensively tested to determine the settings of short-circuit, overload and ground-phase protective devices, in order to determine if the mine power system had supplied the ignition source for the first or second explosion.

The surface substation from which the underground high-voltage circuit originated was examined. The grounding resistor, high-voltage circuit breaker and ground fields were tested by MESA electrical engineers. Tests conducted on the high-voltage circuit breaker revealed that the protective relays were adjusted to activate the circuit breaker at 320 amperes overload and 1,200 amperes short-circuit current. The grounded-phase protective relay was adjusted to activate the circuit breaker at 16 amperes of ground fault current. Tests performed on the oil circuit breaker showed that at the maximum ground fault current of 25 amperes, the circuit breaker would activate in seven seconds.

The ground check monitor and the ground fields of the substation were tested and found to conform to all applicable requirements of Part 75, Title 30, CFR. Appendix M-6 contains test data obtained in the surface substation. The high-voltage circuit breaker protecting the underground circuits activated after each explosion and automatically removed all alternating current power from the mine.

As each portion of the mine was recovered, the distribution circuits and equipment in that area were examined and each power or control circuit that could have been a potential source of ignition was tested. The underground investigation included a visual examination of the high-voltage cable from the bottom of the main power borehole to 3 Southeast Main and in 2 Southeast Main between the mouth and the section power center in 2 Left Section. The investigation revealed that portions of the high-voltage cable were not rated for the voltage of the circuit in that a portion of the cable was rated at 5,000 volts but was energized at 7,200 volts. A high-voltage cable splice located at No. 205 crosscut of the Left Panel Northeast Main was improperly made in that the metallic shielding had not been replaced around the power conductors. The length of high-voltage cable between the belt power center at No. 180 crosscut and the "Y"-box in No. 182 crosscut contained a grounded phase. Portions of the high-voltage cable between 2 Southeast Main and 3 Southeast Main showed evidence of intense heat, but the phase conductors were not grounded. After the splices were reinsulated and covered with metallic shielding, the cable was reenergized to provide power for recovery work. The high-voltage cable coupler for the 2 Southeast Main high-voltage cable was found disconnected at the "Y"-box at the mouth of 2 Southeast Main and dust covers were in place on both the coupler and the receptacle. See Appendix L, Figure 9.

The high-voltage cable in 2 Southeast Main was examined. The outer jacket of the high-voltage cable contained several cuts and abrasions, and tests indicated that one phase was intermittently grounded. A mine rescue team had reported that a high-voltage coupler in this circuit had melted either from electric arcing or the intense heat of the explosion. However, an examination of the aluminum housings at the high-voltage couplers showed no evidence of melting or intense heat.

The "Y"-boxes located in the high-voltage circuit between the bottom of the main power borehole and the section power center in 2 Left Section off 2 Southeast Main contained grounded-phase protective circuits and ground wire monitor circuits which also provided undervoltage protection. The load-break switches of the "Y"-boxes opened automatically after each explosion. All power fuses remained intact.

Appendix M-7 contains test data for the belt power center (EMCO s/n 503-300-P-1) in No. 181 crosscut. Appendix M-8 contains test data for the "Y"-boxes in the high-voltage circuit.

Extensive tests of the high-voltage system were conducted to ascertain why the grounded-phase protective relays in the "Y"-boxes did not activate and disconnect the power only from the affected part of the circuit, thereby preventing the 7.2-kV high-voltage circuit breaker located on the surface from activating and deenergizing the entire mine circuit. These tests revealed that double-grounded phase faults existed in the system which caused short-circuit current to flow and activate a 13.8-kV breaker at the main substation which supplied power to the substation feeding the underground circuit. The results of these tests are included in Appendix M-9.

The forces of the second explosion moved the "Y"-box (Ensign s/n M-1157) located in No. 182 crosscut Northeast Main approximately 70 feet. Both load-break switches in the "Y"-box had apparently been manually placed in the open position and the high-voltage cable extending into 2 Southeast Main had been disconnected before the second explosion.

The EMCO 300-KVA belt power center located in No. 180 crosscut between Nos. 3 and 4 entries Northeast Main supplied 480 volts for operation of a 150-horsepower belt conveyor drive unit, a 75-horsepower belt conveyor drive unit and a small 1-horsepower pump. See Appendix L, Figure 10. The power center was equipped with two duplex 110-volt, single-phase receptacles; however, no circuits were connected to these outlets. The 480-volt circuit, originating at the belt power center and supplying power to the Northeast Main belt conveyor drive unit, consisted of round, 2/0, three-conductor, type G-GC, 600-volt, P102 BM cable. The circuit was protected by a 400-ampere, three-pole molded-case magnetic circuit breaker, labeled belt drive No. 1, equipped with undervoltage protection and adjusted to 4,000 amperes. See Appendix L, Figure 11. The circuit breaker was in the tripped position and the cable coupler was plugged into its mating receptable. The Northeast Main belt conveyor was controlled by means of a 32-volt d.c. control circuit connected through single-pole, single-throw, retaining-type switches. The impedance across the open contacts of the circuit breaker for belt drive No. 1 was measured and found to be 2 megohms across each of the three sets of contacts. The 480-volt circuit originating at the belt power center and supplying power to the 2 Southeast Main belt conveyor drive unit was a flat, No. 4, three-conductor, type G-GC, 600-volt, P102 B M cable with an external ground check conductor. The circuit was protected by a 225-ampere molded-case magnetic circuit breaker, labeled belt drive No. 2, equipped with undervoltage protection and adjusted to 2,250 amperes. See Appendix L, Fig. 11. The circuit breaker was found in the tripped position and the cable coupler was plugged into its mating receptacle. The 2 Southeast Main belt conveyor was controlled by a 32-volt d.c. control circuit connected through single-pole, single-throw, retaining-type on-off switches. The impedance across the open contacts of the circuit breaker designated for belt drive No. 2 was measured and found to be 60,000 ohms, 70,000 ohms, and 2 megohms.

The 2 Southeast Main belt control circuit was interlocked through a centrifugal roller switch so that the belt conveyor would start and stop automatically when the Northeast Main belt conveyor started or stopped.

The No. 14 two-conductor belt conveyor control cable extending into 2 Southeast Main was broken at several locations. One conductor of the control circuit was broken approximately 20 feet from the belt conveyor starter box. See Appendix L, Fig 12. The severed conductor was turned back and taped in a manner that indicated that the control circuit had been intentionally disconnected prior to the first explosion. A 110-volt cable-type receptacle was connected in parallel with the control circuit approximately three feet from the belt conveyor starter box. A short-circuited male plug was inserted into the receptacle, thereby short-circuiting the control circuit inby that point in 2 Southeast Main. See Appendix L, Fig. 13.

The 480-volt circuit extending to the 1-horsepower pump consisted of a No. 10, four-conductor, type SO, 600-volt cable. The circuit was protected by a 225-ampere molded-case magnetic-type circuit breaker (labeled spare) equipped with protection against undervoltage and adjusted to 2,250 amperes. The circuit breaker was in the manually tripped position. See Appendix L, Fig. 11. The cable coupler had been removed from the receptacle and had been partially disassembled. See Appendix L, Fig. 14. The bolts securing the outer metal housing had been removed and the two halves of the coupler had been separated, exposing the cable terminals. The grounding conductor had been disconnected. An Allen wrench was found inserted in the retaining screws securing one of the phase conductors. A 10-inch crescent wrench was lying on top of the belt power center.

A Galis roof-bolting machine, Model 320, 480-volt, was located in the track entry between Nos. 181 and 182 crosscuts Northeast Main. The of the cable had been pulled to the 300-KVA belt power center in No. crosscut and two Allen screws which secured the two halves of the coupler had been removed.

Two Westinghouse battery-powered locomotives (company Nos. 7 and 9) were located in the Northeast Main track entry between Nos. 181 and 182 crosscuts. The No. 7 locomotive was connected to a mine car. The No. 9 locomotive was connected to the Galis roof-bolting machine by means of a 5/8-inch steel wire rope. Both locomotives were manufactured as permissi type; however, they had not been maintained in permissible condition. See Appendix L, Fig. 15.

The light switches were in the outby position, the reverse bars were in the neutral position, the controllers were in the off position, and the parking brakes were in the on position on both locomotives. The batterie on both locomotives were completely discharged and the water had evaporated from the batteries.

The belt deluge system at the 2 Southeast Main belt conveyor drive unit was manufactured by Wise Industries, Incorporated, and powered by two 6-volt batteries.

The permissible-type fire sensor circuit installed along each belt conveyor entry received electric power from a battery-operated power supply located in the supply house on the surface. This circuit was deener from the surface after the first explosion.

The telephone circuit extending into 2 Southeast Main was disconnected near the 2 Southeast Main belt conveyor drive unit after the first explosion. It had been broken at several locations by forces of the explosion.

Immediately after 2 Left Section was recovered, an examination of all electric face equipment and other electric equipment in 2 Left Section and at the mouth of 2 Left Section was made. The three permissible-type Mine Safety Appliances telephones had been removed from the 2 Left Sectic area by a mine rescue team. One telephone had sustained severe mechanic damage to the case and to the internal electric components. See Appendix L, Fig. 16. The investigation revealed that this telephone had been damaged extensively by explosion forces; no evidence of an explosion wit the enclosure was found. The housing of the telephones contained louver that would have allowed any internal pressure to readily escape. All three of the telephones were sent to MESA Approval and Certification Cent in Pittsburgh, Pennsylvania, for tests to determine whether the telephone would ignite methane. The results of these tests are contained in Appendix M-3 and demonstrate that under certain conditions these phones could ignite an explosive methane-air mixture.

The battery-powered deluge system was removed from the 2 Left belt conveyor drive unit. See Appendix L, Figures 17 and 18. This deluge system was non-permissible-type and was powered by two 6-volt rechargeable batteries connected in series. A 120-volt circuit originating in the belt controller compartment had been used to trickle-charge the batteries to maintain the batteries in a fully charged condition. The audible alarm unit (bell) was missing from the control box and could not be located. The deluge system control box, the solenoid valve, and the two 6-volt batteries were sent to MESA Approval and Certification Center, Pittsburgh, Pennsylvania, for testing to determine if circuits within or extending from the control box would ignite an explosive methane-air mixture. The results of these tests are contained in Appendix M-2 and demonstrate that under certain conditions the solenoid valve circuit and sensor circuit could ignite an explosive methane-air mixture.

A 112.5-kVA belt power center supplied power for operation of the 2 Left belt conveyor. This power center was substantially damaged by the explosion. See Appendix L, Figure 19. One of the side covers of the belt power center had been blown off and another was partially blown off. The panel that held the low-voltage molded-case circuit breaker had been pushed in by the forces of the explosion. The low-voltage cable coupler that had been plugged into the belt power center was cracked and the cable coupler was not plugged into the receptacle on the belt power center at the time of the investigation.

The 75-horsepower belt conveyor drive unit and belt controller were non-permissible-type. The 75-horsepower belt conveyor drive motor was an induction motor with no arcing components. However, the belt controller contained relays and contactors which produced incendive arcing each time the belt conveyor was started or stopped. The belt conveyor drive unit was reported by rescue teams to have been moved slightly toward the outby rib of the entry by the first explosion. The belt conveyor drive unit was found to have been moved against the outby rib after the second explosion. See Appendix L, Figure 20. The controller box was turned upside-down by explosion forces, but an internal examination revealed no evidence that the arcing components had ignited a methane-air mixture. See Appendix L, Figure 21.

The 500-kVA section power center that supplied power for operation of all 2 Left electric face equipment was substantially damaged in the explosion. The input receptacle was torn loose from the mounting bracket and one high-voltage phase conductor was grounded. See Appendix L, Fig. 22. Three of the four covers on one side of the power center had been blown off and the fourth was held by the one remaining bolt. The high-voltage cable receptacle was broken loose from the frame of the power center. One of the doors on the low-voltage end of the power center had been blown off and the other door was held by part of one hinge.

The output of the power center consisted of two three-phase, 480-volt circuits protected by two 600-ampere, molded-case shunt-trip circuit breakers which provided short-circuit and grounded-phase protection. relays were broken and there was considerable internal damage inside the power center. See Appendix L, Figure 23. There were no cables plugged into the 480-volt receptacles on the power center at the time of the investigation, but, apparently, one circuit had supplied power to the distribution box which housed the circuit breakers and protective relays for the face equipment trailing cables and the other circuit had supplied power to the battery charger. Due to the physical condition of the section power center and belt power center, electrical testing was not attempted.

All permissible-type electric face equipment in 2 Left Section off 2 South east Main was examined. Explosion-proof housings containing arcing components were disassembled and examined for evidence of ignition. The results of these examinations follow.

The Lee-Norse continuous mining machine, Model No. CM35Y, Approval No. 2F-1604A, Serial No. 3669, was found in the face of No. 4 entry with the cutting bits in the coal face, coal on the conveyor, and the off-standard drive shuttle car in position to be loaded. The shuttle car was approximately one-fourth loaded with coal. The hydraulic tram levers on the continuous mining machine were in position to tram it away from the face. All evidence indicates that the continuous mining machine was cutting and loading coal at the time of the first explosion. No openi were found in explosion-proof compartments. All explosion-proof compa ments containing arcing components were examined internally and no evidenc of fire or smoke was observed. The start switch for the cutting motors was wedged with a nail in the "in" position. A splice in the No. 2/0 trail ing cable was not effectively sealed to exclude moisture and the insulation on the power conductors was visible; however, there was no evidence of arcing. The frame of the machine was effectively grounded through a groun ing conductor in the trailing cable. The Mine Safety Appliances, Model VI, methane monitor was wired into the continuous mining machine control circui so as to cause activation of the main circuit breaker and deenergization of the machine when the methane content of the air exceeded 2 percent. The methane monitor was tested by applying a known methane-air mixture of 2.5 percent methane concentration to the sensor element. The methane monitor was defective at the time of the investigation; it did not cause activation of the circuit breaker when the methane-air mixture was applied to the sensor.

Tests for intermachine arcing were made between the frames of the off-standard drive shuttle car and continuous mining machine by connecting a 0.1 ohm resistor between the machine frames and connecting a millivolt mete across the resistor. The cutting motors on the continuous mining machine and the main motor on the shuttle car were alternately started and stopped, and the millivolt drop across the resistor was measured. When the cutting motors were started, no voltage was measured across the resistor. When the shuttle car motor was started, 140 millivolts were measured across the resistor. This amount of electrical energy is not considered sufficient to create an incendive arc.

The standard drive shuttle car, National Mine Service Company, Model No. 48-43, Approval No. 2F-1490A, Serial No. 702, was located inby No. 3 crosscut in No. 3 entry. A 0.24-inch opening existed between the motor junction box and motor frame. Examination revealed that no arcing had occurred in the motor housing. No openings were found in the other explosion-proof compartments. All explosion-proof compartments containing arcing components were examined internally and no evidence of fire or smoke was observed. The frame ground conductor was not continuous in the trailing cable; however, the ground check conductor was connected as a grounding conductor and provided a path for ground fault current.

The off-standard drive shuttle car, National Mine Service Company, Model No. 48, Approval No. 1490A, Serial No. 130, was at the Lee-Norse mining machine in position to be loaded. No openings were found in explosion-proof compartments. All explosion-proof compartments containing arcing components were examined internally and no evidence of fire or smoke was observed. The frame of the machine was effectively grounded through a grounding conductor in the trailing cable.

A Galis roof-bolting machine, Model No. 320, Approval No. 2G-2631A-1, was found near the face of No. 2 entry and was apparently in operation in the right crosscut at the time of the first explosion. See Appendix L, Figure 24. The canopy of the roof-bolting machine was positioned against the roof and a drill steel was hanging from a hole in the roof. The drill head was resting on the mine floor directly under the drill steel. Unused roof bolts were scattered along the mine floor for a distance of 40 feet outby the machine. No openings were found in explosion-proof compartments. All explosion-proof compartments containing arcing components were examined internally and no evidence of fire or smoke was observed. The frame of the machine was effectively grounded through a grounding conductor in the trailing cable.

A piece of roof rock averaging six inches in thickness and measuring four feet by five feet had fallen on top of the roof-bolting machine. The rock, weighing approximately 900 pounds, fell 21 inches vertically onto the 3-inch diameter pipe supports of the canopy of the roof-bolting machine. The rock slid approximately 30 inches on the pipe supports, which were inclined 30 degrees from the horizontal, and came to rest on the steel plate top of the roof-bolting machine. The top surface of the rock was covered with soot from the second explosion. According to the rescue teams, the rock had not fallen when they saw the machine 10 hours after the first explosion. Thus, the rock fell after the first but before or at the time of the second explosion.

Because it was suspected that the falling rock may have created an incendive frictional spark, samples of the rock were taken for petrographic, chemical and x-ray analyses. Other roof strata from the explosion were also collected and analyzed. The roof-bolting machine and th were transported to MESA's Technical Support Center in Pittsburgh, Pennsylvania, where drop tests were made in a chamber containing an exp sive methane-air mixture. Appendices M-4 and M-11 contain data from t petrographic and x-ray analyses and data from the drop tests.

The studies on the composition of the rock showed that its texture var: both laterally and vertically. Petrographic examination of the sample showed a composition of 48 percent quartz; the quartz crystals were angular and sliverlike. The average grain size was 15 and the range of grain size was from 2 to 0.72 microns. X-ray analysis of the sample showed a composition of 23 percent quartz and a rapid-rock analysis sho 55.7 percent quartz. A chemical analysis by MESA of another specimen s 25 percent quartz.

In the drop tests conducted by MESA, the physical arrangement as it exi in the Scotia mine was duplicated as closely as possible. The rock was dropped five times in a seven percent methane-air mixture onto the pipe supports; no ignitions occurred. The rock, because of breakage, was es mated to lose 40 percent of its weight. A second series of five drop t were made with the remaining piece of rock striking roof bolts, roof bo plates, roof jacks and drill steel; no ignitions occurred.

A Galis roof-bolting machine, Model No. 320, Approval No. 2F-1527, S... No. 3253360, was located inby No. 4 crosscut in No. 1 entry and did appear to be in use at the time of the March 9 explosion. However, ... examined. No openings were found in explosion-proof compartments. One bolt was missing from the controller case cover.

The bottoms of the dust collection boxes on both roof-bolting machines collapsed to the extent that the bottom plates were touching the inside the tops of the dust boxes. See Appendix L, Figure 25.

A Long-Airdox belt feeder, type FBM-56, Serial No. 54110, Approval No. 2F-1750A, was examined for permissibility and no permissibility deficien cies or evidence of ignition were found. The control cable, which conne the interlock switch on a belt roller to the feeder control circuit, had been severed by the explosion forces.

The battery-powered Elkhorn scoop, Model No. AR4, Approval No. 2G2271-1 Serial No. 4753608, was examined for permissibility and found to be in permissible condition. The investigation revealed that the electric com ponents and wiring on the scoop, other than the batteries and battery ca were not instrumental in the ignition of either of the explosions becaus the batteries had been disconnected from the scoop and connected to the battery charger prior to the first explosion. The batteries had been di connected from the charger by the recovery teams prior to reventilating 2 Left Section, and the direct current cables were lying on top of the scoop. Both the battery charger and the scoop had been moved approx mately 8 feet toward No. 4 entry by explosion forces. At the time o the investigation, the charger was positioned upright with the top cover blown off. The charger was located approximately 2 feet from the scoop operator's position. The No. 10/4 conductor, type SO cord, used to supply alternating current to the charger was severed approximately 4 feet from the charger. The nonpermissible-type battery charger reduced and rectified the 480-volt, three-phase alternating current to direct current for charging of the 64-volt batteries. Three of the four insulated covers for the battery trays had apparently been blown away by explosion forces. The three covers were found and examined for evidence of arcing. The fourth battery cover could not be located. Evidence of electric arcing was present in one battery cover. The internal wiring in the battery charger and the input and output circuits were inspected. No evidence of arcing or conditions that may have created arcing was found within the battery charger. The insulation on two output cables from the battery charger was damaged to the extent that the conductors were visible; however, no evidence of arcing was present at those damaged areas of the cables. Electrical measurements were made across the output of the charger and between each conductor and potential grounding points, and tests were conducted to determine current flow through the spilled electrolyte from the batteries to the machine frame. The maximum power measured between any point on the batteries and the metal frame of the scoop was .075 amperes at 55 volts. Since this current flow was through the spilled electrolyte, the circuit was considered to be purely resistive and, therefore, could not have produced sufficient power to ignite methane. However, at the time of the explosions, the conductance of the spilled electrolyte could have been considerably greater. Evidence of arcing was detected at a battery terminal on one battery, but it was impossible to determine when the arcing occurred. Examination of one scoop wheel cover revealed melted metal that may have been the result of electric arcing.

One of the batteries contained dead cells and no perceptible arc could be obtained by short-circuiting the output of the battery. The other battery, however, contained considerable electrical energy. A power resistor was connected across the battery terminals and the current measured with a tong-type ampere meter. The current flowing through the resistor was found to be in excess of 75 amperes. In an effort to discharge the battery, the current was allowed to flow for approximately 30 minutes. The resistor became red hot and the current showed no signs of diminishing.

Immediately after the area of 2 Southeast Main inby 2 Left was recovered and reventilated, examinations were made of the two locomotives. See Appendix L, Figure 26. The power conductors between the batteries and controllers had been cut on both locomotives by recovery teams. The outby locomotive was a Goodman battery-powered locomotive, type 93C04C, Serial No. 5480, designed as company locomotive No. 6. The locomotive was a permissible-type locomotive, Approval No. 1532, originally sold to Industrial Collieries, August 29, 1942. However, the locomotive had not been maintained in permissible condition in that a nonexplosion-proof Guyan headlight, nonpermissible battery connecting plugs and a nonexplosion-proof Jeffrey controller had been installed. See Appendix L, Figure 27. The locomotive was originally equipped with hydraulic and manually-operated brakes which had been removed. A penumatic braking system had been installed on the locomotive by Scotia Coal Company. The braking system consisted of a small air compressor driven by an open-type 1-horsepower motor controlled by an open-type pressure-activated switch. See Appendix L, Figure 28. The air tank was made from 12-inch diameter pipe, 48 inches in length. The pressure-activated switch was the sole means of controlling the compressor motor. No switch was provided to turn the compressor off during idle periods.

The air brake control lever was found in the off position. The electric controller was in the off position. The reverse bar was in position to cause the locomotive to run in the inby direction.

The locomotive was powered by four 48-volt lead acid batteries connected in series-parallel to provide 96 volts for operation of the locomotive. All four covers had been blown from the battery trays. The headlight on the outby end of the Goodman locomotive was a Guyan nonexplosion-proof headlight. The sealed beam bulb had been shattered and the light housing was filled with broken glass and pieces of coal, paper and coal dust. See Appendix L, Figure 29. An examination of the light and compressor motor circuits revealed that power was conducted to the li circuit and compressor motor circuit through a plastic fuse box mount near the operator's deck of the locomotive. The fuse box contained a renewable-type fuse cartridge; however, no fuse link was present inside the cartridge. A piece of No. 12 copper wire was doubled and inserted in the fuse holder clips behind the fuse to provide a circuit through the fuse box. See Appendix L, Figure 30. The impedance of the fuse contact and wire was measured and found to be 200 ohms. An examination revealed that severe arcing had occurred at the fuse holder clips welding the copper wire to one end of the cartridge fuse; however, at the other end of the cartridge fuse, the copper wire was not making good electrical contact with the fuse holder. Appendix J, Figure 1 is a wiring diagram of the headlight and compressor circuit. After the fuse and wire were reinserted into the fuse holder clips and forced to make good electrical contact, the resistance of the fuse box dropped to 0 ohms. A power cable was extended from another locomotive that contained freshly charged batteries and connected to the power conductors on the Goodman locomotive The inby headlight on the Goodman locomotive immediately lit and the compressor started operating. The voltage with the headlight on and compressor operating was 92 volts. The compressor operated until a pressure of approximately 135 psig developed at which time the pressure switch seemed to be stuck and had to be tapped lightly before it would shut off. Afterwards, the compressor switch operated normally. The compressor remained off for 10 minutes until the pressure dropped to 108 psig; then the compressor automatically restarted. The compressor operated for 40 seconds until the pressure increased to approximately

135 psig. After the pressure had dropped to approximately 105 psig, an audible noise was heard from the pressure switch; however, the motor did not start. An accumulation of dust had caused poor brush contact in the motor. The motor was tapped lightly and commenced running and performed normally thereafter. The compressor motor was allowed to again charge the air reservoir to a pressure of 135 psig, when it automatically shut off. The brakes remained in the off position and the compressor remained off for 12 minutes until the pressure dropped to approximately 108 psig, when the compressor automatically restarted. The compressor again operated for 40 seconds until the pressure increased to 130 psig, when the compressor automatically shut off.

An examination of the two front batteries on the Goodman locomotive indicated that these batteries had been connected in series and still contained considerable electrical energy. These batteries were re-connected, in series, and connected to the line side of the compressor pressure switch. The compressor started and the inby headlight lit. The Goodman locomotive's original batteries operated the compressor until it developed a pressure of 135 psig. The voltage on the two batteries connected in series during this test was approximately 48 volts. The compressor on the Goodman locomotive could be heard for a distance of approximately 500 feet and around a corner. This was determined by a member of the investigation team with normal hearing who walked away from the locomotive into No. 5 entry.

The Westinghouse locomotive, Model No. 934-P, Approval No. 1536, issued November 1, 1946, was a permissible-type locomotive; however, it had not been maintained in permissible condition. Nonpermissible battery plugs had been installed and a cable packing gland was missing where a power cable entered the bottom of the explosion-proof controller. The control lever was found in the off position. The reverse bar was found in position to cause the locomotive to move in the inby direction. The light switch was found in position to cause the outby headlight of the locomotive to light. After checking the flame paths on the controller enclosure, which proved to be in permissible condition, the cover of the controller enclosure was removed. The inside of the controller appeared to be in good condition without any soot or excessive dust. A temporary power cable extending to the locomotive with freshly charged batteries was connected to the line side of the fuses for the light circuit and when this was energized, the outby headlight lit. The light switch functioned properly. When in the off position, neither light lit but when in the other position, only the inby light lit. Batteries on the Westinghouse locomotive were in extremely poor condition. Eight battery cells had been bridged-out. The jumpers used to bridge these cells made extremely poor electrical connection and probably arced when current was drawn through them. Two jumpers were extending above the batteries far enough to contact the locomotive battery lids and could have caused electric arcing and sparking. Out of the eight battery lids that were used on the two locomotives, only six battery lids could be found. Since all battery lids were of the same size, it could not be determined on which locomotive each battery lid had been used. Three of the battery lids were insul[illegible] and three were uninsulated. One of the uninsulated battery lids showed evidence of intense electrical arcing.

The Westinghouse locomotive was equipped with a mechanical braking system and an orbital braking system. The mechanical brake was in the off position. The position of the orbital braking system could not be determined since the oil had leaked from the system, allowing the orbital pump to turn freely.

A loaded rail truck was attached to the inby end of the Westinghouse locomotive and the inby wheel of the truck was approximately 21 feet from the end of the mine track.

A mine rescue team visited the area of the locomotives at two different times while recovering bodies after the first explosion. Each of these visits lasted a period of approximately 10 minutes. Another mine rescue team accompanied the first rescue team on the second trip to recover one of the bodies. Neither of these men observed any headlight lit or heard the compressor operating. Due to the manner in which the headlight circuit and the compressor circuit received power through the common fuse box of the Goodman locomotive, since the headlight was not receiving power it would have been impossible for the compressor to have been operating. The headlight was not lit and the air compressor was [illegible] operating at the time the mine rescue teams were in the area because the open circuit in the fuse box. The presence of a surprising amount electrical energy in the batteries on the Goodman locomotive was further proof that the headlights could not have been lit or the compressor operat ing after the first explosion because the current drain would have completely discharged the batteries during the one year that elapsed between the second explosion and the time of the investigation.

After the two locomotives were removed from the mine, the motor boxes were examined internally. No abnormal arcing or evidence of soot was present in either motor box. The pressure switch and compressor motor were removed from the Goodman locomotive and sent to MESA Approval and Certification Center for further testing. The results of these tests are in Appendix M-5. During these tests the pressure switch ignited a methane air mixture when the motor was stopped. No ignitions were obtained during tests of the compressor motor.

MARCH 9 EXPLOSION

Flame and Forces

A formal investigation of the March 9 explosion was not made prior to the second explosion. Therefore, the extent of the flame and the forces of the first explosion can only be established from statements of witnesses who were in the mine when the explosion occurred and from evidence in mine as reported by the mine rescue teams, MESA and State representati[illegible] and company personnel who took part in the recovery operations of March 9-10, 1976.

Flame: Evidence of heat or flame, in the form of coke, soot, partly burned paper, melted plastic brattice material, melted conveyor belt, and charred cable insulation was observed in all of the 2 Southeast Main entries from No. 15 crosscut inby to the farthest point of advance at No. 32 crosscut where the two battery locomotives were located, a distance of approximately 1,600 feet; and in the 2 Left entries off 2 Southeast Main for a distance of approximately 150 feet. The most outby evidence of heat or flame was a piece of melted conveyor belt in the No. 4 entry of 2 Southeast Main at No. 15 crosscut.

The three victims found in No. 2 entry in 2 Southeast Main near the entrance to 2 Left and the two victims found near the battery locomotives located in No. 4 entry in 2 Southeast Main between Nos. 31 and 32 crosscuts were burned severely. The remaining ten victims found near the entrance of 2 Left and in 2 Left Section were not burned, nor showed any evidence of heat or soot coatings from the explosion.

One year after the explosions, MESA's investigation teams found traces of soot in 2 Southeast to No. 38 crosscut. Inby No. 36 crosscut the surfaces gradually became lighter in color. At Nos. 39 and 40 crosscuts the surfaces had the normal appearance of a rock-dusted entry. Thus, it is known that flame did not extend to the faces of 2 Southeast Main in the first or in the second explosion.

The recovery teams reported no evidence of fire from the first explosion in the areas examined. However, this does not preclude the possibility of a smoldering fire.

Forces: The forces of the March 9 explosion radiated from the No. 4 entry 2 Southeast Main near No. 31 crosscut where the two battery locomotives were located; traveled outby in all five entries; traveled in all four entries in 2 Left Section for a distance of about 200 feet; and continued outby in all entries to the junction of 2 Southeast Main and Northeast Main, where the forces diminished. Gusts of wind and dust cloud were detected along the haulage roads in Southeast Main outby the junction of Northeast Main and at the entrance of 2 Left off Northeast Main. The mine fan was unaffected by the explosion and continued to operate normally and the fan pressure recording chart did not indicate any change in fan pressure at the time the explosion occurred. See Appendix I for pressure chart. All of the concrete block stoppings in 2 Southeast Main and in 2 Left (approximately 70) were destroyed and, generally, the displacement was from the intake aircourses toward the returns. Two partially constructed overcasts at the mouth of 2 Left off 2 Southeast Main were destroyed and three of the four overcasts in the Right Panel Northeast Main at the entrance of 2 Southeast Main were damaged by the forces. These damaged overcasts were the most outby evidence of destruction from the forces of the explosion. John Hackworth, belthead attendant, located at the 2 Southeast Main belthead in No. 3 entry, Left Panel Northeast Main, was knocked down and rolled a short distance by the air movement. The 2 Southeast Main belt conveyor, approximately 2,600 feet in length, was partially damaged at some locations; a portion of the belt at the intersection of 2 Left was rolled up in an outby direction. The 2 Left belthead was moved outby a short distance and the 2 Left belt inby the belthead was damaged for a distance of approximately 150 feet.

A mine map showing the areas affected by the explosion, the extent of flame and forces, location of equipment, and location of the bodies is in Appendix D.

MARCH 11 EXPLOSION

Flame

The March 11 explosion was significantly more violent and extensive than the March 9 explosion. Details of the forces and the extent of flame are shown on the map in Appendix E. Soot was found throughout 2 Left and 2 Southeast Main except for approximately 200 feet near the faces of the latter entries. In the Right Panel Northeast Main, soot extended about 800 feet outby and about 3,000 feet inby the junction of 2 Southeast Main. The soot deposits in the Left Panel Northeast Main were appreciably less than those in the Right Panel, except in the areas adjacent to the cross entries inby 2 Southeast Main. Generally, soot was present as a thin, black layer on all mine surfaces; rarely were soot stringers longer than 1/4 inch found.

During final recovery of the mine, the date markings "3-12-76 BP" were found written in chalk on the locomotive at No. 181 crosscut and on a concrete block at No. 184 crosscut, Left Panel Northeast Main. These date markings and some footprints on the floor were clearly visible when the mine was recovered one year later. These footprints and markings would have been covered with a layer of soot had a third explosion occurred in the area.

Coke deposits on the roof were visible throughout 2 Left Section; they were more abundant in the face areas. Except areas inby No. 34 crosscut coke deposits were found in all entries of 2 Southeast Main. The coke deposits were heaviest at the mouth of 2 Southeast Main and inby in the Right Panel Northeast Main to No. 200 crosscut. The coking extended to No. 210 crosscut in this Panel. In and around No. 187 crosscut, coke deposits 1/2-inch thick were found on roof-bolt header blocks. In the Left Panel Northeast Main, coke was found from No. 186 crosscut inby to No. 193 crosscut, particularly in the Nos. 4 and 5 entries.

The coke deposits were formed during the second explosion. They were loosely attached; had they been formed during the first explosion, they would have been swept away by the air movement of the second explosion. The recovery teams for the first explosion reported areas outby No. 15

crosscut in 2 Southeast Main to be free of soot or coke. Mine dust samples were collected for analyses of incombustible and coke. Data on the coke in dust samples are in Appendix H. Chemical analysis for coke is more sensitive to traces of coke than visual observation. Coking was found by chemical analysis beyond the areas where coke was observed. In the areas beyond visible detection, it was believed the coke was transported by the air movements during and after the explosion.

The extent of flame is determined primarily from evidence of visible coking. The total linear extent of flame was 600 feet in 2 Left, 3,400 feet in 2 Southeast Main, 3,000 feet in the Right Panel and about 2,200 feet in the Left Panel, Northeast Main, and connecting cross entries. Evidence of flame or heat was found at innumerable places where plastic brattice was melted and burned, paper was charred or had burnt edges, and cable insulation was melted. No evidence of burnt wood was found in the whole area traversed by flame. Unburned paper from rock dust bags was found on the floor or in some instances caught on protrusions at the roof. Evidence of residual burning, after passage of flame, was found in No. 190 crosscut adjacent to No. 5 entry in the Left Panel Northeast Main. Here, the tops of about 50 rock dust bags which were exposed in a mine supply car were heavily scorched, but not burnt completely. A paper bag on the Galis roof bolting machine in No. 2 entry of 2 Left also showed signs of burning.

Forces

The primary forces of the second explosion, as shown in Appendix E, were directed out of 2 Left Section into 2 Southeast Main, thence both inby and outby in the Right Panel of Northeast Main. In this Panel, minor forces developed toward the outby direction and toward the Left Panel, but the major forces went inby in Northeast Main Right Panel. The farthest evidence of effects of the explosion was damage to overcasts in the Southeast Main, 2,800 feet outby the mouth of 2 Southeast Main; damage to an overcast in 2 East, 8,500 feet from this intersection; and damage to regulator doors, 4,000 feet inby 2 Southeast Main. The mine fan was not affected by the explosion and a barely perceptible change in pressure was shown on the fan chart. See Appendix I.

In 2 Left Section, the conveyor belt was blown completely off the belt structure and was against the right rib toward the intake entry. See Appendix L, Figure 5. The belt drive was twisted in an outby direction and was held from further movement by one jack bar. The scoop in No. 3 crosscut was moved about 8 feet into the track entry. The power center in the track entry was moved about 25 feet outby and the doors were blown off and into the No. 1 entry 2 Southeast Main in an inby direction. In No. 1 entry 2 Left, the dust collector of the Galis roof drill was torn loose, partially crushed and blown about 50 feet outby the roof-bolting machine.

In 2 Southeast Main, the conveyor belt was blown off the roller structure for its entire length. See Appendix L, Figure 6. The portion inby 2 Left was rolled up and about 50 rollers were in a jumbled mass at No. 30 crosscut. See Appendix L, Figure 7. A similar jumbled mass of conveyor belt and rollers was located at No. 20 crosscut, which is outby the intersection with 2 Left. See Appendix L, Figure 8. The outby locomotive near No. 31 crosscut was moved about 20 feet toward the face, to within 8 inches of the inby locomotive. See Appendix K, Figures 2 and 3. The outby end of the outby locomotive was plastered with about 50 pounds of coal dust and lump coal. Piles of debris (timber, brattice, coal) were found in Nos. 4 and 5 entries, 2 Southeast Main, against the ribs opposite the 2 Left Section at Nos. 22 and 23 crosscuts. Outby the 2 Left intersection, posts were blown down in 2 Southeast Main and a 6 by 6-inch by 16-foot cross bar in No. 2 entry at No. 7 crosscut, held by roof bolts, was twisted in an outby direction. About one ton of mine dust and debris was piled against the southeast side of the mine car at No. 181 crosscut, No. 5 entry Left Panel Northeast Main. A power center was moved about 100 feet from No. 5 entry to No. 4 entry at No. 182 crosscut in the Left Panel. In the Right Panel of Northeast Main inby 2 Southeast Main, a number of stoppings were blown out, indicating forces came from the direction of 2 Southeast Main. Stoppings in the cross entries between the Left and Right Panels of Northeast Main were destroyed. A pile of debris was found in 3 Southeast Main about 250 feet from its junction with the Right Panel Northeast Main. This debris was blown against the rib indicating air movement into 3 Southeast Main. Except for one blown-out stopping and regulator, no other damage was observed in 3 Southeast Main. A power distribution box in No. 213 crosscut in the Left Panel of Northeast Main was moved about 25 feet. The conveyor belt in No. 3 entry Left Panel Northeast Main was displaced but not blown off the rollers at No. 199 crosscut; the direction of movement was away from the source of the explosion. Throughout the whole area traversed by flame, pieces of partially melted brattice cloth were found on the floor, indicating that for the most part the primary direction of air flow was away from the explosion source. However, at some locations the brattice was in a position to indicate air movement in the opposite direction.

Information can be obtained on the pressures developed by the explosion from its effects on objects and mine construction. The March 11 explosion partially crushed each of the 1/8-inch thick steel dust collection boxes on the two Galis roof-bolting machines. The box on the machine in No. 2 entry was crushed to a greater extent than the box from the machine in No. 1 entry, 2 Left Section; the latter box was torn off and blown about 50 feet outby. The box from the latter machine was taken to the MESA Technical Support Center, repaired and subjected to methane explosion tests in a 64 cubic foot chamber. To achieve the degree of deformation that was caused by the March 11 explosion, the test explosion pressure had to exceed 30 psig. From the change in original volume of the crushed box, calculation was made of the pressure imposed on the box. The necessary pressure to crush it was calculated to be about 50 psig. The pressure required to rupture a concrete block stopping of the type used in the Scotia Mine is about 3 psig; this estimate is based on the data reported in Bureau of Mines RI 6710 where burst pressures were determined for similar, but not duplicate construction. See Appendix M-10 for test results.

The pressure required to rupture an overcast of the type of construction used in the Scotia Mine was calculated to be about 0.2 psig when pressure was applied from the underside. These data on explosion pressures indicate an extensive methane-air mixture, near the optimum explosive concentration, existed in the 2 Left Section. The relatively high explosion pressure in 2 Southeast Main at the intersection with 2 Left decreased as the explosion spread toward Northeast Main. The explosion pressure at the Right Panel of Northeast Main must have been in excess of 3 psig, whereas the pressure at the Left Panel must have been about 3 psig or lower. The flame velocity associated with a mine explosion pressure of 3 psig is about 300 feet per second, whereas that associated with 50 psig would be sonic or higher. These velocities are consistent with the observed physical damage caused at the respective locations of the two velocities.

Smoking

A careful search was made around the locomotives and in other likely areas in 2 Southeast Main and in 2 Left Section for evidence of smoking. The floor material was collected and screened and only a spent match was found in No. 4 entry 2 Left Section.

Probable Points of Origin

MESA investigators conclude that the explosion of March 9, 1976, originated between the Nos. 31 and 32 crosscuts, No. 4 entry 2 Southeast Main where the Nos. 6 and 8 Goodman and Westinghouse battery-powered locomotives were located. The explosion of March 11, 1976, originated in or near the entrance to the 2 Left Section off 2 Southeast Main.

Potential Ignition Sources

MESA investigators conclude that the No. 6 or No. 8 battery-powered locomotive provided the ignition source for the explosion of March 9, 1976.

A thorough examination of the explosion area in 2 Left Section did not reveal an obvious ignition source for the second explosion. The following are considered possible sources of ignition:

The rock fall on the roof-bolting machine near the face of No. 2 entry 2 Left Section.
The battery-powered deluge system at the belt drive in No. 22 crosscut, No. 3 entry, 2 Southeast Main.
The pager telephone in No. 4 crosscut, No. 1 entry, 2 Left Section.
The pager telephone in No. 22 crosscut, No. 3 entry, 2 Southeast Main.
The Elkhorn AR4 Scoop batteries in No. 3 crosscut, No. 4 entry 2 Left Section.
A smoldering fire near the mouth of 2 Left Section.

As stated in the body of the report neither the battery-operated air compressor nor any other electrical components of the locomotives in 2 Southeast Main were electrically connected to the energized batteries. Because of the above and the fact that they were more than 800 feet from the 2 Left Section, the locomotives were not considered as an ignition source for the second explosion.

An explosion which would develop the high static pressure evidenced by the crushed dust collection boxes of the Galis roof-bolting machines and the high dynamic forces from the high velocity air movement evidenced by the debris in the 2 Left Section and adjoining portions of 2 Southeast Main, probably resulted from a well-mixed methane-air atmosphere, near the optimum explosive concentration extending throughout the 2 Left Section.

Considering the effect of location of ignition source on development of high static pressure and high dynamic forces and other physical evidence, the most likely igniting source of the second explosion was an incendive frictional spark generated by the rock fall on the roof-bolting machine. Incendive frictional sparks from roof falls in gob areas have ignited methane in several American coal mines. Frictional sparks from machine bits striking rock or hard inclusions in the coal occur frequently during mining.

The following are the main factors affecting ignition by impact frictio[n]: angle of impact, methane concentration, energy of impact, quartz conte[nt], grain size and hardness of rock, roughness, oxide coating on metal surface and humidity.

The optimum angle of impact is 40 to 50 degrees; the rock, if it fell vertically, struck at an angle of 30 degrees. The optimum methane concentration for ignition is about 7 percent; it is estimated that the methane concentration in 2 Left Section was 7 percent or higher at the time of the second explosion. Ignitions of methane have been obtained in laboratory tests with as little as 50 foot-pounds of energy; the falling rock developed about 3,000 foot-pounds. High quartz content of the rock, depending on the portion analyzed, ranged from 23 to 56 percent. Laboratory ignitions have been obtained with as little as 20 percent quartz. The grain size of the rock ranged from 2 to 0.72 microns, or somewhat smaller than the grains in sandstones. The angularity of the grains of the rock was conducive to ignition. The rock was shale and could be cut slowly with a hacksaw, indicating a rock type softer than sandstone. The pipe surface of the roof-bolting machine was roughened from use, partly painted and partly rusted. These conditions are conducive to ignition. The mine atmosphere was humid which enhances the chance of ignition.

Although the few experimental drop tests were negative, conditions necessa[ry] for ignition by the rock fall on the roof-bolting machine existed near the face of No. 2 entry 2 Left Section. See Appendix M-4 for report o[f] tests.

The deluge fire suppression system at the belt drive in No. 22 crosscut, 2 Southeast Main was examined in the MESA laboratory. The study showed that ignition of methane was readily achieved if the circuit containing the solenoid was closed. Such a circumstance could have occurred in the Scotia mine by air movement, vibration or direct impact on the wires by a fragment of rock or coal falling from the roof or rib. The deluge system circuit wiring was exposed to the flame of the first explosion and to abrasion by the dispersed dust and debris. These effects could readily have destroyed the insulation on the wires. Nearly all the wiring was destroyed by the second explosion. What little wiring was found showed signs of flame and abrasion. Two factors which detract from the deluge system as a primary ignition source of the second explosion are the location of the system at the intersection of 2 Left and 2 Southeast Main, away from the face area; and the requirement of a rock fall or other agents to cause the wires to make contact. Tests showed that electrical contact had to be made rather than broken because if the wires had been shorted, the battery would have discharged in a three hour period.

The pager telephone in No. 4 crosscut, No. 4 entry, 2 Left Section could have ignited the second explosion. Laboratory tests showed that under certain conditions the telephone would ignite a methane-air mixture. See Appendix M-3. Such conditions could have arisen in 2 Left Section if the telephone fell to the floor, or if on the floor, a piece of roof or coal fell on it and closed the spring-loaded switch while the attached wiring was in intermittent contact. This telephone was close enough to the face to develop a strong explosion such as occurred. The factor detracting from it being considered a primary ignition source is the coincidence of the dropping to the floor or the striking by a rock or coal fragment. The pager telephone in No. 22 crosscut, No. 4 entry, 2 Southeast Main could also have caused the ignition, but this telephone is somewhat removed from the face area of 2 Left.

The battery-powered scoop was in No. 3 crosscut, No. 4 entry, 2 Left. The battery was disconnected from the scoop and was connected to a rectifier for charging. Examination showed visible signs of damage to a cable and arcing on the steel cover and signs of spilled electrolyte on the battery box. The battery covers were blown off by the explosion. The position of these covers after the first explosion is not known. They may have been loosely attached and may have fallen to the cells to cause an incendive spark. The scoop was located sufficiently close to the face to cause a strong explosion. However, there was insufficient evidence to indicate that the explosion originated at this location.

It is possible that a smoldering fire ignited in 2 Left Section from the flame of the first explosion. If a fire had occurred, it probably would have been on the floor where it could burn or smolder but not likely be in contact with the flammable methane-air mixture until a sufficiently high methane concentration developed or slight air movement caused the flammable mixture to extend to the floor. A careful search of likely areas for fire was made during the investigation and no fire residue was found.

This is not conclusive as evidence of the fire could have been destroyed by the second explosion or covered by the deep layer of the coal accumulation on the floor. The flame from the first explosion entered only 150 feet into 2 Left Section. If a fire had existed in this area, a weak rather than a strong explosion would have developed.

During the investigation, several tests were conducted on mine equipment, ventilation, samples of mine rock, mine power system, and individual parts of mine equipment. Following is a resume of the special tests:

Special Tests

Telephones: Three MESA phones which were located in 2 Left Section off 2 Southeast Main and at the intersection of 2 Left and 2 Southeast Main were tested at MESA's Approval and Certification Center, Pittsburgh, Pennsylvania. The tests demonstrated that under certain conditions, as specified in the report in Appendix M-3, these phones could ignite an explosive methane-air mixture.

Deluge System: The deluge system located at the 2 Left belt drive at the intersection of 2 Left and 2 Southeast Main was tested at MESA's Approval and Certification Center. The tests demonstrated that under certain conditions, as specified in the report in Appendix M-2, the solenoid circuit could ignite an explosive methane-air mixture.

Compressor Motor and Control Switch: The compressor motor and control switch from the Goodman locomotive were tested at MESA's Approval and Certification Center. The tests demonstrated that the control switch could ignite an explosive methane-air mixture during normal operation. See Appendix M-5 for test results.

Power System: Tests were conducted at the mine on the high-voltage system which supplied power to the section equipment at 2 Left off 2 Southeast Main. The purpose of the tests was to determine why the surface substation breaker opened at the time of the explosions. The tests, which are described in Appendix M-9, located a defective section of cable which momentarily caused a phase-to-phase fault when one phase was grounded. This condition caused the Westinghouse recloser in the main substation to open, removing power from the oil circuit breaker in the mine substation.

Dust Collection Box: The dust collection box to the roof-bolting machine in 2 Left Section off 2 Southeast Main was tested in the Industrial Safety Branch Laboratory, Technical Support Center, Pittsburgh, Pennsylvania. The box was subject to explosions in a steel gallery. Results of the tests are in Appendix M-10.

Composition of Mine Roof Strata: Rock specimen from the roof strata at 9 locations in the explosion areas of the 2 Left Section and 2 Southeast Main were collected by the investigation team. The rock specimen were tested and examined by MESA and the U. S. Geological Survey, Department of the Interior, for their chemical and physical properties. The results were used in assessing the possibility of ignition of methane by incendive frictional spark from a roof fall. Data from the examinations made by the U. S. Geological Survey are in Appendix M-11.

Rock Fall on Roof-Bolting Machine: Drop tests of the rock which fell onto the canopy of the Galis roof-bolting machine located near the face of No. 2 entry, 2 Left Section, were made by MESA's Technical Support Center in Pittsburgh, Pennsylvania. The rock and the Galis roof-bolting machine were placed in a chamber in which the methane concentration could be controlled. The rock was suspended above the machine and dropped in a manner simulating as closely as possible the conditions that existed in 2 Left Section. A report on these tests is in Appendix M-4.

Ventilation - 2 Southeast Main: Tests to simulate the ventilation that existed in 2 Southeast Main on March 9, 1976, were conducted to determine air flows, rates of methane liberation, the effect of short-circuiting the air through No. 23 crosscut, and the effect of checks in Nos. 4 and 5 intake entries in 2 Southeast Main inby 2 Left Section. A report of the ventilation studies is in Appendix M-1.

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PART VIII

FINDINGS: SUMMARY OF EVIDENCE

The findings in this Part are derived from the following sources: conditions observed in the mine by MESA personnel during the recovery operations and the investigation following the explosions; information obtained from the mine rescue teams and other persons taking part in the recovery operations and the investigation; information obtained from ventilation tests and other special tests conducted by MESA, Bureau of Mines and U. S. Geological Survey; mine records and previous Federal coal mine inspection reports; information received from company officials and miners in the form of sworn statements at official hearings; and sworn statements of company officials and miners obtained by attorneys of the Solicitor's Office of the Department of the Interior. After analysis of all available evidence, MESA investigators have summarized their findings below.

1. Analysis of a coal sample taken from the Imboden seam in the Scotia Mine shows the volatile ratio to be 0.395, indicating that the coal dust is explosive.

2. Several miners had received little or no training, particularly in the use of self-rescue devices, nor had they participated in a program of instruction relative to firefighting and evacuation plans.

3. An agent of the operator recorded that a fire drill had been made when in fact it had not been made.

4. Many persons who were making required tests for methane had not been trained in the use of methane-detecting equipment.

5. Only one fire boss was employed and he could not make the preshift examination of the entire mine in the required period of time.

6. The record of the preshift examination for March 9, 1976, signed by the fire boss, Charles Fields, showed that he made the examination of the entire mine, including 2 Southeast Main. However, Arvil Cornett, third shift Mine Foreman, made the examination in 2 Left Section off 2 Southeast Main but did not examine 2 Southeast Main inby 2 Left. The preshift examiner recorded, as his examination, an examination that he did not make.

7. J. B. Feltner, Underground Construction Foreman, instructed the operators of the Nos. 6 and 8 battery-powered locomotives to transport a load of rails into 2 Southeast Main inby 2 Left. The area had not been preshifted on the morning of March 9, 1976, nor was it examined prior to taking the locomotives inby 2 Left Section.

8. During the investigation following recovery operations, sufficient date marks and initials could not be found to indicate that the required examinations had been made in 2 Southeast Main inby 2 Left Section and in Left Panel Northeast Main.

9. Federal inspection reports of 1975 show that the total methane liberation of the mine was 568,000 cubic feet in a 24-hour period. An air sample collected during the last Federal inspection, completed on February 27, 1976, showed that the 2 Southeast Main area was liberating 69,000 cubic feet of methane in a 24-hour period. Methane had been detected in Southeast Main and in 3 Southeast Main.

10. In December 1975 mechanics working on equipment in the track entry, 2 Southeast Main, about eight crosscuts outby the face area, ignited a methane feeder while using an acetylene torch.

11. During recovery operations following the March 9 explosion, mine rescue teams detected a methane concentration in excess of 5 percent at No. 27 crosscut 2 Southeast Main, and as much as 3 percent in 2 Left Section.

12. Forty-seven days after the second explosion, the methane concentration had increased to 36.5 percent in the explosion area at No. 1 borehole.

13. The approved Ventilation System and Methane and Dust Control Plan for the mine was last reviewed by the MESA District Manager on June 25, 1975. Management submitted a plan for the 6-month review during January, 1976. The plan did not satisfy the criteria for approval and was returned. A revised plan was submitted March 1, 1976. This plan contained minor discrepancies and was being discussed with mine management on March 9, 1976.

14. The approved system for face ventilation for continuous mining sections was an exhaust system. However, it was a practice to reposition the line brattice to a blowing system during the mining of coal. The line brattice was returned to an exhaust system at the end of the shift and prior to miners leaving the section.

15. A 13.5-foot diameter shaft was put into service in Northeast Main July 21, 1975. A revised ventilation plan for the mine was not submitted to the District Manager at that time.

16. All ventilation controls necessary to adequately control the ventilation at the bottom of the 13.5-foot diameter shaft were not installed Therefore, the air intaking through the shaft could not be effectively directed to the working sections. Some of these controls were crucial to the inability of recovery personnel after the first explosion to ventilate 2 Southeast Main inby the last fresh air base at No. 22 crosscut. The company did not at any time inform recovery personnel about these missing controls.

17. The ventilation system as shown on the plan submitted for review March 1, 1976, did not reflect the ventilation as practiced in the mine. Several critical ventilation controls shown on the map submitted with

the plan had not been installed or had been removed. In some cases the direction of the air currents shown on the map were different from those observed during the investigation.

18. Permanent stoppings between the intake and return aircourses in the No. 247 crosscut, Northeast Main Left Panel Section, had been removed and ventilation was short-circuited nine crosscuts outby the faces of the section.

19. Stoppings were not installed in connecting entries between intake and return entries near the Nos. 239 and 240 crosscuts, Left Panel Northeast Main and the intake air current was short-circuited outby the active working section in Right Panel Northeast Main.

20. Plastic checks instead of permanent stoppings were installed in the Nos. 1, 2 and 3 return aircourses, Right Panel Northeast Main, to separate the No. 1 intake entry 3 Southeast Main from the return aircourses.

21. The mining equipment was moved out of the 2 Southeast Main entries in early February, 1976, and was used to activate the 2 Left Section. The new section had been working about one month when the explosion of March 9 occurred and permanent ventilation controls (overcasts or air-lock doors) that would provide positive ventilation in 2 Southeast Main inby 2 Left were not installed. Overcasts were under construction when the explosion occurred.

22. One of the two concrete-block stoppings that were removed at No. 23 crosscut, 2 Southeast Main to permit access into 2 Left Section was replaced with a plastic curtain that was poorly installed and only intermittently maintained. Little effort was made to keep the curtain in place after the track was laid into 2 Left Section several days before the March 9 explosion. The short-circuiting of the ventilating current inby 2 Left by the poorly erected and missing plastic curtain was compounded by the installation of plastic checks across Nos. 4 and 5 intake aircourses of 2 Southeast Main inby 2 Left Section. These conditions and practices permitted methane that was being liberated from the ribs, faces and fractures in the mine floor to accumulate.

23. On the afternoon shift of March 8, 1976, plastic checks were installed across Nos. 4 and 5 intake entries of 2 Southeast Main, which totally restricted the ventilating current which would have ventilated 2 Southeast Main inby 2 Left Section.

24. At the time that J. P. Feltner was in 2 Left Section off 2 Southeast Main on the morning of March 9, 1976, there was no check curtain across the 2 Left track entry near the mouth of the section, and he did not examine any area in 2 Southeast Main inby 2 Left Section.

25. The quantity and velocity of the ventilating currents in 2 Southeast Main inby 2 Left Section were not sufficient to dilute, render harmless and carry away the methane being liberated. An explosive methane-air mixture accumulated in this area.

26. Federal Coal Mine Inspector Cecil Davis made a Health and Safety Technical Inspection of 2 Left Section off 2 Southeast Main on the afternoon shift of March 8, 1976, and found that only 8,092 cubic feet of air a minute was reaching the last open crosscut and that the line brattice in No. 5 entry was 25 feet from the face where a continuous mining machine was operating. Davis rode into the 2 Left Section in a covered vehicle and did not notice whether a plastic curtain was installed across the track near the mouth of the section. He did not inspect any areas in 2 Southeast Main inby 2 Left Section.

27. James Bentley, Assistant Mine Foreman, made an examination of the 2 Southeast Main area, including the faces, and 2 Left Section on March 8, 1976. The highest methane content that he detected in the entire area was 0.3 percent and the amount of air returning from 2 Southeast Main at the regulator located in the No. 1 entry near the junction of Northeast Main was 17,860 cubic feet a minute.

28. During a coal-producing shift, James Bentley adjusted a regulator in 2 Left off Northeast Main on March 9, 1976, shortly before the explosion.

29. Shortly before the explosion on March 9, 1976, Virgil Coots, Section Foreman on 2 Left Section off 2 Southeast Main, said to James Bentley, on the telephone, "I just lost my air."

30. The motor crew delivering the truck load of rails arrived at the destination at the end of the track in 2 Southeast Main about the time the explosion occurred.

31. A methane explosion occurred in the vicinity of No. 31 crosscut, No. 4 entry, 2 Southeast Main, at approximately 11:45 a.m., March 9, 1976, resulting in the death of all 15 men working in the 2 Southeast Main area. This was primarily a methane explosion and coal dust entered into propagation only to a minor degree. Forces of the explosion spread to all five of the 2 Southeast Main entries, extended into 2 Left Section off 2 Southeast Main and dissipated as they reached the Northeast Main junction. There was evidence of heat or flame in all of the 2 Southeast Main entries from No. 15 crosscut inby to the farthest point of advance of the rescue teams at No. 32 crosscut, where the two battery-powered locomotives were located, and in the 2 Left entries off 2 Southeast Main for a distance of about 150 feet.

32. Five of the victims in the 2 Southeast Main area were severely burned and sustained visible injuries as a result of the forces. The other ten victims near the entrance and in 2 Left Section showed no visible signs of injury from flame or forces. Six of the victims were behind a partially erected barricade in No. 5 entry 2 Left, and evidence indicated that they may have worn their self-rescuers for a period of time. The other four victims found outside the barricade had apparently not used their self-rescuers.

33. Mine rescue teams established the first fresh air base at the mouth of 2 Southeast Main at approximately 6:00 p.m. on March 9. The

17,000 cubic feet of air a minute available at the mouth at the beginning of the recovery operation was expended by the time the rescue teams established the last fresh air base at No. 22 crosscut at approximately 1:00 a.m., March 10. Only a perceptible movement of air was measured and this was insufficient to continue recovery efforts.

34. The mine rescue teams found the first body at 10:18 p.m., March 9, and the last two bodies at 1:20 a.m., March 10. All 15 bodies were recovered by the mine rescue teams and brought to the surface by 4:46 a.m., March 10, 1976.

35. After the 15 bodies were recovered by the rescue teams on March 10, rescue operations temporarily ceased due to the lack of sufficient ventilation. The Nos. 1, 2, 3, 4 and 5 entries inby No. 32 crosscut in 2 Southeast Main were not explored by the mine rescue teams.

36. The plan to increase the amount of air in 2 Southeast Main included checking and repairing stoppings between the intake and return aircourses from the portal to the mouth of 2 Southeast Main and adjusting regulators in all sections of the mine. These repairs and adjustments did not increase the amount of air in 2 Southeast Main. Additional plans were developed to increase the amount of air by installing concrete block stoppings in 2 Southeast Main from the mouth to No. 22 crosscut.

37. On the afternoon shift of March 10, the mine rescue teams detected loose, inadequately supported roof over the track haulage road near the mouth of 2 Southeast Main. MESA and company officials who examined the area determined that the loose roof should be roof-bolted to permit safe travel for haulage equipment which was needed to transport supplies for building the concrete block stoppings in 2 Southeast Main.

38. During the preshift examination of the main line haulage road on the afternoon of March 10, Richard Combs, General Mine Foreman, mentioned to B. A. Taylor, Federal Coal Mine Inspection Supervisor, that one of the battery-powered locomotives in the explosion area in 2 Southeast Main was equipped with an air compressor that operated the pneumatic braking system. Between 7:00 and 8:00 p.m., March 11, Taylor mentioned to Bill Clemons, MESA Assistant District Manager, District 6, that one of the battery-powered locomotives in the explosion area was equipped with an air compressor. Several other persons, including company officials and employees and MESA representatives, knew of the presence of the air compressor on the battery-powered locomotive.

39. About 2:00 p.m., March 11, a company repairman, accompanied by a Federal Coal Mine Inspector (Electrical), entered the mine and energized the mine power circuit, except branch lines, from 1 West to Northeast Main. A work crew, accompanied by MESA Inspectors, moved a roof-bolting machine from Northeast Main to the entrance of 2 Southeast Main for the purpose of roof-bolting the loose roof that was observed by the mine rescue teams.

40. During the recovery operations, which lasted about 60 hours, following the explosion of March 9, battery-powered equipment was known to be present in the explosion area which was not ventilated nor completely explored and known methane accumulations were present. Plans to continue the recovery operations under these conditions were developed and partially executed by energizing the mine power circuit in the Northeast Main area and by moving a roof-bolting machine from Northeast Main to the entrance of 2 Southeast Main preparatory to supporting the loose roof and installing concrete block stoppings in 2 Southeast Main.

41. Eight Scotia employees and three MESA Inspectors were in the vicinity of the roof-bolting machine at the mouth of 2 Southeast Main and Rick Parker and Ernest Lee Collins, company repairmen, were in No. 180 crosscut, No. 4 entry, Northeast Main, in the process of removing cable couplers from the trailing cables of the roof-bolting machine and a drainage pump when the second explosion occurred about 11:30 p.m., March 11, 1976. The eleven men died as a result of the explosion. Parker and Collins escaped uninjured with the aid of their self-rescuers. See autopsy report, Appendix N.

42. The explosion of March 11 was more violent, more extensive and developed higher pressure than the explosion of March 9. This explosion originated in or near the entrance of 2 Left Section off 2 Southeast Main when a methane-air mixture was ignited from one of five ignition sources: an electric arc or spark from a battery-operated deluge system; a battery-powered telephone; scoop batteries; residual fires; or a frictional spark from a fall of a section of mine roof on a roof-bolting machine. The forces from the explosion extended throughout 2 Left Section and all five entries of 2 Southeast Main, spread north and south in all entries in both Panels of Northeast Main and dissipated near the junction of 2 Southeast Main in the northern direction and near the junction of Southeast Main in the southern direction. Evidence of flame or heat was present in all entries of 2 Southeast Main including 2 Left, in both Panels in Northeast Main between 2 Southeast Main and 3 Southeast Main, terminating a short distance outby 2 Southeast Main.

43. Shortly after the explosion of March 11, recovery efforts were initiated through the portal slope entries and plans were made to enter the 13.5-foot diameter air shaft. Recovery efforts from the portal entries were abandoned because of disruption of the ventilation at 2 East. Mine rescue teams were lowered into the air shaft by a mobile crane and traveled in fresh air to the entrance of 2 Southeast Main where they found the 11 victims about 12 o'clock noon on March 12. After determining that there were no signs of life, the rescue teams were ordered to return to the surface without recovering the bodies.

44. After several meetings by the participating groups, a consensus decision was made on March 13, 1976, to seal the mine. By March 19, 1976, all openings to the mine had been sealed.

45. During the period of time the mine was sealed, the company obtained mine rescue equipment for and trained three mine rescue teams, with the assistance of the Kentucky Department of Mines and Minerals and MESA.

46. Between April 19 and June 8, 1976, three boreholes were drilled for air sampling from the surface into the explosion area. Surface sampling facilities were established to provide continuous remote sampling of the underground atmosphere at these locations and at the bottom of the air shaft. Samples were analyzed on-site.

47. The recovery plan submitted by Scotia Coal Company, which proposed incremental reentry using controlled ventilation (air-lock method), starting at the mine portal, was approved on July 13, 1976.

48. The seals across the main portal openings were broken on July 14, 1976. The mine was recovered by the air-lock method and 25 sets of seals were constructed to recover the mine to the junction of 2 Southeast Main and Left Panel Northeast Main.

49. On November 19, 1976, the bodies of the 11 victims of the March 11 explosion were recovered and brought to the surface of the mine.

50. On December 8, 1976, in accordance with an approved plan, the process of reventilating all areas of the mine except 2 Southeast Main was begun. Seals on the surface and underground were removed systematically and the necessary ventilation controls were built. By December 21, all areas of the mine except 2 Southeast Main were ventilated and cleared of methane.

51. Ventilation controls were constructed across the 2 Left entries off Northeast Main to control the shaft intake air entering the gob area. With these controls, about 65,000 cubic feet of air a minute was provided at the mouth of 2 Southeast Main.

52. On Monday, February 14, 1977, the recovery of 2 Southeast Main and the 2 Left Section was started, using the air-lock method. By March 9, 1977, the area had been recovered and examined.

53. The 1-1/2 Right Section off 2 East was examined April 14, 1977. This completed the recovery of all accessible areas of the mine.

54. Ventilation tests simulating conditions prior to the March 9 explosion were conducted in 2 Southeast Main from May 17 through 23, 1977, to determine air flows, rates of methane liberation, the effect of the short-circuiting of the air through No. 23 crosscut, and the effect of checks in Nos. 4 and 5 intake entries in 2 Southeast Main inby 2 Left Section. These tests showed that when the air was short-circuited at No. 23 crosscut, the amount of air entering 2 Southeast Main was not sufficient to prevent methane accumulations and when checks were installed across Nos. 4 and 5 intake entries inby 2 Left, methane accumulated more rapidly. See Appendix M-1 for test results.

55. Analysis of the 54 dust samples collected by MESA Inspectors in 2 Southeast Main from May 22, 1975, to January 27, 1976, showed that the incombustible content of 50 samples was more than the minimum required by the Act. The 2 Left Section of 2 Southeast Main had been rock-dusted on the shift preceding the explosion.

56. The incombustible contents of 135 of 239 dust samples collected in areas not affected by the explosions in South Main, Southeast Main and Right Panel Northeast Main were below minimum requirement. See dust analyses in Appendix H.

57. Full-depth samples of mine dust collected by the investigation teams in 2 Left Section and in 2 Southeast Main indicated that there were accumulations of loose coal and coal dust from two to eight inches in depth, partly due to rib sloughing.

58. No evidence of residual fires following the explosion of March 9 was observed by the mine rescue teams.

59. Except in face areas, all areas of the mine examined by the investigation teams had been rock-dusted.

60. At the time of the March 9 explosion, the 7,200-volt circuit, two power centers, a belt conveyor drive unit with associated electric equipment, a continuous mining machine, two shuttle cars, a roof-bolting machine, a belt feeder, two battery-powered telephones and telephone line, two 64-volt scoop batteries connected to an energized charger, a fire-sensor circuit, a battery-powered deluge system, two battery-powered locomotives, and a distribution box were energized and located in the explosion area.

61. At the time of the March 9 explosion, the energized electric equipment present in the explosion area that could create an arc capable of igniting an explosive methane-air mixture during normal operation of the equipment were the battery charger, the battery-powered deluge system, the belt conveyor controller with associated control switches, the distribution box, the two power centers, and the Goodman and the Westinghouse battery-powered locomotives.

62. The rescue teams that recovered the bodies near No. 31 crosscut 2 Southeast Main after the first explosion reported that the explosion forces appeared to originate at the locomotives and extended outward from the locomotives in all directions. The locomotives and the area around the locomotives were "black, sooty-like".

63. The rescue teams found the Goodman and Westinghouse locomotives separated by a distance of approximately 20 feet. A locomotive battery cover was found outby the Goodman locomotive. Appendix K, Figure 2 was made from information supplied by the teams and shows the positions of battery cover, the bodies, and the rail truck in relation to the two locomotives.

64. The first explosion originated in 2 Southeast Main inby 2 Left Section. The only known sources of electrical energy sufficient to create incendive arcing in this area were the Goodman and Westinghouse locomotives located between Nos. 31 and 32 crosscuts.

65. The 7,200-volt alternating current circuit was disconnected at the "Y"-box at the mouth of 2 Southeast Main and dust caps were on the connecting plug and its mating receptacle at the time of the March 11, 1976, explosion. Therefore, all alternating current-powered equipment and circuits in the explosion area were deenergized before the second explosion occurred.

66. The telephone line was disconnected at the mouth of 2 Southeast Main and the fire-sensor circuit was deenergized on the surface before the occurrence of the March 11 explosion.

67. One of the two conductors of the 2 Southeast Main belt conveyor control cable had been intentionally disconnected and short-circuited approximately 3 feet from the control box at the mouth of 2 Southeast Main before the occurrence of the March 9 explosion. Therefore, inadvertent energization of the 2 Southeast Main belt conveyor power circuit by the two repairmen changing the cable couplers at the power center shortly before the second explosion could not have energized the belt conveyor control circuit in the explosion area.

68. The only known sources of electrical energy in the explosion area at the time of the March 11 explosion were the three Mine Safety Appliances battery-powered telephones, the two Elkhorn AR4 scoop batteries, the Goodman and the Westinghouse locomotives, and the battery-equipped deluge system. Each of these sources, under certain conditions, contained sufficient electrical energy to create an incendive arc or spark capable of igniting an explosive methane-air mixture.

69. The compressor on the Goodman locomotive was not operating and the headlights were not lit on either locomotive during rescue operations after the March 9 explosion.

70. The headlight circuit and compressor motor circuit on the Goodman locomotive received power through a common fuse. Therefore, the headlight would be lit at all times that electric power was available for operation of the compressor, regardless of whether the compressor was operating. See wiring diagram, Appendix K, Figure 1.

71. If the headlight had been lit or the compressor on the Goodman locomotive had been operating, the batteries would have been completely discharged by the time of the investigation. The amount of electrical energy remaining in the locomotive batteries at the time of the investigation is proof that the lights did not light and the compressor did not operate at any time after the explosion of March 9.

72. The headlight switch on the Westinghouse locomotive was in position to light the outby headlight but the headlight was not lit because of the open cells and the open circuits in the battery connections.

73. At the time of the investigation, the locomotives were 8 inches apart and separated by a piece of conveyor belt, and the locomotive battery covers were beside and inby the locomotives. See Appendix K, Figures 2 and 3.

74. The outby headlight bulb on the Goodman locomotive was broken and the headlight housing was filled with coal and debris. The bumper and end of the Goodman locomotive was also filled and covered with coal and debris. See Appendix L, Figure 29.

75. The Elkhorn AR4 scoop batteries located in No. 3 crosscut in the track entry of 2 Left Section off 2 Southeast Main were disconnected from the scoop and connected to the battery charger before the March 9 explosion.

76. The scoop batteries contained sufficient energy to create incendive arcing. There was no condition of or in the connecting cables, the internal wiring in the charger, or the battery cell connections that could have existed for the length of time between the explosions and then created an arc initiating the second explosion.

77. Electrical connections between cells of the batteries on the Westinghouse locomotive were not mechanically and electrically proper. The flexible connecting shunts were attached to the lead posts by means of nail. Suitable connectors were not used; the shunts were twisted together.

78. The controller on the permissible-type Westinghouse locomotive was not in permissible condition and created sufficient arcing during normal operation to ignite an explosive methane-air mixture.

79. The cartridge fuse providing overload protection for the 1-horsepower compressor motor, the headlights and associated circuitry on the Goodman locomotive had opened and was shunted by a length of No. 12 wire.

80. The permissible-type Goodman locomotive contained a non-certified pressure switch and a non-certified controller which created incendive arcing during normal operation. The No. 12 wire used to bypass the defective fuse protecting the compressor and light circuit showed evidence of arcing.

81. The insulated wires extending to the compressor motor on the Goodman locomotive did not pass into the metal motor frame through properly insulated bushings.

82. The Goodman locomotive was not provided with automatic brakes, dual braking system, or a similar device.

Many of the conditions and practices summarized above constitute violations of the Federal Coal Mine Health and Safety Act of 1969 and the mandatory health and safety standards contained in Title 30, CFR, as listed below.

Violations of Part 75, Title 30, CFR

75.150	Failure to provide training in use of methane-detecting equipment
75.301	Failure to provide adequate ventilation
75.303 75.314	Failure to make required mine examinations and maintain accurate records
75.305	Lack of initials and dates (to indicate that required examinations were made)
75.316	Violations of Ventilation and Methane and Dust Control Plan
75.403	Incombustible content of mine dust below minimum requirements
75.514	Cells of batteries on locomotive not properly maintained
75.515	Wire passing through metal motor frame on locomotive without insulated bushings
75.518	Wire used in place of fuse on locomotive
75.1404	Dual braking system not provided for locomotive
75.1714	Failure to provide training in self-rescue devices
80.11	Failure to report methane ignition to MESA

Appendix O lists the violations found which did not contribute to the cause or severity of the explosions. Appropriate Section 104 (Act) Notices and Orders shall be issued to Scotia Coal Company for all violations.

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PART IX

Conclusions

MESA investigators conclude that the explosion of March 9, 1976, resulted from inadequate ventilation. The operation of electric equipment that was not maintained in compliance with Part 75, Title 30, CFR, and which contained components that created incendive arcing during normal operation in an area where methane had accumulated and where the required examinations had not been made prior to the operation of the electric equipment in the area were contributing factors of the explosion.

Activating and working the 2 Left Section for a period of approximately one month prior to the first explosion without establishing permanent ventilation permitted the short-circuiting of the ventilating current at the entrance of 2 Left Section for extended periods of time. This resulted in inadequate ventilation in 2 Southeast Main inby 2 Left, allowing methane to accumulate. The construction of plastic checks across Nos. 4 and 5 intake entries of 2 Southeast Main on the evening before the explosion completely restricted the air that would have ventilated 2 Southeast Main inby 2 Left and increased the hazard by permitting methane to accumulate more rapidly.

Preshift examinations were not made in 2 Southeast Main inby 2 Left on the morning of March 9, nor was an examination made prior to the electric equipment entering the area. Therefore, the methane accumulations were not detected. The operators of the Nos. 6 and 8 battery locomotives were instructed and permitted to operate this equipment in this area, precipitating the explosion. Although it cannot be determined with certainty which of the sources of arcing on the two locomotives, as discussed in Part VII of the report, ignited the methane, the most likely source of ignition was the arcing created by the open-type controller on the No. 6 Goodman locomotive when the controller was turned to the "off" position by the locomotive operator after reaching his destination at No. 31 crosscut, 2 Southeast Main. Coal dust entered into the explosion only to a minor degree and pressure relief inby and outby the ignition point prevented high pressure and flame velocity.

MESA investigators conclude that the explosion of March 11, 1976, resulted from a lack of sufficient air to ventilate the area in 2 Southeast Main inby No. 22 crosscut, including the 2 Left Section, and remove from the mine the known methane accumulations. The lack of air prohibited safe and timely completion of the recovery operations.

The planning and subsequent unsuccessful attempts to increase the ventilation in 2 Southeast Main consumed approximately 45 hours. During this period, methane increased to an explosive concentration in the unventilated explosion area, which had not been completely explored and where battery-powered equipment was known to be present. Efforts to increase the ventilation in 2 Southeast Main failed primarily because of the inaccur[ate] mine map which was prepared by the company and used by officials as a [basis] to develop recovery plans. This contributed to the second explosion. [Other] possible contributing factors were that the planners, controllers, and directors of the rescue and recovery operations did not give due consideration to the potential ignition hazard of the battery-powered equipment in the unventilated and contaminated environment of the 2 Southeast Main area and to the increased risks associated with prolonged recovery efforts in the area and exposure to such conditions.

The methane was ignited near the entrance of or in 2 Left Section off 2 Southeast Main by one of five possible ignition sources: An electric arc or spark from a battery-equipped deluge system; three battery-equipped telephones; the scoop batteries; a frictional spark from a fall of mine roof on a roof-bolting machine; or heat from residual fires. While it cannot be definitely determined which source ignited the methane, MESA investigators conclude that the most likely ignition source was a frictional spark created when a section of mine roof fell on the roof-bolting machine located near the face of No. 2 entry in 2 Left Section. Coal dust entered into the explosion and aided in its propagation.

Respectfully submitted,

/s/ James D. Micheal

James D. Micheal
Coal Mine Specialist

/s/ Ray G. Ross

Ray G. Ross
Supervisory Mining Engineer

/s/ Lawrence D. Phillips

Lawrence D. Phillips
District Manager, District 6

/s/ Cecil E. Lester

Cecil E. Lester
Coal Mine Specialist

/s/ John Nagy

John Nagy
Physical Scientist

Approved by:

/s/ Joseph O. Cook

Joseph O. Cook
Assistant Administrator--Coal Mine Health and Safety

APPENDIX A

Victims of Mine Explosions, Scotia Mine Scotia Coal Company

March 9, 1976, Explosions

Name and Social Security Number	Age	Sex	Job Classification	Experience at that Job	Total Mining Experience	First Aid Training	Mine Rescue Training
Dennis Boggs 223-72-5664	27	M	Utility man	2 years	2 years	—	—
Everett Scott Combs 401-66-5309	29	M	Ventilation	5 years 3 months	5 years 3 months	—	—
Virgil Coots 400-78-5777	24	M	Section Foreman	7 months	4 years 2 months	—	—
Earl Galloway 407-38-8738	44	M	Shuttle car operator	11 years 7 months	14 years 7 months	—	—
David Gibbs 402-60-6984	30	M	Repairman	10 years 9 months	10 years 9 months	—	—
Robert Griffith 404-72-1494	24	M	Belt cleaner	2 years	2 years	—	—
Larry David McKnight 402-68-6170	28	M	Motorman	1 year 10 months	3 years 5 months	—	—
Roy McKnight 400-60-5448	31	M	Timberman	4 years 6 months	4 years 6 months	—	—
Lawrence Peavy 402-74-2453	25	M	Supplyman	6 years 8 months	6 years 8 months	—	—

Appendix A continued

Name and Social Security Number	Age	Sex	Job Classification	Experience at that Job	Total Mining Experience	First Aid Training	Mine Rescue Training
Tommy Ray Scott 403-76-1698	24	M	Continuous mining machine operator,	3 years 6 months	3 years 6 months	—	—
Ivan Gail Sparkman 405-58-0950	34	M	Bratticeman	1 year 11 months	1 year 11 months	—	—
Jimmy W. Sturgill 405-86-6173	20	M	Utility man	1 year 6 months	1 year 6 months	—	—
Kenneth Turner 279-48-1805	25	M	Roof bolter	3 years 9 months	3 years 9 months	—	—
Willie D. Turner 367-46-5589	32	M	Shuttle car operator	5 years 8 months	5 years 8 months	8-8-73	—
Denver Widner 405-56-8562	31	M	Ventilation	1 year 11 months	1 year 11 months	—	—
			March 11, 1976, Explosion				
Glenn Barker 404-66-5046	29	M	Motorman	5 years	5 years	8-8-73	—
Don Creech 482-54-1519	30	M	Utility man	4 months	8 years 4 months	2-19-76	—
John Hackworth 404-66-2089	29	M	Timberman	2 years [illegible]onths	2 years 6 months	8-8-73 2-19-76	—

Appendix A Continued

Name and Social Security Number	Age	Sex	Job Classification	Experience at that Job	Total Mining Experience	First Aid Training	Mine Rescue Training
J. B. Holbrook 402-42-6308	43	M	Tipple Operator	13 years	13 years	—	—
Kenneth B. Kiser 229-34-0403	45	M	Federal Coal Mine Inspector	5 years	27 years	8-72	10-72
Carl Polly 412-38-5051	47	M	Roof bolter	7 years 2 months	7 years 2 months	—	—
Richard M. Sammons 405-18-8288	55	M	Federal Coal Mine Inspector	5 years	26 years	10-70	12-70
James Sturgill 403-30-9768	46	M	Belt cleaner	1 year 11 months	11 years 11 months	—	—
Monroe Sturgill 406-44-6936	40	M	Roof bolter	3 years 10 months	13 years 10 months	—	—
Grover Tussey 406-32-3098	45	M	Federal Coal Mine Inspector	1 year	26 years	4-75	5-75
James Williams 401-80-2418	23	M	Section Foreman	6 months	4 years	—	—

Appendix B

MINE RESCUE TEAMS

Blue Diamond Coal Company
Leatherwood, Kentucky

Team No. 1

Robert Hamilton, Captain
Alger Bowen
Darrell Rice
Hubert Smith
Ronnie Halcomb
Brunner Caudill
Marty Turner

Team No. 2

Charlie Fields, Captain
Jerry Baker
Archie Craft
J. C. Osborne
Garland Farley
Johnny Josuah, Jr.
Eugene Sizemore

Scotia Coal Company
Oven Fork, Kentucky

Team No. 1

Charles Kirk, Captain
Jerry Herrin
B. D. Baker
Bobby Collins
J. Kirk
Wayne McDougal
Willard Back

Team No. 2

David McKnight, Captain
C. Turner
Gary J. Shelton
Larry Barker
J. D. Polli
Kenneth Fields
G. Halcomb
William D. Napier

Team No. 3

Jimmy Cornett, Captain
W. Rosenbaum
Kenneth Goins
M. Duff
Benny Adams

Kentucky Department of Mines and Minerals

Kenneth Dupree, Captain
Douglas Monroe
Dewey Middleton
Lloyd Adams
Bobby Baker
Leroy Gross

Appendix B continued

INDUSTRY MINE RESCUE TEAMS

Clinchfield Coal Company
Moss No. 2 Team
Dante, Virginia

Harold Phillips, Trainer
Milton Kiser, Captain
Wayne Fields
Larry Breeding
Larry Meade
Bobby Tompa
Kenneth Brooks, Jr.
Guy Jessee

United States Steel Corporation
Team
Lynch, Kentucky

Albert C. Wagers
Hubert L. Payne
Jimmy R. Boggs
James M. Vicini
Sammy D. Farris
Ray McKenna
John Dixon

Westmoreland Coal Company
Big Stone Gap, Virginia

Team No. 1

Jerry Fritz, Captain
Jack Collinsworth
Glen Bowen
Matt E. Smith
Gerald Tate
Hubert Kimberlin, Jr.

Louis E. Henegar, Trainer

Team No. 2

Billie R. Person, Captain
Gerald A. Wolfe
Ronald W. Willis
Lloyd Robinette, Jr.
James D. Garrison
Raymond Carnes
David M. Breedlove

Beth-Elkhorn Coal Corporation
Jenkins, Kentucky

Mine No. 22

Charlie Adams, Captain
Herschel Slone
Paul Gilliam
Kyle Walker
Doug Moncrief
Thurman Hall
James Salyers, Trainer

Mine No. 26

Claude Brown, Trainer
Larry Minnix, Captain
Danny Hause
Danny Robinette
Emmett McCullum
Ward Carter
George Potter

Mine No. 29

Burley Wright, Captain
Jack Quillen
Paul Little
Leonard Fleming
Johnny Green
Kelly P. Desimone
Arnold E. Williams

Appendix B continued

International Harvester
Benham, Kentucky

Don Disney, Captain
Ronald Boggs
Allen Evans
Lonnie Buchanan
David Howard
Jerry Williams

National Mines Corporation
Wayland, Kentucky

John Collins, Captain
J. C. Spencer
Burl Scott
Herman Allen
Danny Patton
Charles Senters
Luther Russell, Trainer

Mining Enforcement and Safety Administration (2 Teams)

Herschel Lough, Manager
Harrison Summers, Manager

Morgantown, West Virginia

Raymond Strahin
Richard Vasicek
William Reid
Harry Markley
Starr Powers
Michael Evanoff
James Satterfield
John Floyd

Pittsburgh, Pennsylvania

John E. Chambers
Gerald E. Davis
William A. Dupree, Captain
William E. Humbert
Walter T. Magera
Charles W. Pogue
Ernest C. Teaster, Jr.,Captain

SCOTIA COAL COMPANY

Jasper K. Cornett, Director of Recovery
Woods G. Talman, Consultant
Richard Carter, Resident Manager
Harvey Creech, Assistant Resident Manager
Walter Williamson, Supervisor of Mine Rescue Teams
Luther Kirk, Mine Rescue Team Instructor

Arvil Cornett, Foreman
Verle Boggs, Foreman and Fireboss
David Adams, Maintenance Foreman

Bruce Jones, Foreman
Merle Rhodes, Foreman and Fireboss
Hargis Maggard, Maintenance Foreman

Gerald Thornsberry, Foreman
Carl Wheatley, Foreman
Carrell Williamson, Fireboss
Randy Morris, Maintenance Foreman

Appendix B continued

SCOTIA EMPLOYEES ASSOCIATION

David T. McKnight
Kenneth Goins
Benny Adams

KENTUCKY DEPARTMENT OF MINES AND MINERALS

Kenneth Dupree, Mine Inspector
Douglas Monroe, Mine Inspector

MINING ENFORCEMENT AND SAFETY ADMINISTRATION

Lawrence D. Phillips, District Manager
Ray G. Ross, Supervisory Mining Engineer, Manager Control Center
Ernest Teaster, Coal Mine Inspection Supervisor, District 2
Frank C. Mann, Supervisory Mining Engineer, District 5
Merian O'Bryan, Supervisory Coal Mine Technical Specialist
(Accident Investigation), District 5
James Bowman, Supervisory Coal Mine Technical Specialist
(Ventilation), District 5
Ronald W. Franks, Coal Mine Inspection Supervisor, District
Russel Tackett, Coal Mine Inspection Supervisor, District 6
William Cupp, Supervisory Coal Mine Inspection Supervisor
(Electrical), District 2
Robert J. Moran, District 3
Ellis Mitchell, District 3
William H. Bunter, District 3
Charles Cruny, District 3

APPENDIX H

ANALYSIS OF MINE DUST SAMPLES TAKEN IN EXPLOSION AREA

Location	Average Percent Incombustible	Number of Samples
	2 SOUTHEAST MAIN	
5-1 to 5-5	62.0	16
5-6 to 5-11	50.5	26
5-12 to 5-18	47.3	33
5-19 to 5-24	44.3	30
5-25 to 5-30	42.8	30
5-31 to 5-36	45.1	30
5-37 to 5-43	57.9	35
	2 LEFT OFF 2 SOUTHEAST MAIN	
10-1 to 10-5	42.7	18
	NORTHEAST MAIN - RIGHT PANEL	
4-1 to 4-10	69.1	47
4-11 to 4-17	48.6	38
4-18 to 4-22	44.8	25
4-23 to 4-27	48.6	23
4-28 to 4-32	60.4	19
4-33 to 4-40	60.7	32
	NORTHEAST MAIN - LEFT PANEL	
3-1 to 3-10	80.0	42
3-11 to 3-17	74.1	27
3-18 to 3-24	77.5	32
3-25 to 3-30	83.2	30
3-31 to 3-46		
INTAKES	79.2	46
RETURNS	85.4	19

ANALYSIS OF MINE DUST SAMPLES COLLECTED IN 2 SOUTHEAST MAIN PRIOR TO EXPLOSIONS

Location	Average Percent Incombustible	Number of Samples	Number of Samples out of Compliance	Percent of Samples out of Compliance
		2 SOUTHEAST MAIN		
INTAKE	81.3	36	0	0%
RETURN	82.6	18	4	22%

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS
SOUTH MAIN AND SOUTHEAST MAIN

Sample No.	A INTAKE	B INTAKE/BELT	Entry Number C INTAKE/TRACK	D INTAKE
1-1	44.1N	90.2N	92.1N	89.3N
1-2	89.7N	95 N	85 N	75 N
1-2x	92.3N	94.2N	87.3N	-
1-3	74.7N	86.5N	87.8N	69.7N
1-4	70.5N	75.8N	87.7N	NS
1-5	70.8N	75.9N	94.1N	66.3N
1-6	48.2N	61.5N	78.6N	58.2N
1-7	54.3N	66.5N	89.8N	NS
1-7x	NS	NS	72.8N	NS
1-8	NS	NS	NS	NS
1-9	NS	63.7N	90.3N	80.9N
1-9x	NS	NS	NS	NS
1-10	NS	67.4N	87.6N	65 N
1-11	NS	NS	85 N	NS
1-12	NS	56.5N	83.5N	NS
1-12x	NS	NS	NS	NS
1-13	NS	66 N	86.4N	NS
1-14	NS	81.2N	86 N	NS
1-14x	NS	88.9N	NS	NS
1-15	NS	76.9N	90.7N	NS
1-16	NS	68.9N	77 N	NS
1-17	80.8N	90.9N	53.4N	NS
1-18	77.9N	80.3N	54 N	NS
1-18x	NS	65.8N	NS	NS
1-19	57.1N	87.1N	37.3N	NS

NOTE: Abbreviations -

x = crosscut
NS = no sample
N = no coke
O,A,B,C,D,E,F,G,H, I = entry number
L = large coke
T = trace coke
S = small coke

APPENDIX H - Continued

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS
SOUTH MAIN AND SOUTHEAST MAIN

Sample No.	Entry Number A RETURN	B INTAKE/BELT	C INTAKE/TRACK	D INTAKE
1-20	51.1N	82.3N	73.8N	69.6N
1-21	66.3N	83.5N	86.0	NS
1-21x	67.5N	78.3N	64.2N	NS
1-22	75.1N	76.3N	82.3N	66 N
1-23	NS	86.7N	82.3N	54.1N
1-24	NS	77.4N	73.5N	57.5N
1-25	56.2N	85.7N	70.9N	52.2N
1-25x	NS	81.1N	72.7N	NS
1-26	60 N	87.6N	67.8N	55.1N

APPENDIX H - Continued

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS
SOUTHMAIN AND SOUTHEAST MAIN-RIGHT PANEL

Sample No.	Entry Number A RETURN	B INTAKE/BELT	C INTAKE/TRACK	D INTAKE
1-27	68.1N	87.0N	82.8N	55.4N
1-27x	NS	94.8N	53.8N	-
1-28	58.5N	84.5N	77.4N	67.6N
1-29	58.5N	83.7N	89.3N	53.3N
1-29x	51.1N	81.7N	61.3N	-
1-30	44.2N	88.8N	85.9N	52.2N
1-31	NS	99.5N	83.6N	48.1N
1-32	58.9N	88.6N	79.7N	48.6N
1-33	82.4N	94.9N	87.7N	67.6N
1-34x	61.0N	85.0N	78.6N	-
1-34	84.8N	90.8N	88.3N	71.6N
1-35	78.2N	97.5N	89.7N	74.1N
1-36	79.1N	96.6N	94.3N	63.1N
1-37	80.7N	93.2N	92.4N	54.7N
1-37x	NS	NS	84.7N	-
1-38	85.0N	86.9N	89.9N	NS
1-39	95.7N	96.4N	81.7N	59.6N

SOUTHMAIN AND SOUTHEAST MAIN RETURNS

Sample No.	Entry Number A RETURN	B RETURN	C RETURN	D RETURN
2-1	79.1N	86.4N	86 N	-
2-2	70.9N	85 N	88.8N	-
2-2x	NS	NS	96.3N	-
2-3	NS	88.9N	99.6N	-
2-4	52.9N	92.1N	95.1N	-
2-4x	NS	62.1N	96.1N	-
2-14	50.6N	61.9N	NS	46.7N
2-14x	49.1N	44.6N	NS	NS
2-15	NS	NS	56.6N	NS
2-16	NS	65.3N	60 N	NS
2-16x	NS	NS	58.4N	NS
2-17	64.2N	NS	61 N	NS
2-18	NS	NS	NS	NS
2-18x	NS	NS	NS	NS
2-19	45.6N	68.2N	58.8N	56 N
2-20	54.9N	62.7N	70.4N	33.3N
2-20x	46.5N	NS	NS	NS

APPENDIX H - Continued

SOUTHMAIN AND SOUTHEAST MAIN RETURNS (Continued)

Sample No.	Entry Number A RETURN	B RETURN	C RETURN	D RETURN
2-21	NS	NS	66.6N	NS
2-22	NS	55.4N	NS	47.4N
2-22x	NS	NS	NS	NS
2-23	58.5N	49.5N	52.6N	49 N
2-24	NS	50.8N	59.5N	61.1N
2-25	50.1N	73.1N	74.5N	66.9N
2-26	69.6N	83.6N	78.3N	58.6N
2-27	65.2N	78.7N	87.3N	80.2N
2-28	67.2N	71.2N	82.6N	NS
2-29	56.7N	72.8N	77.6N	75.5N
2-30	NS	65.7N	66.4N	72.7N
2-31	70.9N	81.7N	56.3N	70.1N
2-31x	46.2N	55.1N	77.2N	-
2-32	54.9N	71.5N	76.8N	59.6N
2-33	59.8N	63.7N	69.9N	48.8N
2-33x	45.0	52.8N	54.3N	-
2-34	63.3N	65.4N	84.4N	74.1N
2-35	83.3N	89.7N	55.4N	79.1N
2-35 (dog leg)	E-75.5 (INTAKE) N		F-79.2 (INTAKE) N	
2-36	NS	85.1N	82.2N	NS
2-37	NS	59.4N	74.9N	75.9N
2-37		E-58.8N	F-93.1N	

APPENDIX H - Continued

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS
NORTHEAST MAIN - LEFT PANEL

Sample No.	Entry Number A RETURN	B RETURN	C INTAKE/BELT	D INTAKE/TRACK	E INTAKE
3-1	70.1N	67.9N	95.2N	69.7N	90.3N
3-2	67.7N	97.5N	94.2N	67.3N	78.4N
3-2x	82.1N	75.3N	76.4N	70.7N	-
3-3	65.7N	69.3N	100.0N	60.6N	69.0N
3-4	81.2N	58.1N	71.0N	NS	NS
3-4x	NS	NS	90.2N	-	-
3-5	-	77.1N	91.3N	62.5N	83.9N
3-6	-	87.6N	89.5N	91.5N	83.8N
3-6x	-	92.6N	92.6N	87.1N	-
3-7	-	NS	92.7N	NS	NS
3-8	-	NS	NS	76.4T	72.0T
3-9	-	NS	83.5N	81.7T	NS
3-10	-	NS	94.1N	82.6T	68.0N
3-11	-	63.6T	81.0N	70.7L	71.2L
3-12	-	69.1T	65.0S	73.7L	73.8L
3-13	-	78.0S	76.5L	69.1L	77.3L
3-14	-	77.5S	82.1T	63.7L	81.0L
3-15	-	68.8S	83.1T	gob	69.3L
3-16	-	fall	100.0N	59.1L	75.5L
3-16x	-	-	87.0T	74.1L	-
3-17	-	57.6T	90.0N	66.2T	76.6T
3-18	-	57.0N	83.0N	68.5S	77.3S
3-19	-	55.0N	39.0N	71.2S	70.5S
3-20	wet	100.0N	94.0N	65.6T	76.2S
3-21	82.0N	87.0N	93.0N	66.7T	73.6T
3-22	70.0N	77.0N	93.0N	75.9T	79.2T
3-23	66.0N	94.0N	95.0N	75.2T	100.0N
3-24	65.0N	100.0N	100.0N	42.0N	94.0N
3-25	79.0N	100.0N	100.0N	79.0N	89.0N
3-26	52.0N	66.0N	100.0N	85.0N	80.0N
3-27	84.0N	66.0N	90.0N	77.0N	70.0N
3-28	69.0N	99.0N	100.0N	77.0N	95.0N
3-29	41.0N	84.0N	95.0N	75.0N	95.0N
3-30	79.0N	95.0N	99.0N	79.0N	97.0N
3-31	80.0N	100.0N	95.0N	gob	94.0N
3-32	67.0N	95.0N	87.0N	gob	91.0N
3-33	85.0N	86.0N	100.0N	70.0N	94.0N
3-34	NS	gob	95.0N	82.0N	86.0N
3-35	92.0N	95.0N	89.0N	53.0N	97.0N

APPENDIX H - Continued

NORTHEAST MAIN - LEFT PANEL (Continued)

Sample No.	Entry Number A RETURN	B RETURN	C INTAKE/BELT	D INTAKE/TRACK	E INTAKE
3-36	93.0N	96.0N	92.0N	63.0N	100.0N
3-37	wet	87.0N	95.0N	78.0N	100.0N
3-38	wet	100.0N	100.0N	95.0N	96.0N
3-39	wet	71.0N	80.0N	97.0N	62.0N
3-40	wet	fall	83.0N	85.0N	55.0N
3-41	70.0N	87.0N	100.0N	NS	64.0N
3-42	wet	81.0N	83.0N	84.0N	50.0N
3-42x	63.0FN	45.0GN	65.0HN	90.0IN	-
3-43	wet	90.0N	84.0N	78.0N	65.0N
3-44	66.0N	wet	76.0N	79.0N	59.0N
3-45	wet	81.0N	50.0N	wet	wet
3-46	wet	wet	54.0	64.0N	wet

APPENDIX H - Continued

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS NORTHEAST MAIN - RIGHT PANEL

Sample No.	Entry Number A RETURN	B RETURN	C RETURN	D RETURN	E RETURN
4-1	62.0N	81.4N	94.7N	78.2N	67.9N
4-2	84.1N	73.5N	86.7N	79.5N	77.7N
4-3	65.7N	62.1N	77.1N	81.7N	NS
4-3x	68.1N	60.7N	87.4N	91.5N	-
4-4	89.4N	75.4N	94.5N	76.5N	89.8N
4-5	66.8N	68.9N	82.6N	81.8N	89.1N
4-6	39.2T	50.1N	59.8N	NS	80.6N
4-6x	NS	78.9N	73.5N	NS	-
4-7	38.5S	NS	50.7T	NS	58.5N
4-8	39.2S	NS	49.7T	60.7T	-
4-9	40.9S	NS	45.8S	67.7T	-
4-9x	64.6S	69.5T	NS	-	-
4-10	47.5S	NS	39.1S	NS	-
4-11	40.1L	46.7L	48.5L	42.3L	-
4-11x	42.0L	47.7L	51.3L	-	-
4-12	45.7L	42.1L	56.8L	41.6L	-
4-13	61.5L	42.9L	56.4L	45.9L	-
4-13x	58.4L	60.4L	54.7L	-	-
4-14	63.9L	51.5L	62.7L	46.9L	-
4-15	51.0L	54.6L	55.1L	47.7L	-
4-15x	44.3L	41.3L	43.2L	39.9L	-
4-16	44.0L	46.0L	53.1L	43.8L	-
4-17	41.8L	48.8L	43.0L	37.4L	45.7L
4-18	42.6L	39.4L	46.2L	41.8L	44.2L
4-19	40.4L	43.0L	43.6L	40.4L	44.3L
4-20	42.3L	42.0L	46.2L	54.1L	47.1L
4-21	42.1L	42.9L	45.0L	48.7L	48.3L
4-22	39.0L	66.9L	42.1L	39.4L	48.2L
4-23	40.8L	49.2L	43.8L	43.5L	46.9L
4-24	41.5L	46.6L	48.6L	41.6L	47.7L
4-25	53.5L	NS	46.0L	46.7L	45.8L
4-26	50.0L	52.5L	50.1L	56.4L	57.1L
4-27	NS	54.9L	45.7L	54.5L	54.4L
4-28	55.8L	52.0L	45.6L	46.1S	45.9T
4-29	68.9L	55.0L	45.4S	47.5T	55.0N
4-30	74.5L	72.1S	55.7T	69.4T	64.0N
4-31	64.7L	NS	58.5T	76.0N	60.0N
4-32	NS	55.2T	73.0N	NS	NS
4-33	57.2S	55.0N	47.0N	NS	NS

APPENDIX H - Continued

NORTHEAST MAIN - RIGHT PANEL (Continued)

Sample No.	Entry Number A RETURN	B RETURN	C RETURN	D RETURN	E RETURN
4-34	NS	57.0N	76.0N	NS	NS
4-35	60.0N	41.0N	72.0N	65.0N	70.0N
4-36	54.0N	64.0N	76.0N	55.0N	NS
4-37	74.0N	59.0N	75.0N	56.0N	75.0N
4-38	64.0N	NS	70.0N	NS	90.0N
4-38x	65.0FN	75.0GN	-	-	-
4-39	52.0N	37.0N	36.0N	35.0N	70.0N
4-40	57.0N	NS	42.0N	NS	61.0N

APPENDIX H - Continued

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS
2 SOUTHEAST MAIN

Sample No.	Entry Number: 0 RETURN	A RETURN	B INTAKE/BELT	C INTAKE/TRACK	D INTAKE
5-1	-	59.7S	79.3L	78.3S	59.8S
5-2	-	81.2S	NS	68.8S	NS
5-3	-	67 L	73.7L	56.3XL	NS
5-3x	-	43.3L	65.7L	63.3L	NS
5-4	-	41.6L	NS	63.3L	47.2L
5-5	-	41.2S	NS	70.1L	78.8L
5-6	-	39.7L	61.2L	65.2L	NS
5-6x	-	52.9XL	NS	NS	NS
5-7	-	48.8XL	55 L	51.7L	39.9XL
5-8	-	45.6L	61.8L	47.7L	50.9L
5-9	-	45.4L	57 L	61.5L	44.3L
5-10	46.2L	43.5L	55.4L	52.2L	46.4L
5-11	45.3L	47 L	56.7L	46.7L	45.9L
5-12	46.3L	45.2L	54.9L	45.7L	44.1L
5-13	44.6L	46.2L	55.5L	49.1L	45.1L
5-14	NS	45.5L	52.2L	62.7L	38.5L
5-15	47.5L	47.4L	48.1L	62.4L	38.1L
5-16	46.9L	45.1L	47 L	47.5L	48.1L
5-17	NS	43.7L	48.6L	43.2L	42.1L
5-18	46.3L	42.5L	44.8L	61.1L	34.9L
5-19	45.8L	45.1L	49.1L	56.9L	37 L
5-20	40.5L	45.5L	40.3L	60.2L	32.8L
5-21	50.6L	47.1L	45.6L	46.3L	31.6L
5-22	49.7L	48 L	48.5L	60.4L	31.8L
5-23	47.3L	48.9L	41.4L	44.5L	29.8S
5-24	42 L	51.9L	44.5L	37 L	29.2S
5-25	42.4L	62.1L	44 L	43 L	36.8S
5-26	48.3L	40.2L	45.4L	64.5L	37.3S
5-27	37.8L	43.5L	46.2L	49.5L	34.8S
5-28	42.4L	44.5L	43.1L	60 S	32.0S
5-29	37.4L	33.8S	44.1S	46 S	33.9S
5-30	41.6L	35.3S	40.6S	41.6L	32.8S
5-31	42.5L	33.9S	47.4S	37.5L	31.6S
5-32	37.3S	46.5S	39.3T	43.8L	36.4T
5-33	45.2S	43.9S	38 L	44.9L	36.6L
5-34	64.5S	41.9S	43.5S	44.2L	44.7L
5-35	52.5L	49.6L	42.3S	56.9S	59.4L
5-36	59.1L	49.5L	50.5L	48.9S	41.1L
5-37	53.3L	49.2L	57.4L	70.1L	41.5L
5-38	43.3L	42.3L	52.7L	47 L	55.7L
5-39	65.8L	48.6S	56.3T	49.7L	64.3L
5-40	82.5L	72.6S	62.8T	79.7L	57.1S
5-41	72 T	51.9T	54.8N	67 T	68.5T
5-42	56.6N	45.6N	41.5N	59 T	64.6L
5-43	60.6N	60.7N	46.9N	57.9N	66.3T

APPENDIX H - Continued

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS
3 SOUTHEAST MAIN

Sample No.	Entry Number A INTAKE	B INTAKE/TRACK	C INTAKE/BELT	D RETURN	E RETURN
6-1	71.0N	85.0N	79.0N	50.0N	59.0N
6-2	56.0N	86.0N	81.0N	50.0N	NS
6-3	54.0N	76.0N	NS	NS	NS
6-4	64.0N	80.0N	90.0N	NS	49.0N
6-5	65.0N	92.0N	90.0N	100.0N	50.0N
6-6	79.0N	99.0N	84.0N	NS	58.0N
6-7	NS	82.0N	90.0N	95.0N	NS
6-8	43.0N	100.0N	75.0N	100.0N	51.0N
6-9	65.0N	95.0N	65.0N	57.0N	45.0N
6-10	81.0N	100.0N	NS	NS	NS
6-11	79.0N	57.0N	91.0N	NS	90.0N
6-12	95.0N	77.0N	56.0N	77.0N	65.0N
6-13	84.0N	72.0N	65.0N	72.0N	76.0N
6-14	84.0N	80.0N	NS	80.0N	76.0N

APPENDIX H - Continued

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS
2 LEFT OFF NORTHEAST MAIN

Sample No.	A RETURN	B RETURN	C INTAKE/BELT	D INTAKE/TRACK	E INTAKE/TRACK
			Entry Number		
7-1	-	70 N	92 N	81 N	-
7-2	81 N	NS	90 N	90 N	76 N
7-3	81 N	73 N	NS	NS	NS
7-4	-	97 N	84 N	84 N	-

APPENDIX H - Continued

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS
1 WEST RIGHT PANEL

Sample No.	Entry Number A RETURN	B INTAKE/BELT	C INTAKE/TRACK	D INTAKE
8-1	NS	NS	100 N	NS
8-2	95 N	85 N	NS	NS
8-3	89 N	97 N	NS	NS
8-4	100 N	77 N	100 N	NS
8-5	100 N	100 N	100 N	80 N
8-6	NS	100 N	98 N	83 N
8-7	87 N	100 N	87 N	NS
8-8	NS	84 N	100 N	69 N
8-9	100 N	100 N	100 N	94 N
8-10	NS	100 N	100 N	NS
8-11	NS	NS	100 N	NS

Sample No.	Entry Number A RETURN	B RETURN	C INTAKE/BELT	D INTAKE/TRACK	E INTAKE
8-12	-	100 N	88 N	NS	-
8-13	-	100 N	99 N	NS	-
8-14	NS	NS	100 N	95 N	70 N
8-15	46	NS	97 N	95 N	93 N
8-16	37 N	100 N	96 N	99 N	NS
8-17	NS	NS	84 N	84 N	NS
8-18	NS	NS	NS	NS	NS
8-19	NS	NS	81 N	100 N	60 N
8-20	40 N	76 N	80 N	79 N	NS
8-21	46 N	61 N	100 N	100 N	55 N
8-22	66 N	75	100 N	100 N	91 N
8-23	78 N	76 N	NS	NS	75 N
8-24	84 N	66 N	65 N	95 N	32 N
8-25	NS	NS	100 N	43 N	NS
8-26	NS	NS	NS	NS	NS

APPENDIX H - Continued

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS
1 WEST LEFT PANEL

Sample No.	Entry Number A RETURN	B RETURN	C RETURN	D RETURN
9-1	NS	NS	82 N	96 N
9-2	44 N	68 N	93 N	95 N
9-3	78 N	NS	85 N	92 N
9-4	NS	NS	NS	88 N
9-5	NS	87 N	90 N	83 N
9-6	NS	NS	NS	100 N
9-7	73 N	59 N	NS	87 N
9-8	61 N	61 N	80 N	NS
9-9	68 N	69 N	60 N	NS
9-10	NS	NS	NS	NS
9-11	NS	NS	NS	NS

APPENDIX H - Continued

ANALYSES OF MINE DUST SAMPLES COLLECTED AFTER EXPLOSIONS
2 LEFT OFF 2 SOUTHEAST MAIN

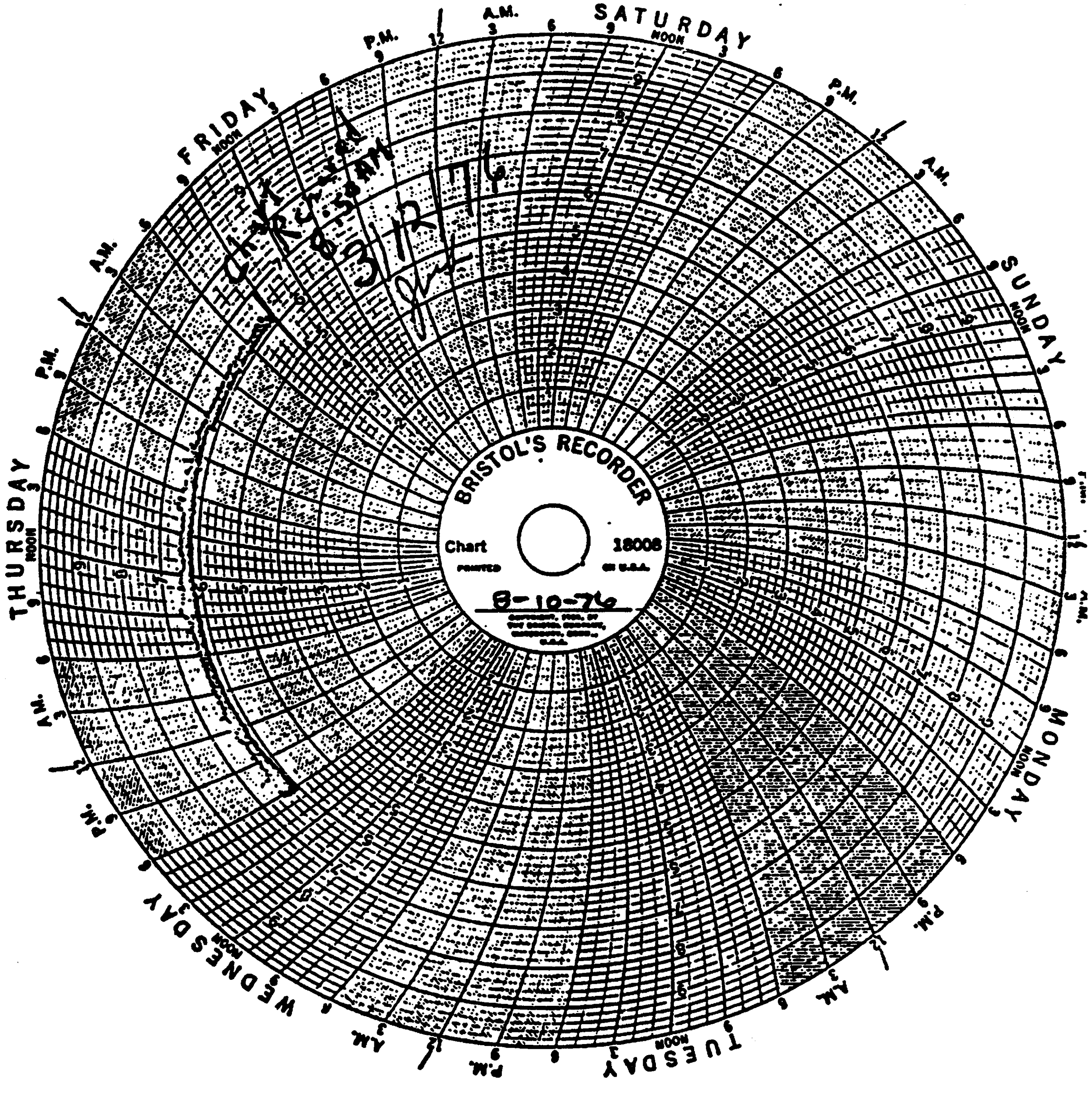
Sample No.	Entry Number A RETURN	B RETURN	C INTAKE/BELT	D INTAKE/TRACK
10-1	47.8T	40.5L	42.7L	42 L
10-2	41.3T	42.8L	41.6L	41.1L
10-3	38.6L	39.7L	45.8L	41.4L
10-4	NS	44.4L	47.4L	40.9L
10-5	NS	44 L	45.2L	42.1L

APPENDIX H - Continued

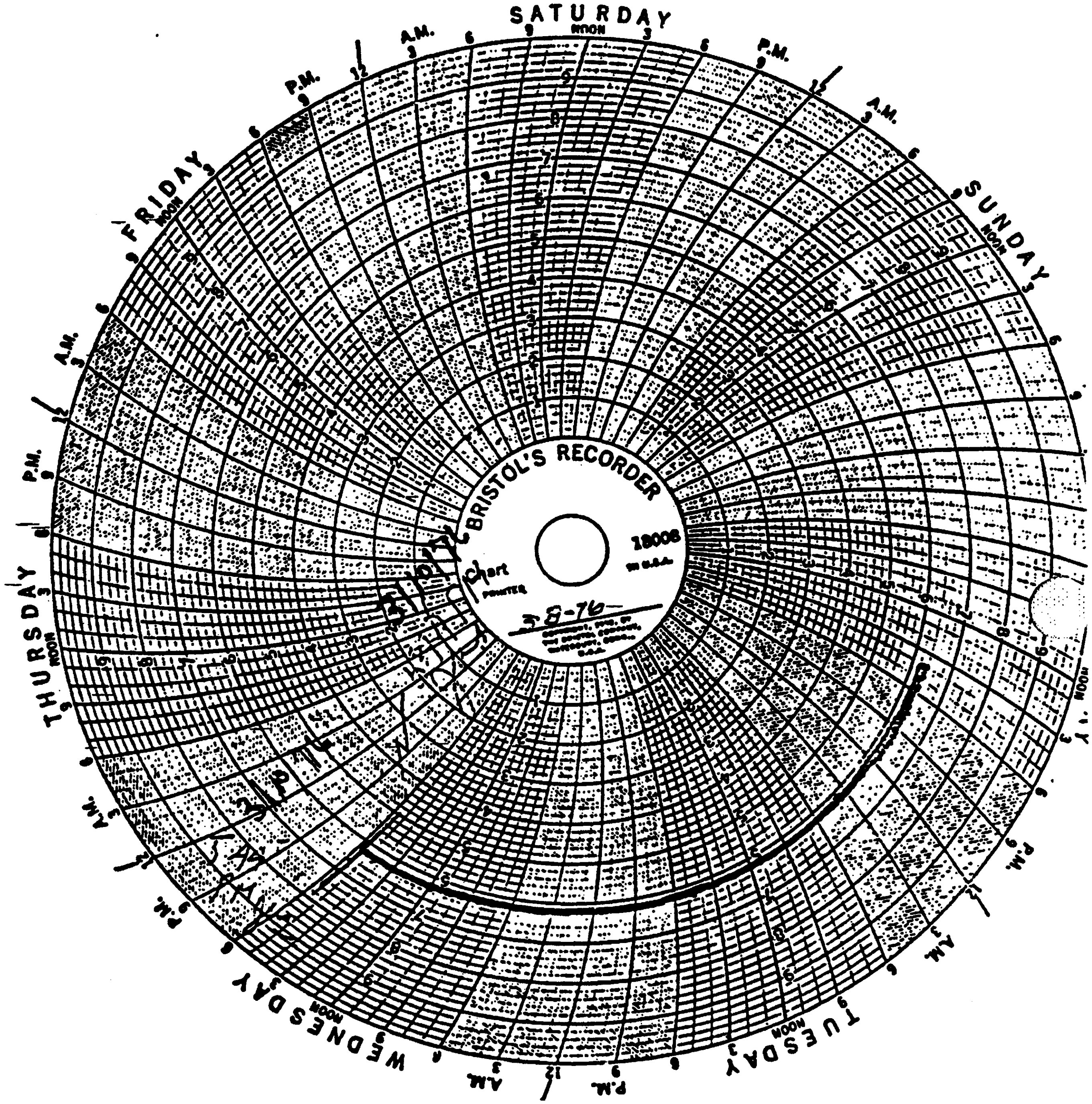
ANALYSES OF MINE DUST SAMPLES COLLECTED IN
2 SOUTHEAST MAIN PRIOR TO MARCH 9, 1976

		Entry Number				
Sample No.	DATE	O RETURN	A RETURN	B INTAKE/BELT	C INTAKE/TRACK	D INTAKE
5-9	5-22-75	-	-	-	94	86
5-18	11-3-75	83	82	90	82	66
5-20	11-3-75	wet	wet	wet	85	67
5-22	11-3-75	85	90	66	80	73
xcut	11-3-75	-	-	-	-	82
5-23	11-3-75	92	69	91	81	86
5-25	11-3-75	63	97	70	73	80
xcut	11-3-75	-	-	-	93	80
5-26	11-3-75	65	89	85	83	73
5-27	11-3-75	70	85	75	66	wet
5-34	1-27-76	wet	89	93	87	78
5-36	1-27-76	wet	89	89	wet	72
5-38	1-27-76	wet	82	93	89	90
xcut	1-27-76	wet	87	85	86	-
5-40	1-27-76	89	80	wet	70	87

Appendix I


BRISTOL'S RECORDER
Chart
18008
PRINTED IN U.S.A.
8-10-76
SATURDAY
SUNDAY
MONDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
NOON
A.M.
P.M.

Appendix I



SATURDAY
SUNDAY
TUESDAY
WEDNESDAY
THURSDAY
FRIDAY
BRISTOL'S RECORDER

Appendix J

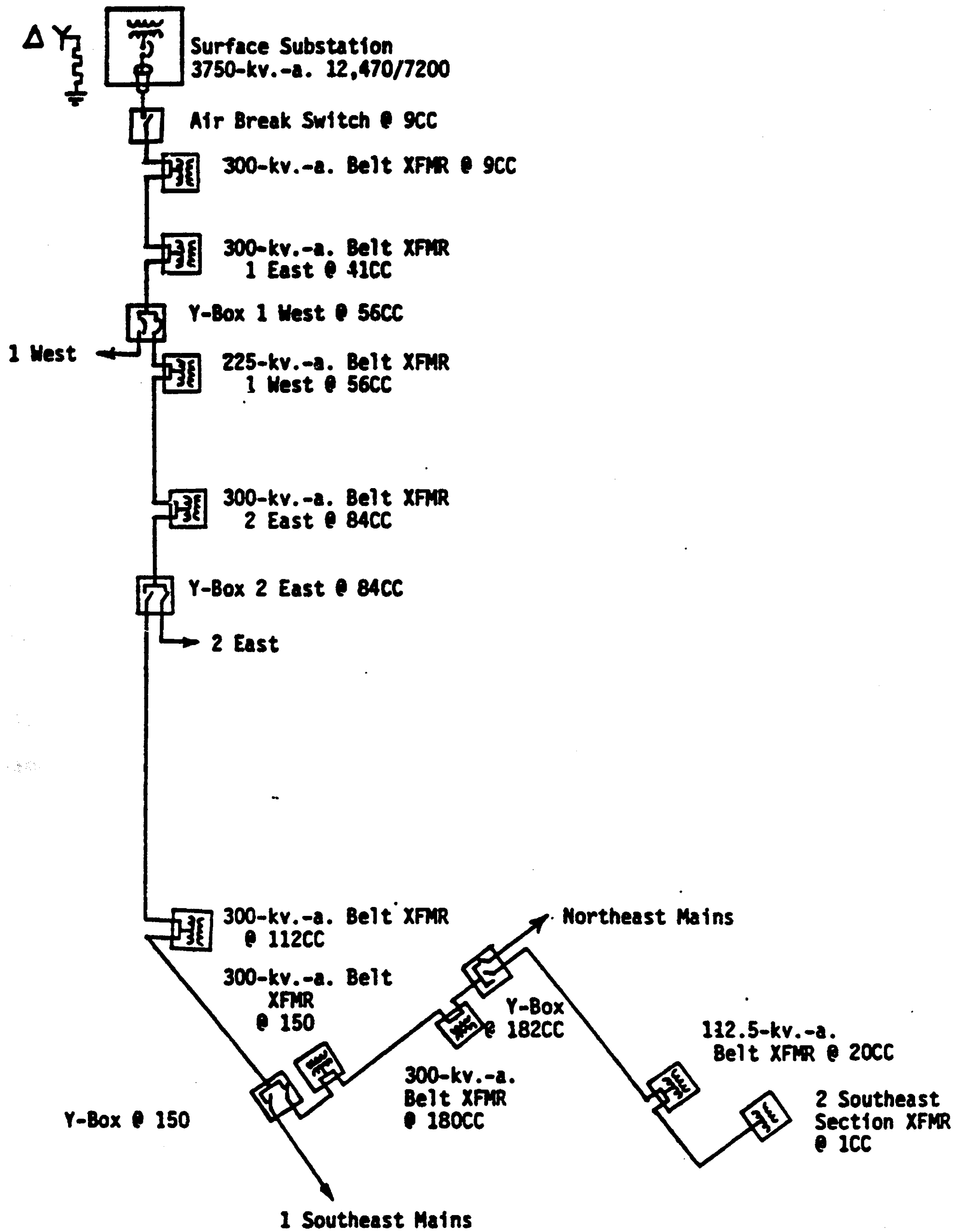


FIGURE 1. - HIGH-VOLTAGE DISTRIBUTION

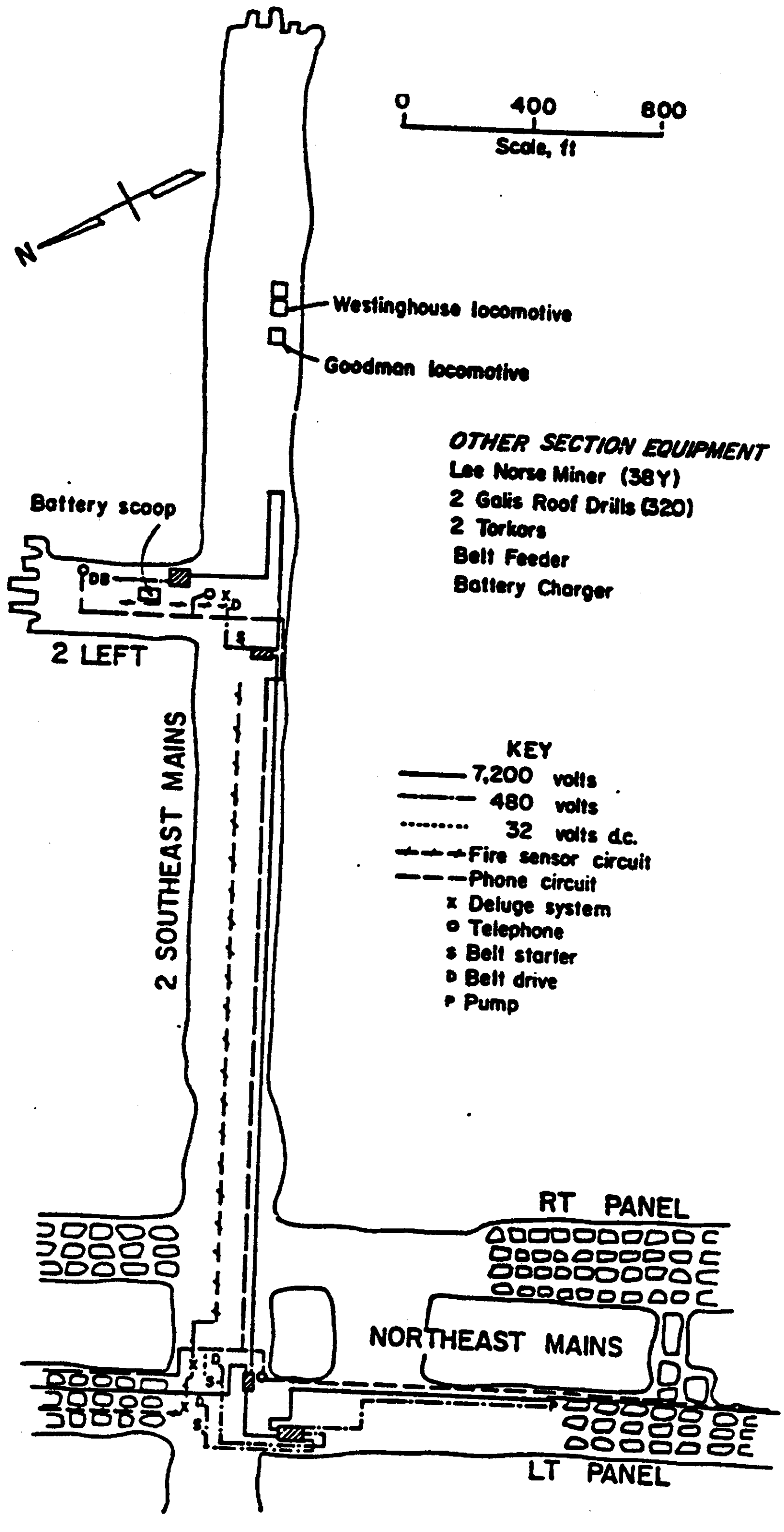


Figure 2.- Energized circuits prior to first explosion. (03-09-76)

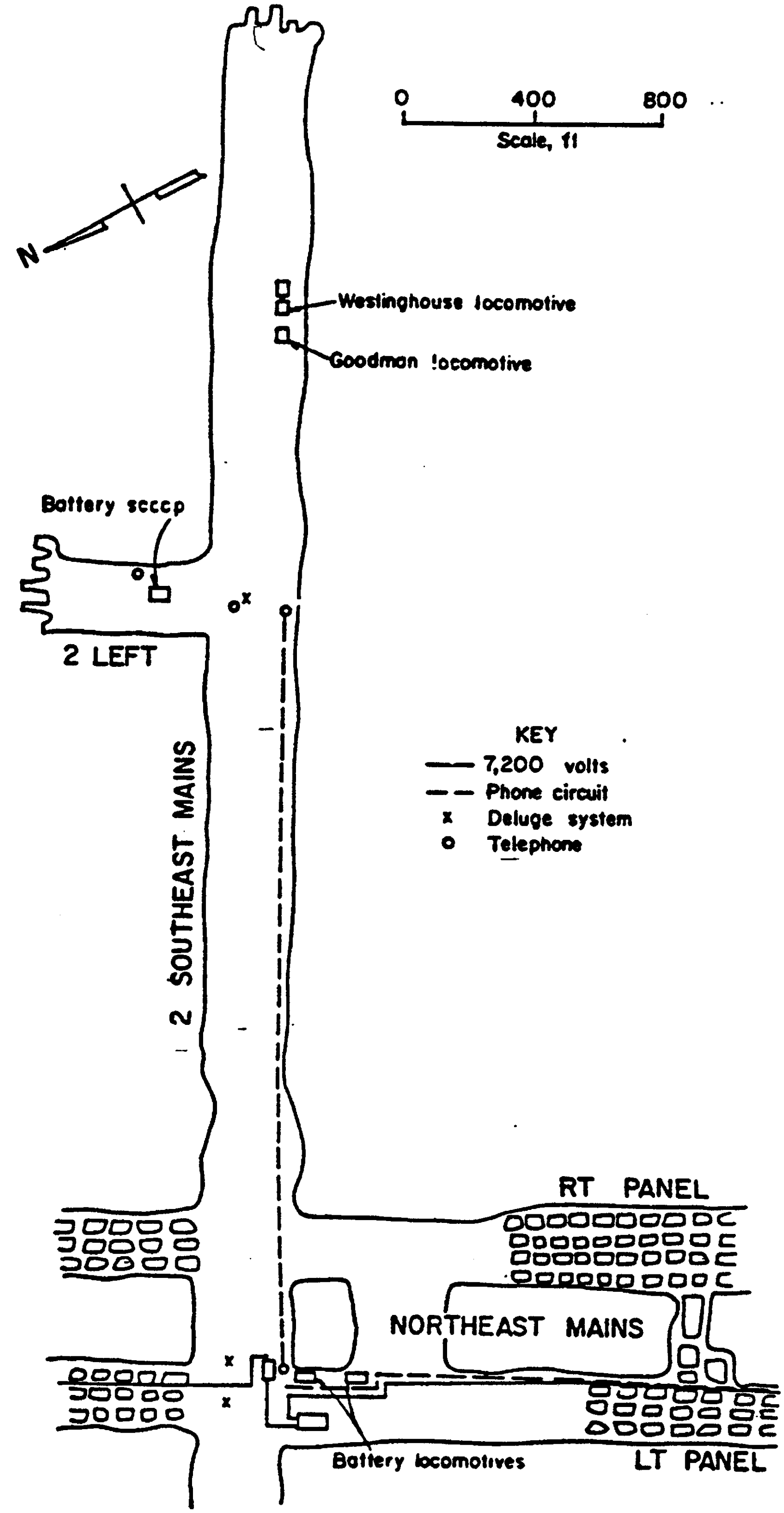
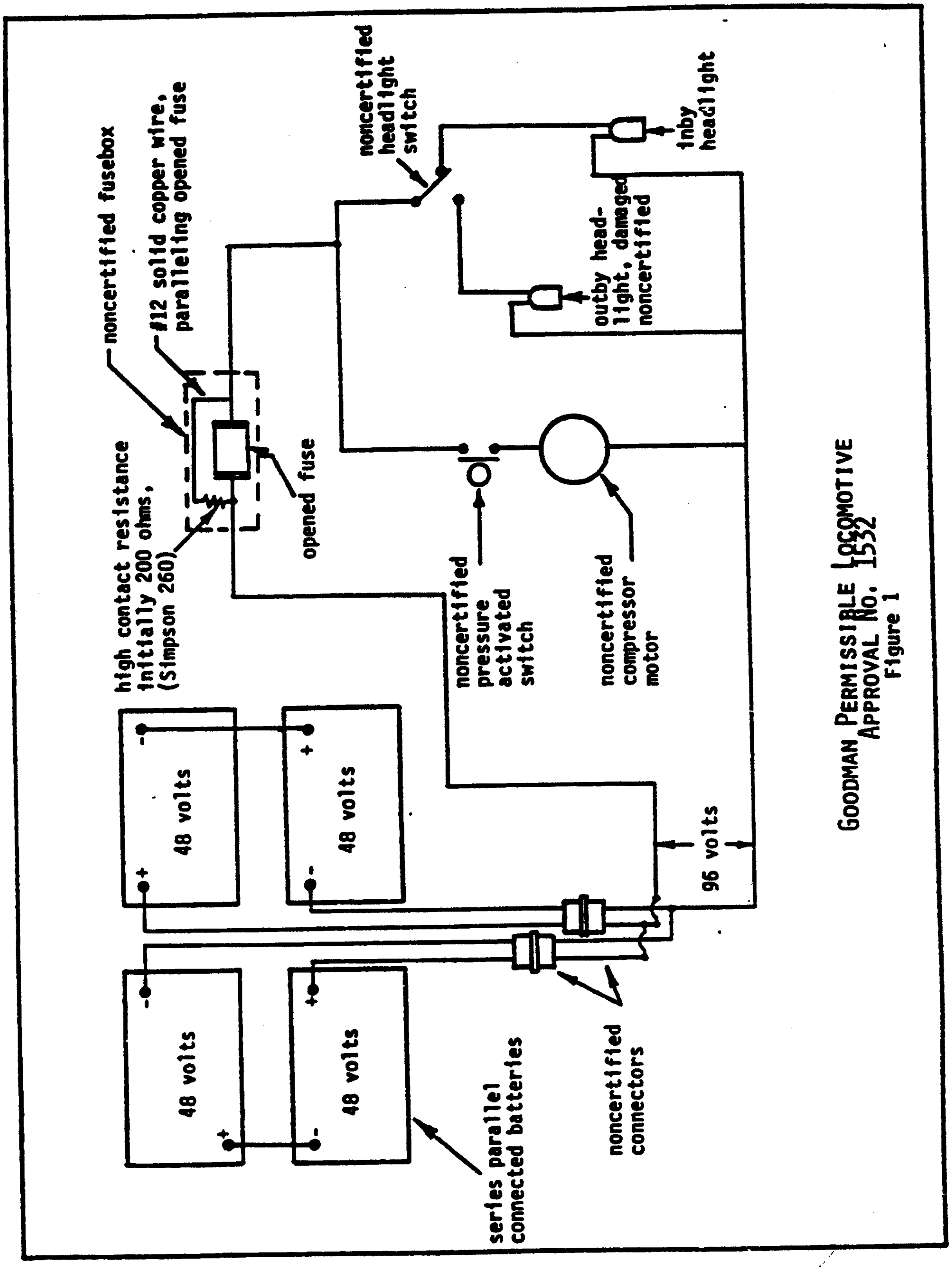


Figure 3.- Energized circuits prior to second explosion. (03-11-76)

Appendix K



GOODMAN PERMISSIBLE LOCOMOTIVE APPROVAL No. 1532
Figure 1

Appendix K

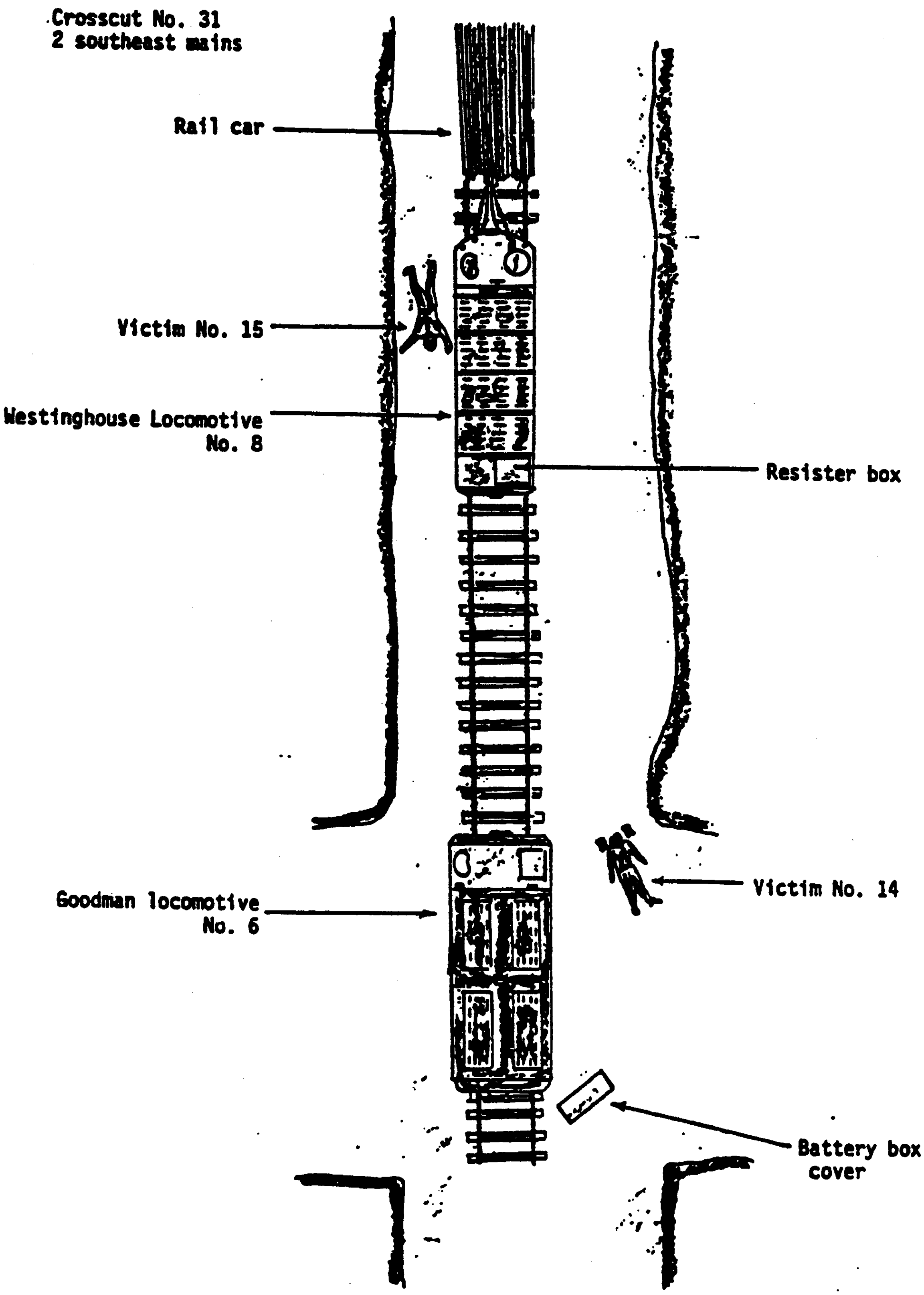


Figure 2

Appendix K

Crosscut No. 31
2 southeast mains

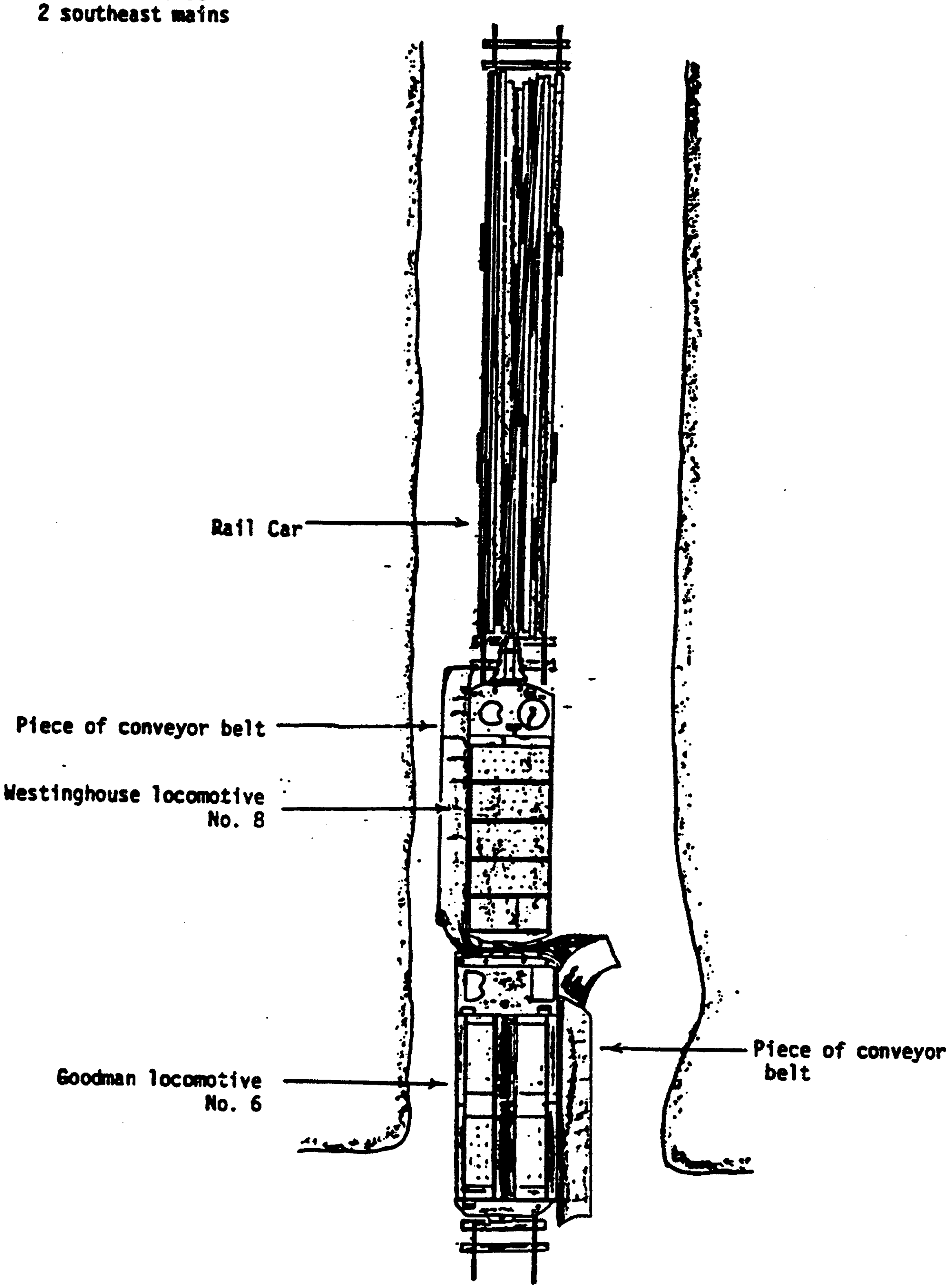


Figure 3

APPENDIX L

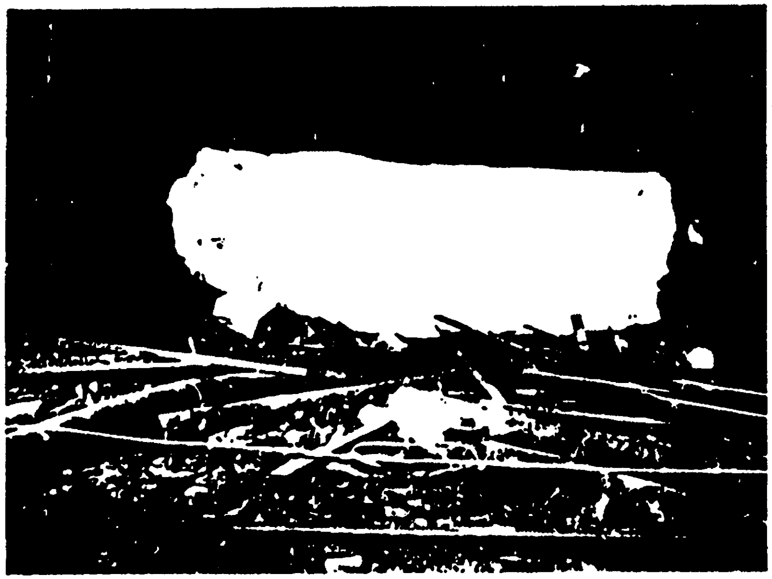


FIG. 1 CONSTRUCTION OF TEMPORARY SEAL

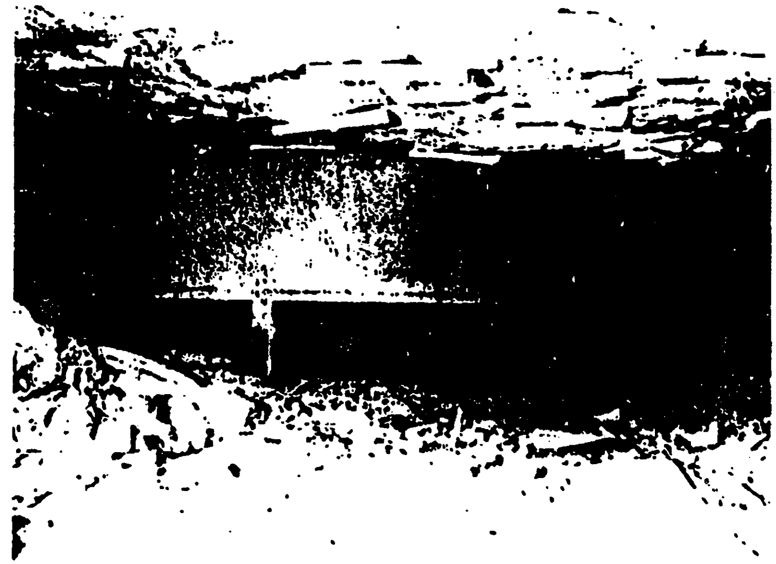


FIG. 2 BELT ENTRY OVERCAST

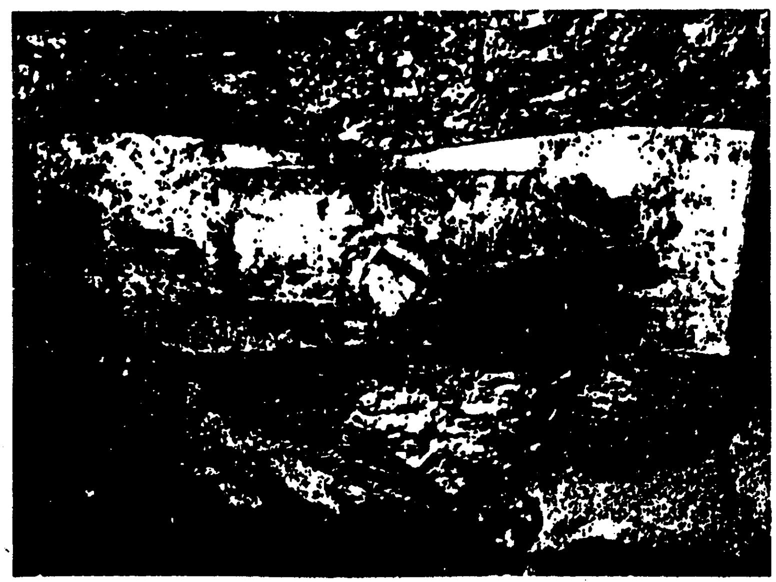


FIG. 3 DATE AND INITIALS, 2 SOUTHEAST MAIN

FIG. 4 DATE AND INITIALS, 2 SOUTHEAST MAIN

APPENDIX L

FIG. 5 DESTRUCTION 2 LEFT BELT ENTRY

FIG. 6 DESTRUCTION 2 SOUTHEAST MAIN BELT, No. 12 CROSSCUT

FIG. 7 BELT DESTRUCTION INBY 2 LEFT

FIG. 8 BELT DESTRUCTION OUTBY 2 LEFT

APPENDIX L

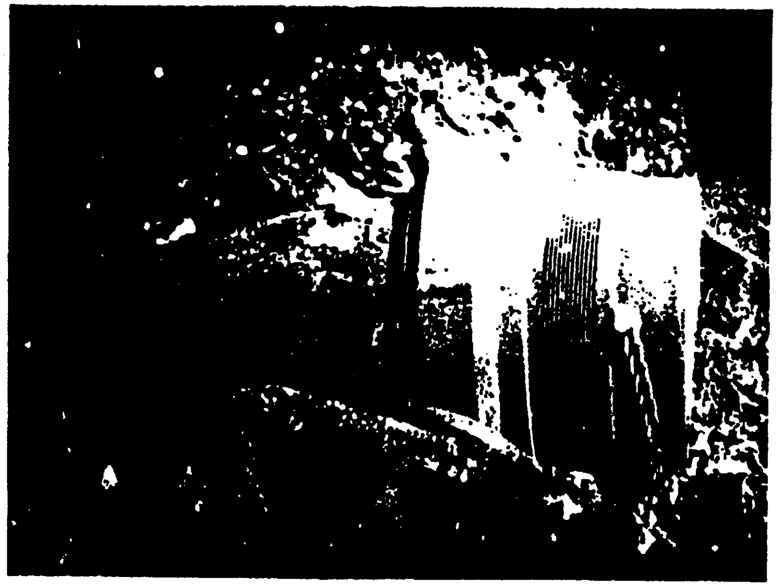


FIG. 9 HV CABLE COUPLER, 2 SOUTHEAST MAIN POWER CIRCUIT

FIG. 10 POWER CENTER, CROSSCUT 180

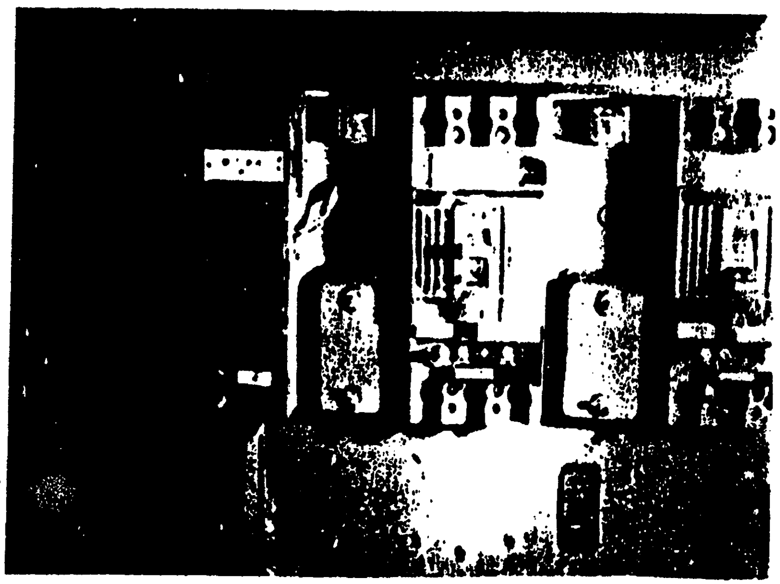


FIG. 11 CIRCUIT BREAKERS IN POWER CENTER, CROSSCUT 180

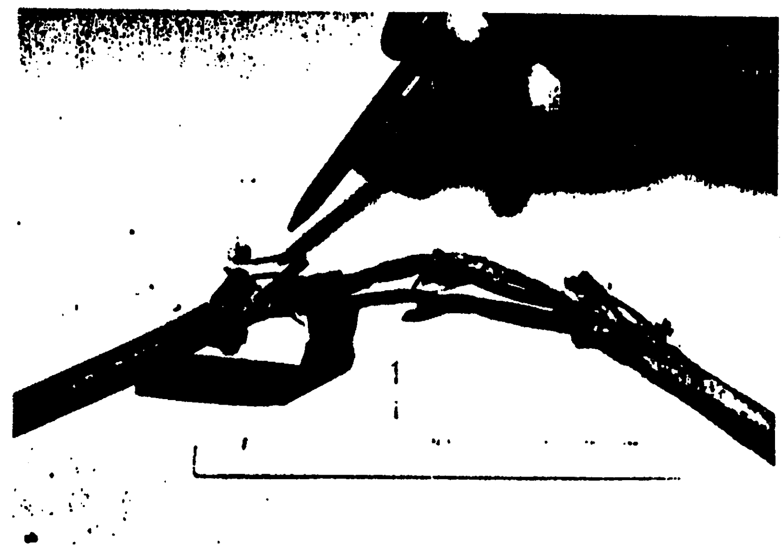


FIG. 12 BELT CONVEYOR CONTROL CIRCUIT, 2 SOUTHEAST MAIN

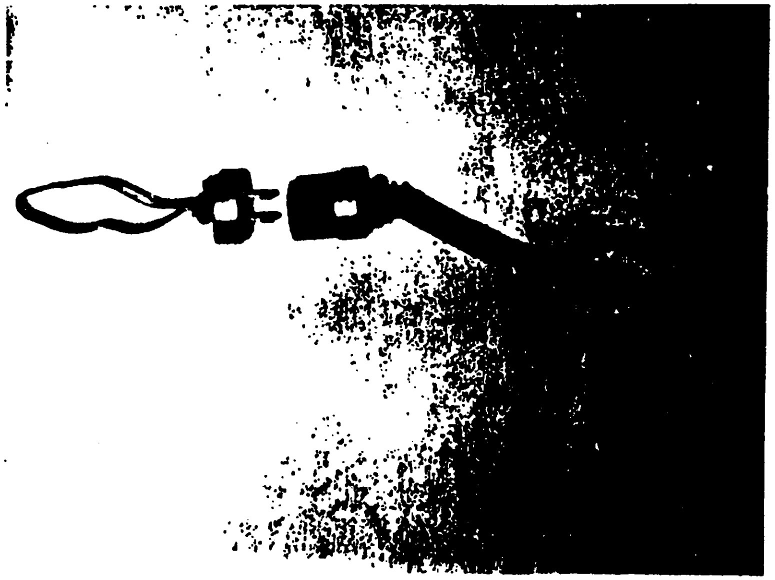


FIG. 13 SHORT CIRCUITING PLUG IN BELT CONVEYOR CONTROL CIRCUIT

FIG. 14 PARTIALLY DISASSEMBLED CABLE COUPLER

FIG. 15 LOCOMOTIVES NOS. 7 AND 9

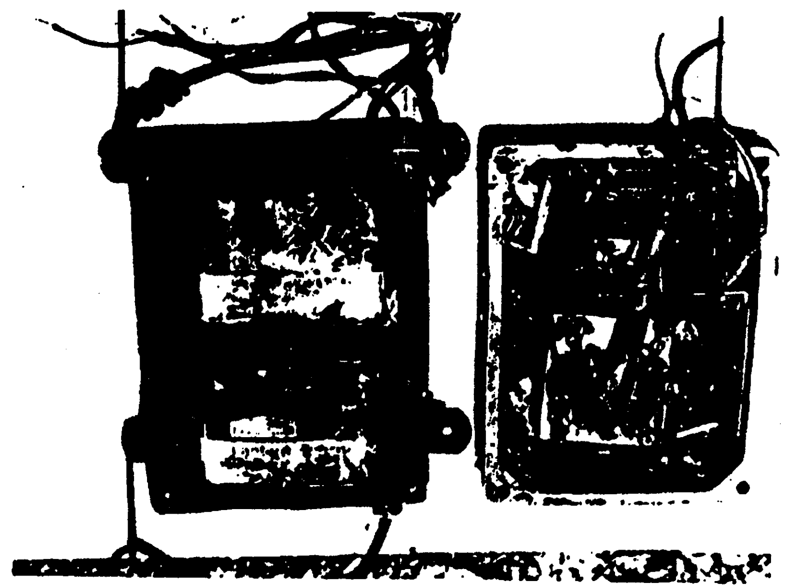


FIG. 16 BATTERY POWERED TELEPHONE

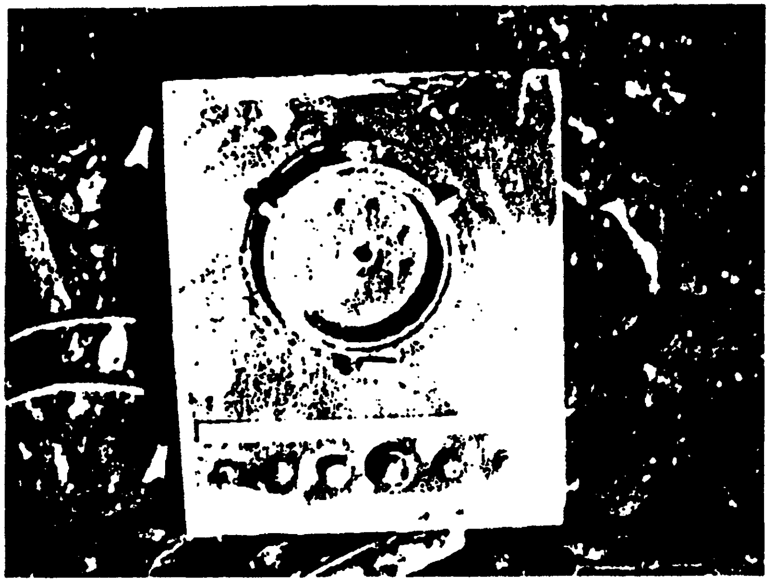


FIG. 17 DELUGE SYSTEM (EXTERIOR)

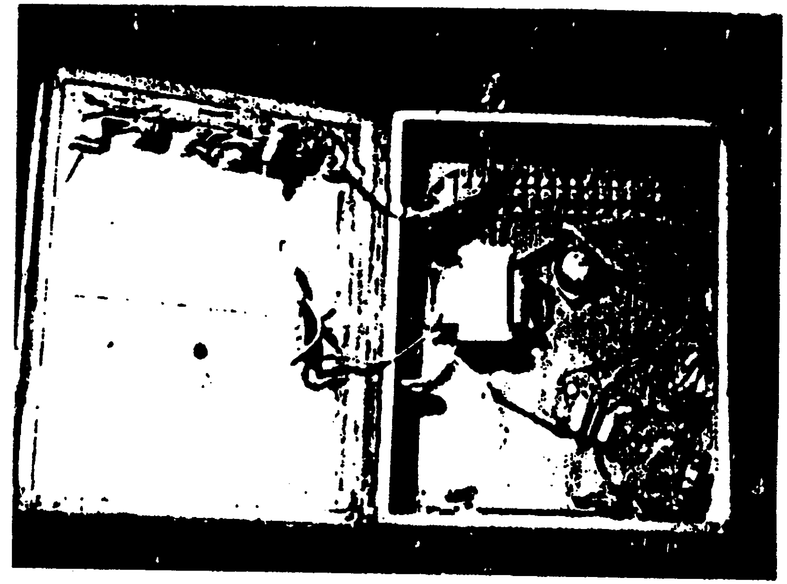


FIG. 18 DELUGE SYSTEM (INTERIOR)

FIG. 19 BELT CONVEYOR POWER CENTER, 2 LEFT

FIG. 20 BELT CONVEYOR DRIVE UNIT, 2 LEFT

FIG. 21 BELT CONVEYOR CONTROL BOX, 2 LEFT

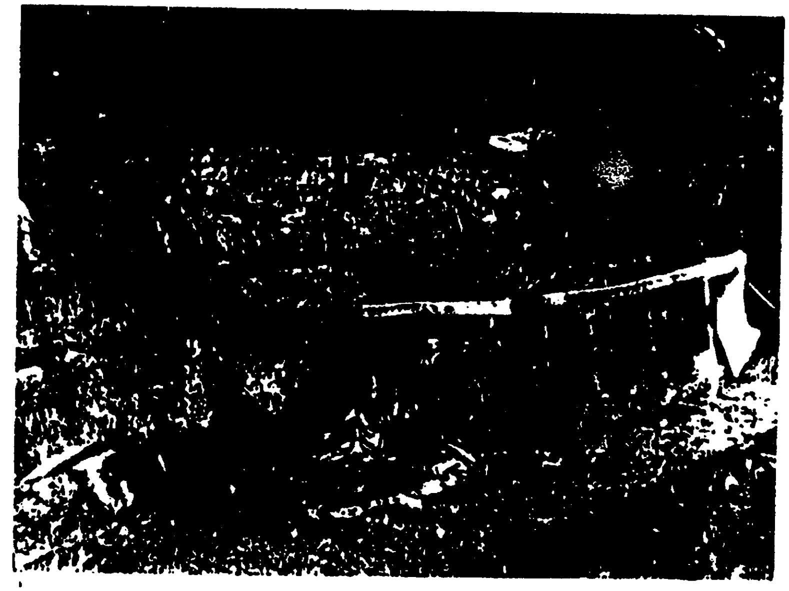


FIG. 22 SECTION POWER CENTER, 2 LEFT

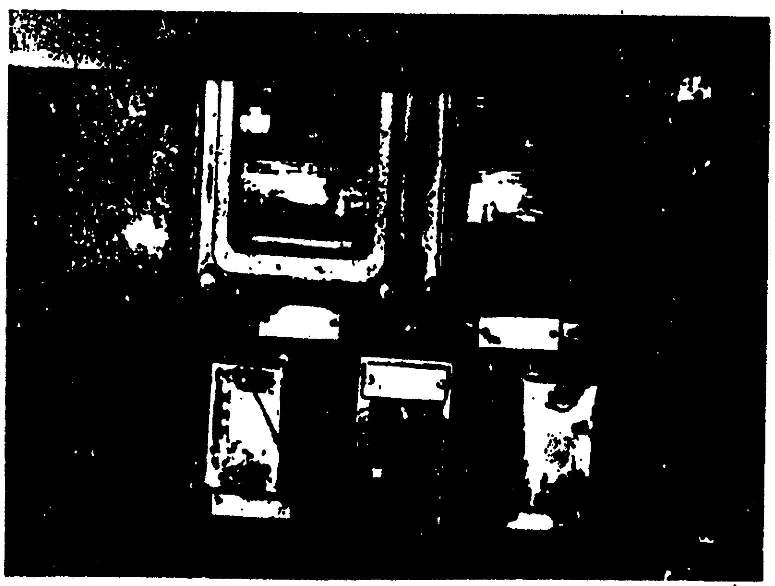


FIG. 23 RELAYING SECTION POWER CENTER, 2 LEFT

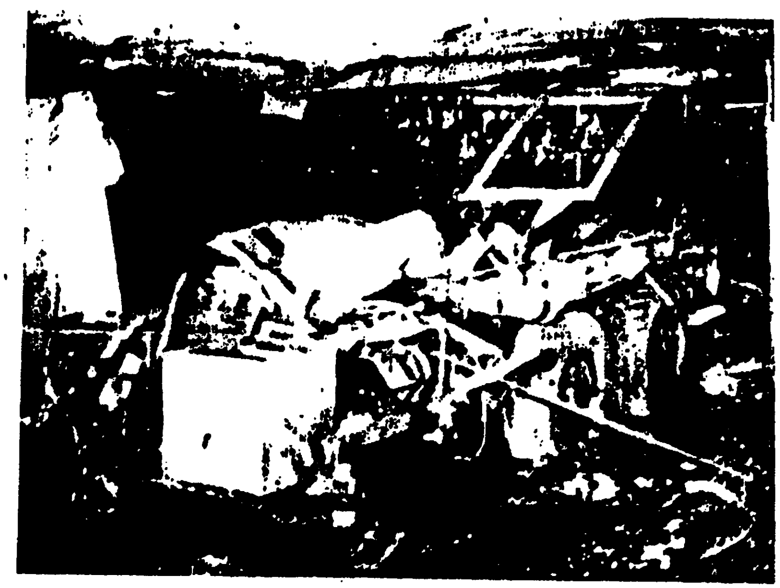


FIG. 24 ROOF BOLTER, NO. 2 ENTRY, 2 LEFT

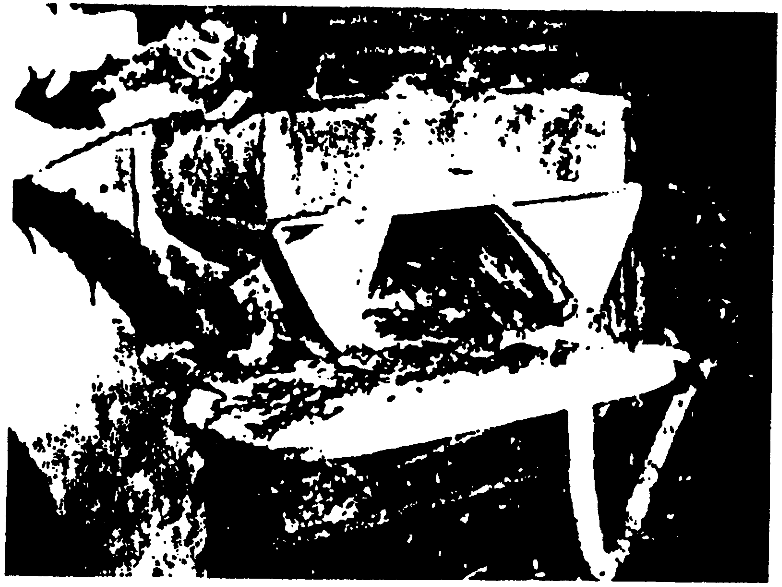


FIG. 25 DUST BOX ON ROOF BOLTER, NO. 2 ENTRY, 2 LEFT

FIG. 26 LOCOMOTIVES NOS. 6 AND 8

FIG. 27 OPERATING CONTROLS GOODMAN LOCOMOTIVE NO. 6

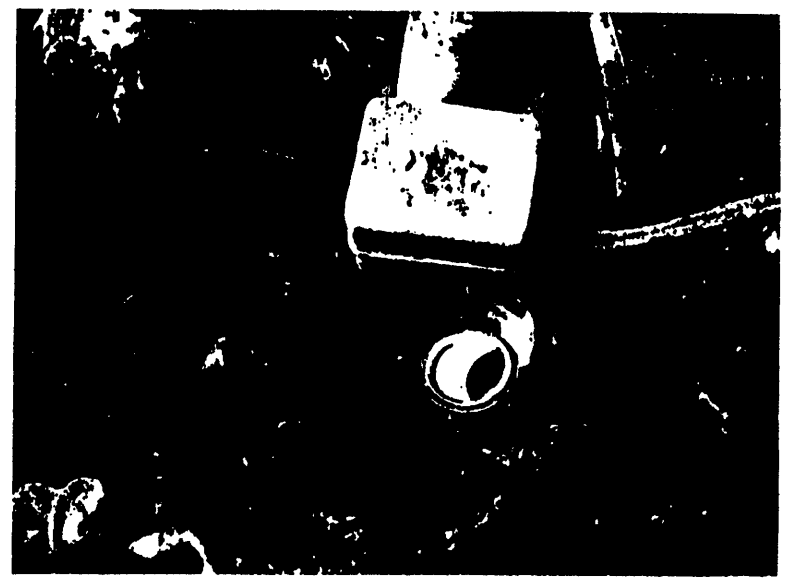


FIG. 28 COMPRESSOR CONTROL SWITCH, LOCOMOTIVE NO. 6

APPENDIX L

FIG. 29 DEBRIS BLOWN INTO LOCOMOTIVE NO. 6, CROSSCUT 31

FIG. 30 FUSE BOX, LOCOMOTIVE NO. 6

Appendix M-1

REPORTS OF SPECIAL TESTS
PART 1
VENTILATION

2 Southeast Main
Scotia Mine I.D. No. 15-02055

May 17-23, 1977

by

J. L. Banfield, Jr.[1/], R. A. Haney[2/],
S. M. Hoover[2/], and H. Schade[3/]

INTRODUCTION

From May 17-23, 1977, inclusive, four ventilation tests were conducted in the 2 Southeast Main (2SEM) section of the Scotia Mine. These tests were proposed by the committee investigating the Scotia disasters and the tests were performed by personnel from the Ventilation Branch, Pittsburgh Technical Support Center and Coal Mine Health and Safety Districts 3 and 6. A list of personnel who assisted in gathering the data is attached. The purpose of this study was to conduct the following tests:

1/ Engineer-in-charge, Ventilation Branch, Division of Health Technology, Pittsburgh Technical Support Center, Mining Enforcement and Safety Administration, U. S. Department of the Interior, Pittsburgh, Pa.
2/ Mining Engineer, same as above.
3/ Mining Engineering Technician, same as above.

1. Establish methane liberation rates in 2SEM and 2 Left off 2 Southeast Main (2LT-2SEM).

2. Control the return air quantity at the mouth of 2SEM to 15,000 cfm and measure methane concentrations and air quantities in the last open crosscuts of 2SEM and 2LT-2SEM with all of the available intake air ventilating the 2SEM faces before ventilating the 2LT-2SEM faces.

3. Control the return air quantity in the last open crosscut of 2LT-2SEM to approximately 11,000 cfm, open the airlock doors in crosscut 23, measure methane concentrations and air quantities in the 2SEM area, and evaluate the system.

4. Install two checks in entries 4 and 5 immediately inby 2LT-2SEM and measure methane concentrations in this area inby 2LT-2SEM for six hours.

TEST DESCRIPTION AND INSTRUMENTATION

Figure 1 shows the test site, the location of ventilation controls in the test area, the location of instrumentation, and the location of the sites chosen to determine methane liberation flow rates.

The methane liberation flow rate tests were designed to determine the liberation flow rates in 2SEM and 2LT-2SEM at the locations shown in Figure 1. These methane liberation flow rates were determined by measuring the necessary air quantities with chemical smoke clouds and methane concentrations by analyses of 250 ml vacuum air sample bottles at the MESA Gas Laboratory in Mount Hope, West Virginia.

The air velocity measurements needed to describe ventilation system performance were obtained with vane anemometers or chemical smoke clouds. Permissible battery-powered recording anemometers were also installed in the 2SEM regulator and in the last open crosscut 2LT-2SEM to indicate air velocity changes (figure 1). Three ventilation systems were tested. The first system tested was the system as shown on Figure 1. In the second test system, the airlock doors in crosscut 23 were opened; and in the third system, check curtains were installed in entries 4 and 5 between crosscuts 23 and 24. The test air quantity in 2SEM was controlled to the desired quantity by a regulator installed in the 2SEM return airway between crosscuts 2 and 3, Figure 1.

Methane concentrations were determined for these three ventilation systems with permissible, battery powered recording methane detectors. Three detectors were located in each of the five entries inby crosscut 23, 2SEM, and one methane detector was also located in the last open crosscut 2LT-2SEM. Bacharach Model CD800W[4/], 110 VAC powered recording methane detectors were installed in the intake air near the 2SEM overcast and in the return air at the 2SEM regulator. The location of all recording methane detectors are shown in Figure 1.

During the 95-hour methane test period, the area was inspected constantly and methane concentrations between recorder locations and in the 2SEM faces were measured with handheld methane detectors. The recording methane detectors were installed on the 7:00 a.m. - 3:00 p.m. shift, May 17, 1977, and removed on the 3:00 p.m. - 11:00 p.m. shift, May 22, 1977.

METHANE LIBERATION RATES - TEST 1

The total measured and balanced methane flow rate at each measuring location on the first and last day of the test is shown in Table 1. The average of two determinations is also provided.

Table 2 shows the balanced methane liberation rate at each location (figure 1) on May 17 and 23, 1977. These values represent the difference between the total methane quantities in the return airways and the total methane content in the intake airways. The methane liberation rate for the area of 2SEM inby 2LT-2SEM was approximately 5.7 cfm and the liberation rate for 2SEM was 10.7 cfm.

4/ Reference to specific brands, equipment, or trade names in this report is made to facilitate understanding and does not imply endorsement by Mining Enforcement and Safety Administration.

TABLE 1. - Methane liberation rates

Station	Location	Total Methane, cfm					
		Measured			Balanced		
		5/17	5/23	Average	5/17	5/23	Average
1-I	2SEM intake	1.8	1.3	1.55	2.1	2.3	2.20
2-I	2SEM intake outby 2 Left	3.3	3.2	3.15	3.2	3.0	3.10
3-I	2SEM intake inby 2 Left	3.9	2.9	3.40	4.5	3.4	3.95
4-I	2SEM return faces	5.6	4.7	5.15	6.0	5.3	5.65
4-R	2SEM return faces	6.6	6.5	6.55	7.6	7.2	7.40
3-R	2SEM return inby 2 Left	8.6	8.2	8.20	9.7	9.6	9.65
5-I	2LT-2SEM intake	11.5	9.7	10.60	10.2	9.8	10.00
6-I	2LT-2SEM intake faces	10.4	11.9	11.15	10.5	10.6	10.55
6-R	2LT-2SEM return faces	12.1	11.9	12.00	11.2	10.8	11.00
5-R	2LT-2SEM return	9.9	9.3	9.60	11.2	11.7	11.45
2-R	2SEM return outby 2 Left	12.8	14.4	13.60	11.9	12.1	12.00
1-R	2SEM return	14.4	13.2	13.70	13.0	12.4	12.70

TABLE 2. - Balanced methane liberation rates (cfm CH_4)

Station	Location	5/17	5/23	Average
1	2SEM	10.9	10.1	10.50
2	2SEM outby 2 Left	8.7	8.7	8.70
3	2SEM inby 2 Left	5.2	6.2	5.70
4	2SEM faces	1.6	1.9	1.75
5	2LT-2SEM	1.0	1.9	1.45
6	2 Left Faces	.7	.2	.45

AIR QUANTITIES AND METHANE CONCENTRATIONS - TEST 2

In Test 2, the return air quantity in 2SEM was reduced from about 34,000 to 15,000 cfm by adjusting the 2SEM regulator. The ventilation controls were maintained as shown in Figure 1.

The intake airflow was coursed to the 2SEM faces through entries 4 and 5, ventilated these faces and returned through entries 1, 2, and 3, 2SEM to 2LT-2SEM. At crosscut 23, this airflow was diverted into 2LT-2SEM to ventilate this area and then returned to 2SEM at crosscut 21. From this point, the airflow continued to the Northeast Main (NEM) return airways through 2SEM entries 1, 2, and 3. With an air quantity of approximately 15,000 cfm at the 2SEM return air regulator, the air quantity in the last open crosscut of 2SEM was 12,000 cfm and the methane concentration measured with a handheld methane detector was approximately 0.10 percent. In the last open crosscut of 2LT-2SEM, the measured air quantity was 15,000 cfm and the methane concentration measured with a handheld detector was 0.10 percent.

AIR QUANTITIES AND METHANE CONCENTRATIONS - TEST 3

In Test 3, there were two changes made in the 2SEM ventilation system. The airlock doors in crosscut 23 were opened, and the air quantity in the last open crosscut of 2LT-2SEM was reduced from approximately 15,000 to 11,000 cfm by adjusting the 2SEM regulator.

After the air quantity was reduced to 11,000 cfm, the pressure drop across the 2SEM return air regulator was 0.25 inches of water, and the pressure drop between the intake and return airways immediately inby the regulator was 0.02 inches of water.

The airlock doors were opened at 12:48 p.m. on May 18, 1977 and remained open until 12:00 p.m. on May 22, 1977. During this test, air measurements were made on each shift at the 2SEM intake overcasts, 2SEM return regulator airlock door (crosscut 23), last open crosscut, 2SEM, and last open crosscut 2LT-2SEM. The results of these measurements are shown in table 3.

TABLE 3. - Air quantity measurements during Test 3 May 18-22, 1977

	Range	Avg.
2SEM intake	14,200 - 16,500	15,100
2SEM return	11,700 - 13,200	12,700
Airlock door, No. 23 crosscut	9,800 - 11,100	10,100
Last open crosscut, 2SEM	1,100 - 1,800	1,600
Last open crosscut, 2LT-2SEM	11,000 - 12,600	11,800

Table 3 indicates that the measured air quantities in the last open crosscut of 2SEM ranged from about 11,000 to 12,600 cfm and the average airflow was approximately 11,800 cfm. The charts from the two recording anemometers indicate constant average air velocities with short-term fluctuations. These rapid fluctuations, varying approximately ±25 percent in 2LT-2SEM, are characteristic of turbulent airflow and lasted generally less than 30 seconds. The range of measured air quantities from the average of these measurements, ±8 percent, is typical of the expected accuracy of measurement in such airflows. In the last open crosscut, 2SEM, there was a small air quantity (average approximately 1600 cfm) ventilating the 2SEM area inby crosscut 23. The results of these air quantity measurements show that most of the intake air available at crosscut 23 went directly into the 2LT-2SEM intake airways and ventilated the 2LT-2SEM without ventilating the 2SEM faces.

A plot of methane concentration versus time for each recording methane detector location is shown in figures 2, 3, 4, and 5. The information on these figures shows that, generally, the methane concentrations at the test locations inby crosscut 23 increased for approximately 24 hours and then remained relatively constant until the conclusion of this phase of the test at 6:00 a.m. on May 22, 1977. The length of this test phase was approximately 89 hours. Table 4 shows the average equilibrium methane concentration at recording methane detectors located inby 2LT-2SEM.

TABLE 4. - Methane concentrations at recording methane detector locations inby crosscut 23 Tests 3 and 4

Entry	Average Equilibrium Methane Concentration			Final Methane Concentration with checks installed		
	A	B	C	A	B	C
1	.33	.31	.29	.39	---	.46
2	.25	.31	.27	.36	.37	.26
3	.31	.31	.27	.00	.35	.38
4	.08	.07	.11	.10	.28	.23
5	.05	.13	.75*	.15	.14	1.34*

*Location of methane layer

In patrolling the entries, higher methane concentrations were found in entry 5 between crosscuts 39 and 40 than at other locations in entry 5. The C5 recording methane detector was moved to this location on the second day of this test phase (figure 1). Methane concentrations at this location averaged about 0.75 percent and occasionally peaked at 0.90 percent. A methane layer was forming at this location. The layer extended approximately 12-18 inches down from the roof and the entire length of entry 5 between crosscuts 39 and 40. The methane concentration at this location was sensitive to air movement and fluctuated as personnel traveled near the detector location in this entry. Concentrations occasionally fell to less than 0.20 percent when personnel walked past the detector. With care and an extensible eight foot long probe, methane concentrations in cracks along the roof line could be detected in excess of 3 percent. Vacuum bottle air samples could not be taken to document these concentrations due to the layer's sensitivity to air movement.

Methane in trace amounts (less than 0.01 percent) was found in the intake air entering 2SEM. The methane concentration at the regulator in 2SEM returns ranged from 0.06 to 0.13 during this phase of the tests. The plot of methane concentration versus time for this location (figure 5) shows an initial rise from 0.06 to approximately 0.11 percent during the first 24 hours of this test phase and then the methane concentration remains relatively constant at approximately 0.12 percent until the conclusion of this test phase. The methane concentration in the last open crosscut of 2LT-2SEM ranged from 0.06 percent to 0.16 percent during this test phase (figure 5).

Just prior to the conclusion of this phase of the test, methane concentrations in the deadend 2SEM faces made by handheld methane detectors were (1) Entry 1, 1.00 percent; (2) Entry 2, 0.70 percent; (3) Entry 3, 0.70 percent; and (4) Entry 5, 1.00 percent.

AIR QUANTITIES AND METHANE CONCENTRATIONS - TEST 4

For Test 4, the only change in the ventilation system was to install checks in entries 4 and 5 between crosscuts 23 and 24, 2SEM. These checks were installed tight against roof, rib, and bottom. These checks were put in service at 6:00 a.m., May 22, 1977 and remained installed until 12:00 p.m., May 22, 1977.

The measured air quantity in the last open crosscut of 2LT-2SEM immediate before check installations was 11,200 cfm, and immediately after the check installations was 11,600 cfm. The charts from the recording anemometers indicate that the average velocity was relatively constant at that time. This information indicates that installation of these check curtains would not increase the air quantity in the last open crosscut of 2LT-2SEM. After these checks were installed, no discernable air movement was observed in the 2SEM area inby crosscut 23.

After the checks were installed, the methane concentration at most of the recording methane detectors inby crosscut 23 showed an increase (figures 2, 3, and 4). The data on figures 2, 3, and 4 does not indicate the methane concentrations had reached equilibrium in this area during the six hour test.

Table 4 shows the methane concentrations at recording methane detectors just before the checks were removed. The highest methane concentration was 1.34 percent at location C5. This was also the location of a methane roof layer. The maximum methane concentration at any other methane recorder station was 0.46 percent at location C1.

The concentrations at the deadend faces of 2SEM taken with handheld methane detectors just prior to the test conclusion were: Entry 1, 0.70 percent; Entry 2, 0.75 percent; Entry 3, 0.80 percent; and Entry 5, 1.40 percent. The methane concentrations in airflow in the last open crosscut of 2LT-2SEM was approximately 0.09 percent throughout this test phase, and the methane concentration in the airflow through the 2SEM regulator was also relatively constant at approximately 0.10 percent (figure 5).

When the checks were removed in entries 4 and 5 between crosscuts 23 and 24 and the airlock doors in crosscut 23 closed, the same air quantity (average 11,800 cfm) used throughout the methane tests was used to clear methane from the entries inby crosscut 23. Shortly after the airflow reached the faces of 2SEM, the methane concentration in these faces returned to concentrations present when the tests were started.

When the methane moved out of 2SEM, the methane concentration of the airflow in the last open crosscut of 2LT-2SEM increased to 0.35 percent and in the 2SEM regulator increased to 0.28 percent. The methane quantity that accumulated inby crosscut 23 during the test was determined by averaging short time increments on the recorder readout tapes, multiplying the time increment and air quantity and then subtracting a base liberation rate at each recorder. The results of the calculations indicate that approximately 7,000 cubic feet of methane accumulated in the area inby crosscut 23 during the test. The volume of the area inby crosscut 23 is approximately 1,400,000 cubic feet.

At approximately 4:00 p.m., May 22, 1977, the regulator installed in the 2SEM return airway to control airflow during the tests was removed. With the removal of the regulator, the ventilation system in 2SEM was the same as when the tests started.

CONCLUSIONS

Methane Liberation Rate - Test 1

The methane liberation rate during the tests was determined to be approximately 5.7 cfm for the area inby crosscut 23, 2SEM and approximately 10.5 cfm for the entire 2SEM area.

Air Quantities and Methane Concentrations - Test 2

With the existing ventilation system (figure 1), an air quantity of 15,000 cfm at the 2SEM regulator was sufficient to dilute present methane liberation rates in 2SEM to 0.10 percent.

Air Quantities and Methane Concentrations - Test 3

When the airlock doors in crosscut 23 were opened, most of the available intake air bypassed the 2SEM faces and went directly to the 2LT-2SEM faces through crosscut 23 and the 2 Left intake airways. The average air quantity in the last open crosscut of 2LT-2SEM during this 89 hour test was approximately 11,800 cfm and data collected by recording anemometers indicate this was a relatively constant air quantity. There was also a small airsplit (average - approximately 1,600 cfm) ventilating the 2SEM faces.

With this ventilation system, the analyses of data collected by recording methanometers (figures 2-4) indicate that the methane concentrations in the entries inby crosscut 23, 2SEM increased for 24 hours and then remained relatively constant for the remainder of the test (figures 2, 3, and 4). The highest average methane concentration found (table 4) was 0.75 percent in entry 5 between crosscut 39 and 40, and was the location of a roof layer extending approximately 12-18 inches below the roof line and the length of entry 5 between crosscuts 39 and 40 (table 4). The highest average methane concentration detected at any other location was 0.33 percent at location A1. The maximum methane concentrations measured with handheld methane detectors in the deadend faces of 2SEM just before the test conclusion was 1.00 percent in entries 1 and 5.

Air Quantities and Methane Concentrations - Test 4

With checks installed in entries 4 and 5 between crosscuts 39 and 40, 2SEM, no discernable air movement was observed in the area inby crosscut

23, 2SEM. The average measured air quantity (11,800 cfm) in the 2LT-2SEM last open crosscut was not significantly changed by the installation of checks in entries 4 and 5 immediately inby crosscut 23, 2SEM.

The methane concentrations in the area inby 2SEM crosscut 23 increased during this six hour test but did not appear to reach equilibrium (figures 2, 3, and 4). The maximum methane concentration during this test was 1.34 percent at location C5 which was also the location of a methane roof layer (table 4). The maximum methane concentration at the other recording methane detectors was 0.46 percent at location C1. In the deadend faces of 2SEM immediately before the test conclusion, the maximum methane concentration, measured with a handheld detector was 1.40 percent in entry 5. The results of calculations based on data collected by the methane recorders in the last open crosscut of 2LT-2SEM and 2SEM while the 2SEM area was being cleared of methane indicate that approximately 7,000 cubic feet of methane accumulated in the area inby crosscut 23, 2SEM, during the tests.

/s/ J. L. Banfield, Jr. /s/ S. M. Hoover

/s/ R. A. Haney /s/ H. Schade

Approved:

John W Stevenson

J. W. Stevenson, Chief,
Ventilation Branch

MESA Personnel Participating in Ventilation Test

James D. Michael	Coal Mine Safety Specialist
Ray Ross	Supervisory Mining Engineer
Douglas Fleming	Coal Mine Inspector
Joseph R. Tankersley	Coal Mine Inspector
Reed Kiser	Coal Mine Inspector
Robert Sturgill	Coal Mine Inspector
Raymond Strahin	Coal Mine Inspector
Arthur Cross	Coal Mine Inspector
Ely Smith	Coal Mine Inspector
Arlie A. Webb	Mining Engineering Technician
Ronnie J. Deaton	Mining Engineering Technician
Paul Componation	Supervisory Mine Technical Spec. (Ventilation)
Allen J. Grose	Coal Mine Inspector
Robert L. Fleming	Coal Mine Inspector
Carlos Smith	Coal Mine Inspector
James L. Banfield, Jr.	Mining Engineer
Robert A. Haney	Mining Engineer
Stanley M. Hoover	Mining Engineer
Herman Schade	Mining Engineering Technician
Joseph W. Nugent	Mining Engineering Technician (Student Assista
John E. Urosek	Student Trainee (Engineering)

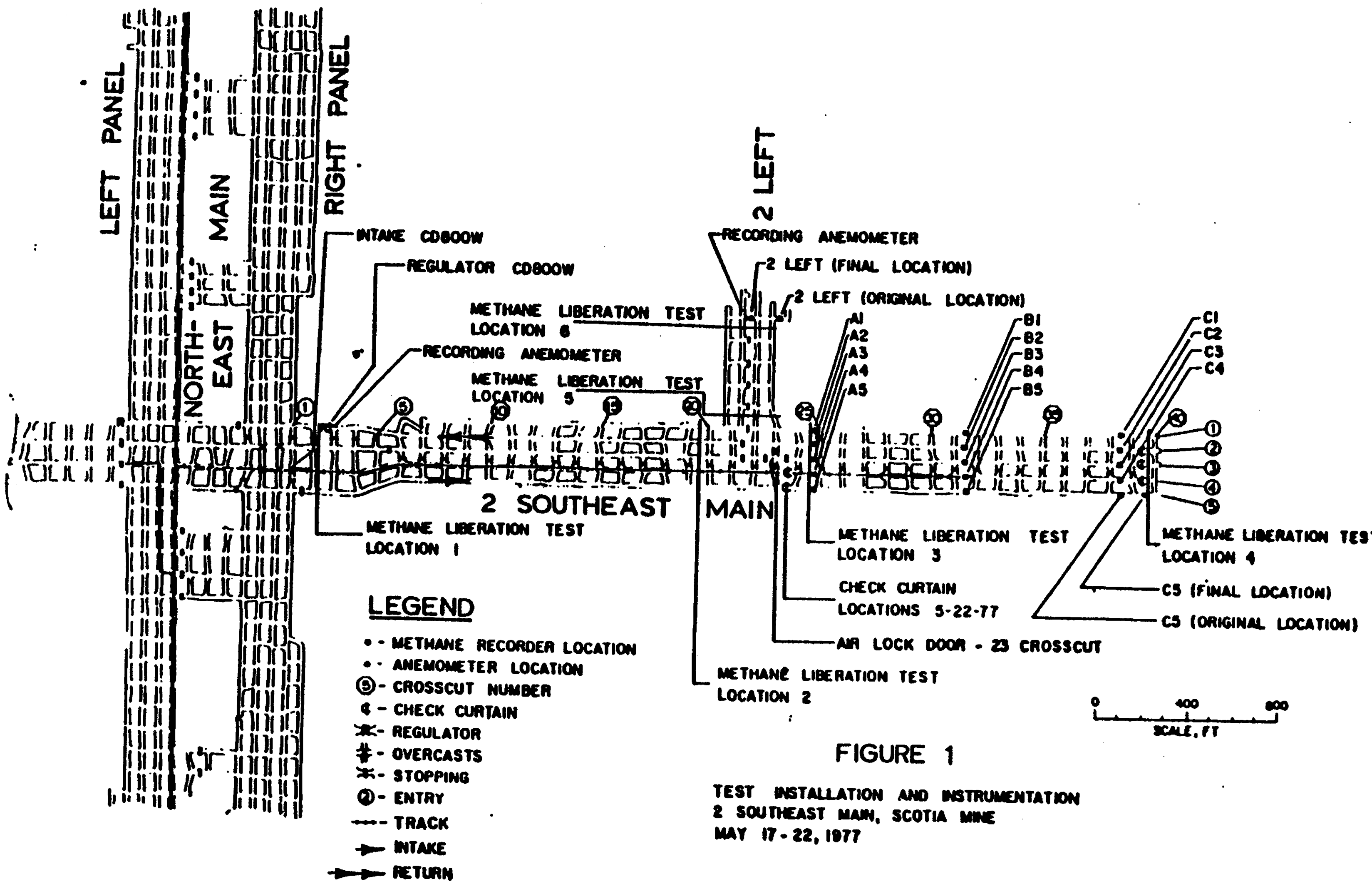


FIGURE 1

TEST INSTALLATION AND INSTRUMENTATION
2 SOUTHEAST MAIN, SCOTIA MINE
MAY 17 - 22, 1977

Appendix M-2

United States Department of the Interior

MINING ENFORCEMENT AND SAFETY ADMINISTRATION
4800 FORBES AVENUE
PITTSBURGH, PENNSYLVANIA 15213

JUN 27 1977

Memorandum

To: Acting Assistant Administrator--Coal Mine Health and Safety

Through: Assistant Administrator--Technical Support

From: Acting Chief, Approval and Certification Center

Subject: Evaluation of the ignition capabilities of a Wise Industries Deluge System consisting of two Globe Gel Cel batteries, GC680 (Item No. 73), a control box (Item No. 79), and a Gould Type M4 solenoid valve (Item No. 97), from the Scotia Mine investigation

The subject articles were received for evaluation by the Intrinsic Safety and Instrumentation Branch of the Electrical Division of the Mining Enforcement and Safety Administration Approval and Certification Center, on March 7, 1977.

Photographs were taken to show the condition of the deluge system components as received. A brief description of the features of each photograph follows:

Photographs	Description
H 98542-P	Exterior of the deluge system control box
H 98555-P	Interior of the deluge system control box
H 98544-P	Deluge system batteries, terminals were taped before these batteries were removed from the mine
H 98543-P	Deluge system water solenoid valve with #22 AWG steel wire used in spark tests
H 98549-P	Spark test apparatus contact arrangement

An initial visual examination was made of all components in an effort to locate any possible sources of thermal ignition. There was no evidence of excessive heat or burning of any particular component. A thick layer of dust blanketing all parts precluded any definite determination of ignition points based on a visual inspection. Similarly, a visual inspection gave no conclusive evidence of electrical shorting within the items.

An evaluation of the circuit diagram indicated that an incendive spark could be produced by an intermittent short on the heat sensor line or a break of the valve line. The heat sensor line is constantly energized but the valve coil line is only energized when the heat sensor line is shorted. This actuates a relay and delivers power to the solenoid valve line.

The deluge system was incapable of causing ignition when received because of the discharged state of the batteries.

When a comparison was made between the circuit diagram and the components of the box, a diode, which was not shown on the schematic diagram, was found to be connected across the actuating relay contacts.

Therefore, the conditions required for an ignition to occur as a result of a fault on the sensor line are:

1. The suppression diode would have to fail in the open condition (the diode had not shorted).

2. There would have to be an intermittent short on the line.

3. The short would have to be in the presence of an explosive atmosphere.

4. The batteries would have to be charged.

An intermittent short on the heat sensor line was tested by shorting pairs of wire contacts in an 8.0 to 8.6 percent methane-air mixture. The batteries were charged before these tests since they were discharged when received. The test results are summarized below:

Test	Sparking Contacts	Sparks	Ignition	Remarks
1	#30 AWG, Copper	1	Yes	Without Diode
2	#30 AWG Copper	2	Yes	Without Diode
3	#22 AWG Steel	3	Yes	Without Diode
4	#30 AWG Copper	84	Yes	Without Diode
5	#30 AWG Copper	8	Yes	Without Diode
6	#22 AWG Steel	10	Yes	Without Diode
7	#30 AWG Tungsten with cadmium disk	6000	No	With Diode

These tests show that this diode would prevent an incendive spark on the sensor line or at the test switch. If the diode had failed in an open condition, then an intermittent short on the sensor line could produce an incendive spark. One of the diode leads came off when it was bumped while the circuit was being compared to the schematic diagram. This made it impossible to tell whether the diode had been making suitable electrical contact with the rest of the circuit at the time of the explosion.

Test No. 7 was conducted by reconnecting the diode lead which was disconnected during the circuit comparison.

For ignition as a result of a break on the solenoid valve line, the following conditions are needed:

1. The sensor line would have to be shorted or the test switch or heat sensor would have to be closed.

2. There would have to be a break or intermittent short on the valve line.

3. The break or short would have to occur in the presence of gas and before the batteries became discharged.

An intermittent short on the solenoid line after it was energized was tested by reconstructing the solenoid line circuit while using No. 22 AWG steel wires as the sparking contacts. The test results are summarized below:

Test	Inductance in Circuit	Sparks	Ignition
1	Solenoid valve	2	Yes
2	Solenoid valve	2	Yes
3	Solenoid valve	1	Yes
4	Belt Drive Relay Coil	4	Yes
5	Belt Drive Relay Coil	4	Yes

These tests show that an incendive spark could occur if this line was broken while energized. According to the battery capacity and resistance measurements of the components on the solenoid line, the line would contain a hazardous amount of energy for a maximum of about three hours if the sensor line were continuously shorted. That is, an incendive spark could occur during that time span if the line were broken.

Since the deluge system warning alarm was not submitted for testing, it was excluded from the evaluation.

Frank R. Lee for
Donald W. Mitchell

Appendix M-3

United States Department of the Interior

MINING ENFORCEMENT AND SAFETY ADMINISTRATION
4800 FORBES AVENUE
PITTSBURGH, PENNSYLVANIA 15213

JUN 27 1977

Memorandum

To: Acting Assistant Administrator--Coal Mine Health and Safety

Through: Assistant Administrator--Technical Support

From: ActChief, Approval and Certification Center

Subject: Evaluation of the ignition capabilities of three MSA Page Phones (Item Nos. 74, 75, and 78) from the Scotia Mine investigation. Item No. 74 bore an approval plate, Approval No. 9B-8

The subject articles were received for evaluation by the Intrinsic Safety and Instrumentation Branch of the Electrical Division of the Mining Enforcement and Safety Administration Approval and Certification Center on March 7, 1977.

Photographs were taken to show the external and internal condition of Items 74 and 75. Since Item 78 was received in two parts, no photograph of the phone exterior was taken. A brief description of the features of each photograph follows:

Photograph	Description
H 98546-P	Exterior of Item 74 with page switch toggle showing.
H 98556-P	Interior of Item 74 showing that the page switch body was separated from the toggle.
H 98550-P	Item 74 with components moved to show broken page switch.
H 98547-P	Exterior of Item 75, note absence of page switch toggle.
H 98554-P	Interior of Item 75.
H 98551-P	Interior of Item 75 with transformer panel removed to show page switch which was found to be electrically open.
H 98545-P	Interior of Item 78

Photograph	Description
H 98552-P	Interior of Item 78 with transformer panel removed to show broken page switch.
H 98549-P	Spark test apparatus contact arrangement.

An initial visual examination was made of all components in an effort to locate any possible sources of thermal ignition. There was no evidence of excessive heat or burning of any particular component. A thick layer of dust blanketing all parts precluded any definite determination of ignition points based on a visual inspection. Similarly, a visual inspection gave no conclusive evidence of electrical shorting within the items.

An examination of the pager wiring diagram revealed that an ignition could occur under the following conditions:

1. The batteries must have some remaining capacity.

2. The page switch has to be switched to the page position.

3. There has to be an intermittent short on the page line.

4. There must be an explosive concentration of gas in the vicinity of the short.

Ignition was not possible with the phones as received since the page switches on all the phones had failed in an electrically open condition. This prevented the application of any voltage to the page line.

To simulate the above conditions to perform spark tests, the page switches were shorted as if permanently held in the page position.

The spark tests on the page line were conducted as follows:

1. Strands of No. 30 AWG copper wire were removed from the actual page line.

2. Single strands of this wire were made to scrape across each other to create sparks.

3. The chamber containing these wires was filled with a test gas of 8.0 to 8.6 percent methane-in-air at atmospheric pressure.

4. The paging circuits of each of the phones were reconstructed and the page line was connected to the sparking contacts.

5. The page switches were shorted as if permanently held in the page position.

6. The first test was performed using the partially charged batteries from Item 74, as received. No tests were made with the original batteries of Items 75 and 78 since these batteries were discharged when received. New fully charged batteries were used in tests two through seven.

The results of these tests are summarized below:

Test	Item	Sparks	Ignition	Remarks
1	74	750	No	Original batteries
2	74	1	Yes	New batteries
3	74	1	Yes	New batteries
4	75	1	Yes	New batteries
5	75	1	Yes	New batteries
6	78	1	Yes	New batteries
7	78	1	Yes	New batteries

Additional tests were conducted to determine if a hazardous amount of energy might have been present on the phone line at any time other than during paging. The page phones submitted for test were not operational, therefore an identical phone was obtained and connected to the sparking contacts described above. No ignitions occurred when talking into the phone or when the press-to-talk switch was repeatedly operated. Approximately 1000 breaks of the page line were conducted.

A third series of tests was conducted with a continuous short on the page line. In this case, a spark would occur at the page switch when it is thrown.

Only the switch from Item No. 75 contained both contacts. Therefore this was the only switch tested. Since the other switches were identical, this test is valid for each of the phones.

The test was conducted by reconstructing the paging circuit using the paging coil from Item 75 and manually operating the switch in the presence of the same test gas mixture as above. The test gas was directed to flow directly onto the sparking switch contacts. Over 2000 sparks were produced and no ignition of the test gas occurred.

The only other possible source of an incendive spark in the page phones would be a shorting of the battery leads. These wires were well insulated, and firmly connected to a terminal strip. There was no evidence of a short occurring on these wires.

Frank R. Lee for
Donald W. Mitchell

Appendix M-4

United States Department of the Interior

MINING ENFORCEMENT AND SAFETY ADMINISTRATION
4800 FORBES AVENUE
PITTSBURGH, PENNSYLVANIA 15213

July 8, 1977

Memorandum

To: James D. Michael, Coal Mine Safety Specialist, Coal Mine Health and Safety, Arlington, Virginia

From: Chief, Industrial Safety Branch, Division of Safety Technology, Pittsburgh Technical Support Center
Chemical Engineer, Industrial Safety Branch, Division of Safety Technology, Pittsburgh Technical Support Center

Subject: Potential gas ignition source in Scotia Mine Explosion - simulated rock fall on roof bolter

Introduction

During post-explosion investigations in the Scotia Mine, a large slab of rock was found on the top surface of a roof bolter in No. 2 Entry of No. 2 Left Panel off 2 Southeast Mains as shown in Figure 2. It was speculated that this rock may have generated sufficient frictional heat energy during its fall to ignite an explosive methane-air mixture. Evidence collected and observed during the investigation indicated that the second explosion may have originated in the No. 2 Left Panel.

Test Procedure

At a meeting of the Scotia investigating teams and Coal Mine Health and Safety officials at the MESA Academy on March 16, 1977, it was decided that tests be conducted on the roof bolter to determine the potential of frictional gas ignitions. The roof bolter, rock slab and miscellaneous materials were transported to the Mine Simulation Complex at the Bruceton Station on May 24, 1977. The bolter was positioned in the modified gas ignition chamber for the proposed drop tests. A 1200 cubic-foot segment of the gallery, (20' long, 10' wide, 6' high) was partioned off for the tests. Over 100 square feet of vent opening was covered with polyethylene film to confine the gas-air mixture in the chamber and provide relief from explosion pressures. In all tests the chamber contained approximately 7 percent methane. Experimental data has shown that this concentration requires the least amount of energy for ignition. Homogeneity of the mixture was attained by fan circulation with continuous sampling and analysis at three separate locations by infrared devices.

The general size and shape of the rock is shown in Figure 1. The rock appeared to be of a gray fine-grained composition and strongly resembled shale. By water displacement techniques the rock density approximated 168 pounds per cubic foot and weighed between 800 and 900 pounds. It was drilled and fitted with an eyebolt anchored with roof-bolt resin, also shown in Figure 1. The eyebolt was anchored at the approximate center of gravity of the rock. After orientation of the rock with the bolter canopy framing, according to the schematic diagram provided by Gary Perry, Coal Mine Inspector (Figure 2), a 3-inch conduit with flange was installed in the chamber roof. A one quarter-inch steel cable was fastened to the eyebolt, threaded up through the conduit to a hydraulic release mechanism which was attached to the boom of an 8-ton crane. This arrangement, along with continuous monitoring of the methane-air mixture, enabled repeated drops of the rock in the same gas body without purging between successive tests. A color TV camera arrangement was set up to monitor and record all tests on video tape for subsequent viewing and general review.

Test Results and Conclusions

Figure 2 shows the original and final location of the rock with respect to the position of the roof bolter. Prior to the five initial drop tests, the bolter was stripped of roof bolts, roof bolt plates, roof jacks and drill steel. No ignitions occurred in this series of tests nor were sparks observed. Breaking of the rock at the outer edges reduced its size by about 40 percent. The second series of 5 drops were made with the above hardware positioned beneath the rock. Again, no ignitions nor sparking occurred and the rock was completely broken up which precluded additional drop tests. After each series of 5 drops, the methane-air mixture within the chamber was ignited with a remotely actuated electric match to verify the presence of an explosive mixture.

Table 1 gives the results of both series of drop tests. Although ignitions in this manner were not obtained, the evidence is not conlcusive. Previous experimental studies indicate that mechanical energy produced between contact of sliding or impacting surfaces must be concentrated in a small enough area such that when converted to heat energy, sufficient temperatures are attained to cause ignition.[1] Other studies have shown that ignitioas were obtained by rubbing friction between shale and roof bolt steel surfaccs.[2]

Edward M. Kawenski

Edward M. Kawenski

Steven J. Luzik

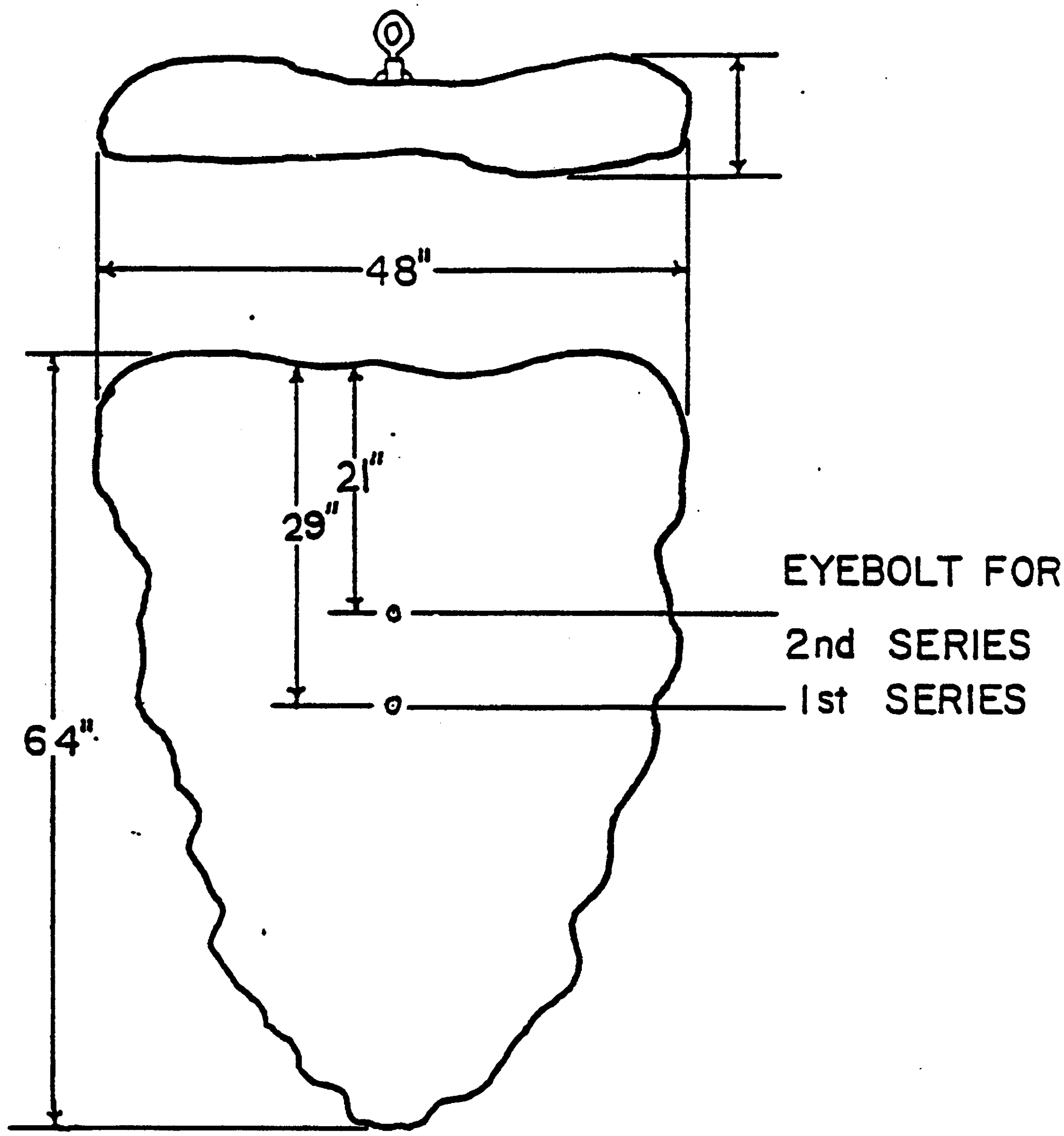
Steven J. Luzik

[1]Burgess, J. J., R. V. Wheeler. Ignition of Firedamp by the Heat of Impact of Rocks, SMRE Paper No. 46, 1928

[2]Nagy, John, E. M. Kawenski. Frictional Ignition of Gas During a Roof Fall, U. S. Bureau of Mines Report of Investigatons 5548, 1960

Enclosures

SHALE ROCK DETAILS



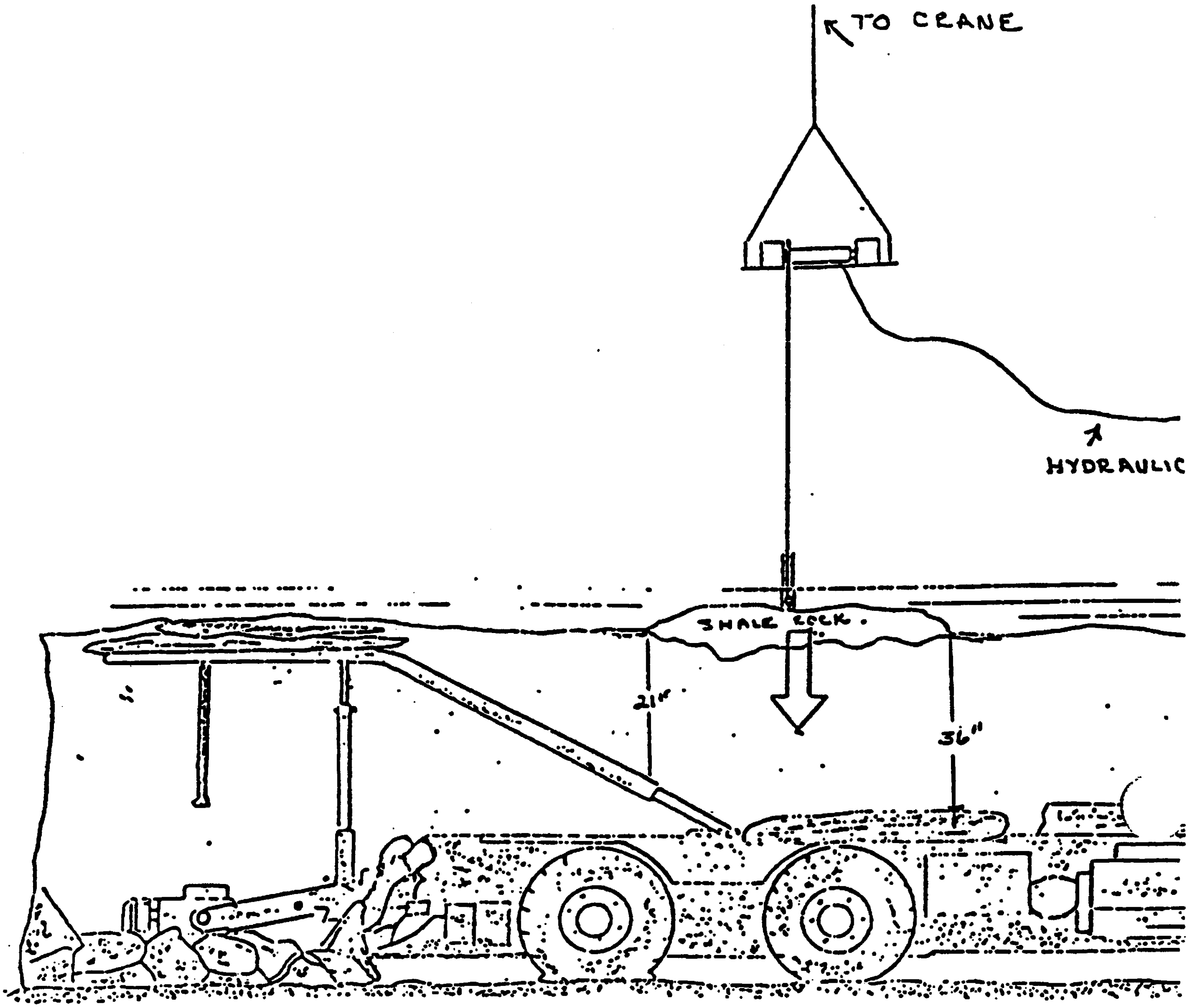
AVG. THICKNESS ≅ 6"

DENSITY ≅ 168 lb/ft^3

WT. ≅ 800-900 lbs

FIGURE 1

SCALE 3/4" = 1'



ORIENTATION OF ROCK AND ROOF BOLT

Figure 2

TABLE 1. - Results of Shale Rock Drop Tests

Series 1 — Date: 6/08/77 — Temp. 65° F — R.H.=35%

TEST	PERCENT CH_4	COMMENTS
1	7.2	no ignition
2	7.1	no ignition
3	7.1	no ignition
4	7.0	no ignition
5	6.9	no ignition
6	6.9	ignition with match head

Series 2 — Date: 6/14/77 — Temp. 75° F — R.H.=75%

TEST	PERCENT CH_4	COMMENTS
1	7.1	no ignition
2	7.1	no ignition
3	7.1	no ignition
4	7.1	no ignition
5	7.1	no ignition
6	7.1	ignition with match head

Appendix M-5

United States Department of the Interior

MINING ENFORCEMENT AND SAFETY ADMINISTRATION
4800 FORBES AVENUE
PITTSBURGH, PENNSYLVANIA 15213

JUL 21 1977

Memorandum

To: Acting Assistant Administrator--Coal Mine Health and Safety

Through: Assistant Administrator—Technical Support

From: Chief, Approval and Certification Center

Subject: Evaluation of the ignition capabilities of a DC motor used to drive an air compressor and a pressure switch, UL tag number A163 from the Scotia Mine investigation

The subject articles were received for evaluation by the Electrical Testing Group, Division of Electrical Equipment of the Approval and Certification Center on May 31, 1977

Two sets of photographs were taken to show the components as received and as set up for testing in the explosion-test chamber. Brief descriptions of the features of each photograph are as follows:

Photograph	Description
H-98574-P	Cable entry side of Scotia motor with pressure switch
H-98573-P	Pulley end of Scotia motor with Furnas Electric, Catalog 69HA2 Pressure Switch
H-98575-P	Side opposite cable entry, Scotia motor
H-98576-P	Commutator end, Scotia motor
H-98640-P	Scotia motor rigged for explosion tests while driving General Electric motor Model 5BT2376C16
H-98642-P	Scotia motor coupled to General Electric motor in gallery for explosion test

Photograph	Description
H-98644-P	Scotia motor coupled to General Electric motor in gallery
H-98641-P	Scotia motor, General Electric motor, pressure switch after gallery explosion
H-98645-P	Rear of gallery (raised) with paper heads ruptured as a result of explosion

The Scotia motor and pressure switch as received at the Approval and Certification Center laboratory were determined upon visual inspection not to meet the design and construction requirements of 30 CFR, Part 18. The motor had clear openings at the commutator end and at the wiring entry, and a generally dirty and much used appearance. The wiring was frayed and marginally serviceable. The pressure switch also showed evidence of much use and had the same frayed wiring condition as the motor. There was no visual evidence that the components were involved in an explosion in that there were no signs of excessive heat or burning.

On June 6, 1977, Thomas E. Scholl, Electrical Engineer, was assigned by Robert E. Marshall, Chief, Division of Electrical Equipment, Approval and Certification Center, Pittsburgh, Pennsylvania, to conduct tests on a motor and pressure switch removed from the Scotia Mine. Assisted by W. F. Radi, Jr., and W. H. Gilbert, Laboratory Technicians, Electrical Division, Approval and Certification Center, test procedures were determined. The purpose of the tests were to determine whether or not the Scotia motor would ignite an explosive mixture of methane in air.

The Scotia motor has no identifying markings, but from observation and information from R. L. Reynolds, Chief, Mine Electrical Systems Group, Pittsburgh Technical Support Center, it was concluded that the motor was a compound wound DC motor, 1-HP, 96-volts, used to drive an air compressor (not furnished for tests). The motor was an open type and, obviously, not Mining Enforcement and Safety Administration certified as explosion-proof.

The pressure switch used as a control was a Furnas Electric Company, Batavia, Illinois, Catalog 69HA2 Switch rated 2-HP, 115-230 volt, DC. It had a UL tag number A163. The switch was housed in a case constructed of 1/32" thick steel sheet, had two clear openings to the outside where the wiring entered, and, obviously, was not MESA certified.

The first series of tests were made with no load on the motor and wired per Figure 1. The gallery was charged with an 8.6% methane-mixture and the motor was started and stopped four times. The running times were 2, 1-1/2, 1/2, and 2-1/4 minutes. The current was 2.4 amps, 96 volts, DC with an in-rush current of 30 amps. No arcing was observed at the brushes and no ignition occurred. On the basis of the results of the first series of tests, it was proposed that the motor should be loaded to better simulate actual mine operating conditions. A second series of tests with the motor loaded was begun.

The second series of tests wired per Figure 2, included a General Electric motor, series wound, 20-HP, Model 5BT2376C16. This motor had successfully passed MESA explosion test requirements and was in the process of being certified. General Electric's permission was requested and granted to use the motor for our tests. The General Electric motor was coupled to the Scotia motor and the inertia load at the rotor of the General Electric motor increased the load on the Scotia motor to 7.5 amps at 96 volts DC. No electrical energy was applied to the General Electric motor. Four start-stop tests in an 8.6% methane-air mixture were conducted under the above conditions and no ignition occurred.

In an effort to increase the load, a third series of tests wired per Figure 3, was begun with the field of the General Electric motor energized with a General Electric FWL-520-54-5 motor-generator buck boost set in series with a 1-ohm, 500 watt resistor (ohmite No. 0650). The General Electric motor with its field energized was now acting as a generator. The load current increased to 10-amps, 96-volts, DC. Four start-stop tests in an 8.6% methane-air mixture were conducted and no ignitions occurred. It was suggested that the 1-ohm resistor used to measure current in series with the Scotia motor power leads was limiting the in-rush current. This resistor was then shorted out and four more tests in an 8.6% methane mixture were made. The in-rush current increased from 30 amperes to approximately 37 amperes, however, no ignition occurred. The 1-ohm resistor was removed and a DC ammeter was installed to measure the Scotia motor current. Additional tests with the ammeter in the circuit failed to cause an ignition. Present for the second series of tests were: R. L. Reynolds, Mine Electrical Systems, Pittsburgh Technical Support; R. E. Marshall, Chief, Division of Electrical Equipment, Approval and Certification Center; C. Lester, Coal Mine Safety Specialist; F. R. Lee, Staff Engineer, Approval and Certification Center; T. E. Scholl, Electrical Engineer, Approval and Certification Center; W. H. Savatt, W. F. Radi, W. H. Gilbert, Engineering Technicians, Division of Electrical Equipment, Approval and Certification Center. All witnesses were MESA personnel.

Rather than radically overload the Scotia motor to attempt an ignition, it was decided that adding the pressure switch to the set-up would be a more likely source of ignition.

The pressure switch was added per Figure 4. During dry run tests arcing was easily detected at the contacts of the pressure switch when opened under load. Although an ignition was readily predictable, a test in a 7% methane-air mixture was made and an ignition occurred on the first energization of the motor. No further tests were made. Considering the obvious arcing the Scotia motor current was reduced to 7.5 amps at 90 volts DC for the above test.

Donald W. Mitchell

Enclosures

First Series

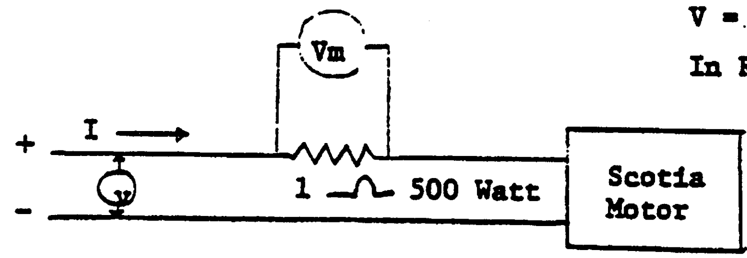
Figure 1

RPM = 2250

I = 2.4 Amps

V = 96 Volts

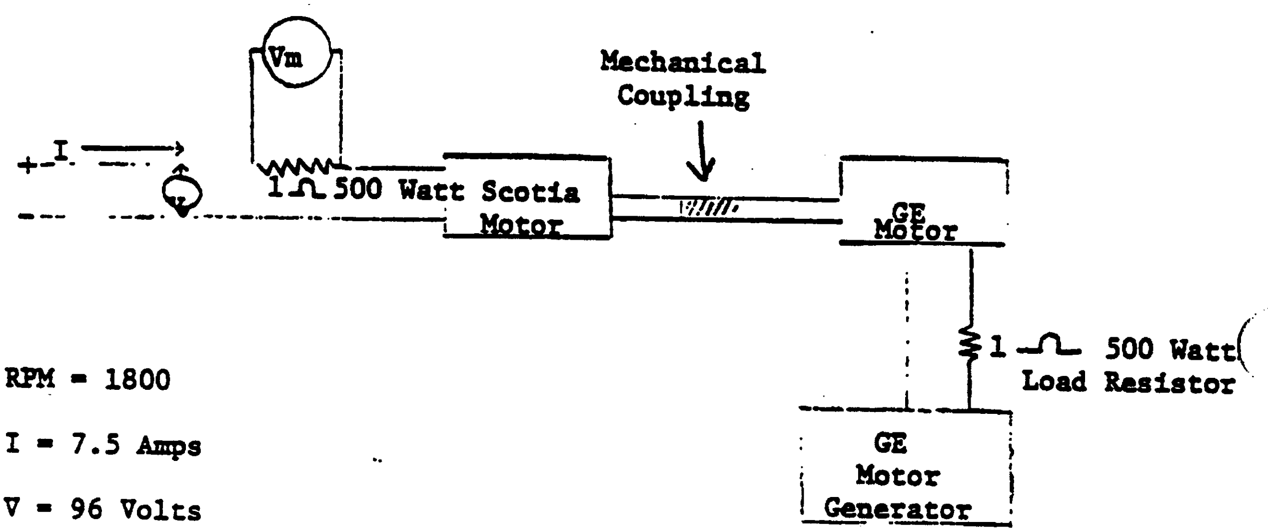
In Rush = 30 Amps



Vm - used to measure current

Scotia Motor - No Nameplate
Determined to be Compound Wound
1-HP, 96 Volts, D.C.

Second Series
Figure 2



RPM = 1800

I = 7.5 Amps

V = 96 Volts

In Rush = 30 Amps

In Rush = 37 Amps with Vm short circuited

Scotia Motor - See Figure 1

General Electric Motor - Series Wound

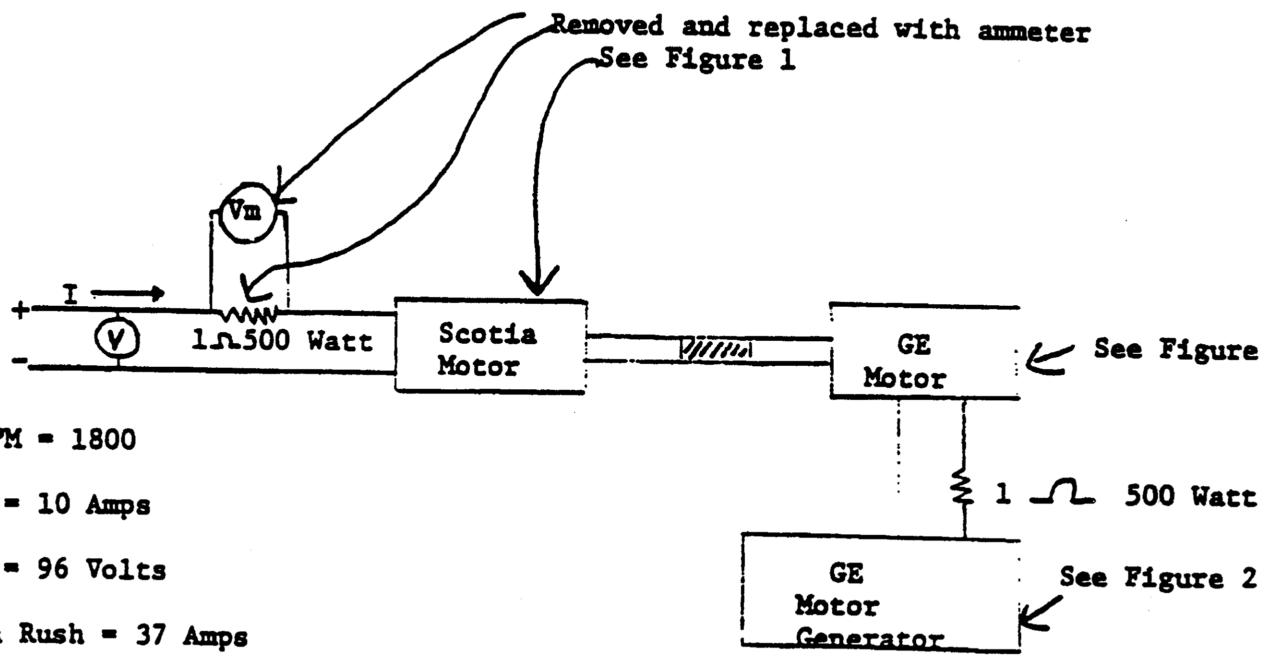
20 HP, Model 5BT2376C16

Load Resistor - Ohmite No. 0650

Note - Motor Generator not energized.

Third Series

Figure 3



RPM = 1800

I = 10 Amps

V = 96 Volts

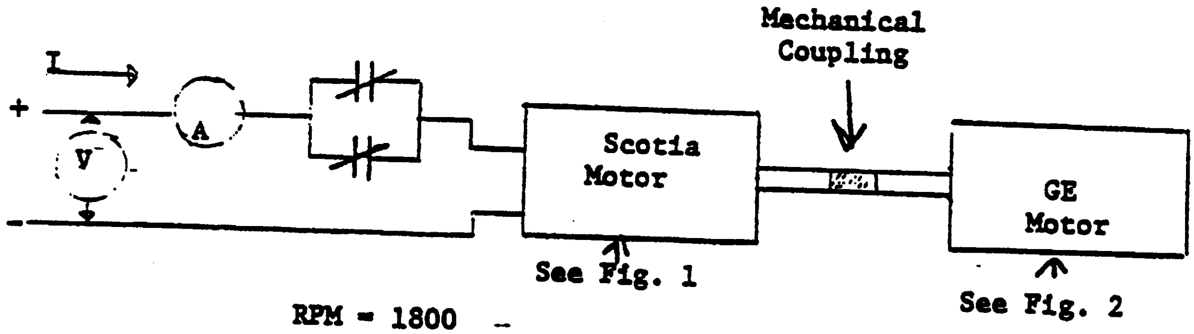
In Rush = 37 Amps

GE Motor 20-Amps, 6.5 Volts (Generator Action)

Fourth Series

Figure 4

Pressure Switch
130 PSI to Open



RPM = 1800

I = 7.5 Amperes

V = 90 Volts D.C.

Gallery ignited (7% mixture) from spark at pressure switch upon opening contacts under load

Pressure Switch - Furnas Electric Co., Batavia, Illinois, Catalog 69HA2, rated 2 HP-115-230-volts D.C.

COMPANY NAME Scotia Coal Company
MINE NAME/NO. Scotia
LOCATION Ovenfork, Letcher County
MINE I.D. NO. 15-02055

DATE 4-13-76

TESTING OF HIGH VOLTAGE CIRCUIT BREAKERS

Transformers - MFG Westinghouse KVA Three 1250 KVA Units

Connections - Primary Delta Secondary WYE
Voltage - Primary 12,470 Secondary 7200 Y/4160

All frames in enclosure grounded to: Power Company
4th wire no Ground Field yes
Note: Resistance of field wasn't checked.

Circuit breaker - MFG General Electric Oil Blast Circuit Breaker Type or Model FKD - 14.4 - 250 - 3
Continuous Rating 600 Amps Interupting Rating 10,000 Amps at 14,400 volts

Overcurrent relays - MFG General Electric Type IAC, Over-current - 12IAC51B101A Ground - 12IAC53A3A

Tap setting as found (a) Tap 8 (b) Tap 8 (c) none
As left (a) same (b) same (c) --
C.T. Ratio 40:1

Long Time Delay
Current (a) (b) (c)
Time (a) (b) (c)

Short Time Delay
Current (a) 960 amps (b) 960 amps (c)
Time (a) 1 sec. (b) 1 sec. (c)

Instantaneous
Current 1200 amps
Time less than one second

Type of ground fault protection. current transformer
Residual Direct GE - type JKW - 4
Balanced flux Potential
C. T. Ratio 40:5 Pt. ratio

Ground resistor - MFG Ensign Rating 25 amps

Fail Safe ground check monitor
MFG Ensign

Maximum allowable ohms to trip 4 ohms
Actual ohms to trip 2.2 ohms
Under voltage - % to trip 57%
Ground field resistance 5 ohms

REMARKS Ground Trip Relay

Tap setting - 2.0 Pickup - (2.0) x (40.5) = 16 amps

Time dial setting - 2.5

Note: Relay tripped breaker in 62.5 seconds at pickup.

Relay tripped breaker in 7.0 seconds at 25 amps.

At the request of the company no adjustments were made to the electrical equipment tested.

The resistance of the station ground field was not measured due to the possibility of causing electrical potentials on the borehole casing which extends into the possibly explosive mine atmosphere.

SIGNATURE

EMCO Belt Power Center Data

Location -- 180 crosscut
Manufacturer -- EMCO
Serial No. -- 503-300P-1
300 KVA
Transformer Connections -- ΔY, resistance grounded secondary. Ohmic value of grounding resistor -- 19.5 ohms.
Primary Fuses -- 50 amp oil fused cutouts
High-Voltage Monitor Circuit -- Feedthrough from previous circuit, looped externally

High-Voltage Couplers
- a. Feedthrough: Yes ___X___ No ______
- b. Incoming: Connected ___X___ Disconnected ______
- c. Outgoing: Connected ___X___ Disconnected ______

Frame grounded to track: Yes ______ No ___X___

Couplers, Low-Voltage
- Ckt. #1. Belt Drive 1: Connected _X_ Disconnected ______
- Ckt. #2. Belt Drive 2: Connected _X_ Disconnected ______
- Ckt. #3. Spare (Pump): Connected ____ Disconnected ___X___

Monitors, Low-Voltage
- Ckt. #1. Manufacturer -- EMCO (autotransformer added)
  Ohms to Trip -- 2.2 ohms
- Ckt. #2. Manufacturer -- EMCO
  Ohms to Trip -- Would not trip with 55 ohms inserted in pilot.
  Would trip when pilot was opened.
- Ckt. #3. Manufacturer -- EMCO
  Ohms to Trip -- Would not trip with 55 ohms inserted in pilot.
  Would trip when pilot was opened.

Low-Voltage Molded Case Circuit Breakers
- Ckt. #1. Manufacturer -- General Electric
  Catalog # -- TJK-436F000
  Undervoltage Release: Yes ___X___ No ______
  - a. Nominal Voltage -- 120 volts
  - b. Dropout Voltage -- 60 volts
  - c. Percent Nominal -- 50 percent

  Instantaneous Setting -- (1200 - 4000 range) set on 4000
- Ckt. #2. Manufacturer -- General Electric
  Catalog # -- TFK-236T225
  Undervoltage Release: Yes ___X___ No ______
  - a. Nominal Voltage -- 120 volts

b. Dropout Voltage -- N/A (UV tripping mechanism was inoperative)

c. Percent Nominal -- N/A (UV tripping mechanism was inoperative)

Instantaneous Setting -- (1000 - 2250 range) set on 2250

Ckt. #3. Manufacturer -- General Electric

Catalog # -- TEK-236T225

Undervoltage Release: Yes ____X____ No __________

a. Nominal Voltage -- 120 volts

b. Dropout Voltage -- Not recorded

c. Percent Nominal -- Not recorded

Instantaneous Setting -- (1000 - 2250 range) set on 2250

Ground Fault Protection

Ckt. #1. Relay operated at 3.9 amps

Ckt. #2. Relay operated at 3.5 amps

Ckt. #3. Relay operated at 6.2 amps

Ralph L [signature]

Jaron U. Jones

Y-BOX DATA

Y-Box Location	Manufacturer	Ser. #	Circuit Destination		Overcurrent Protection		Ground Fault Protection				Ground Fault Relay Operating Time @ 25 amps, Primary Injection		UV or Shunt Trip
			CKT. 1	CKT. 2	CKT. 1	CKT. 2	CKT. 1 Mfg	CKT. 1 Type	CKT. 2 Mfg	CKT. 2 Type	Circuit 1	Circuit 2	
56 crosscut	Ensign	120	1 West	Y-Box at Mouth of 2 East	* Relays @ 200 amps	Relays @ 200 amps	Westinghouse	1811251	Westinghouse	1811251	* Instantaneous Only Pickup - 7 amps	Instantaneous Only Pickup - 6.3 amps	* Shunt Trip
84 crosscut	Line Power	677	Y-Box at 150 cc	2 East Belt Trans-formers	Fuses 7.2 kv 160 amp Hub-bell CLF's	Fuses 7.2 kv 160 amp Hub-bell CLF's	Westinghouse	CO-11	Westinghouse	CO-11	.19 seconds tap - .5 time dial - .5	.12 seconds tap - .5 time dial - .5	UV Trip
150 crosscut	Line Power	676	Y-Box at 182 cc	South-east Mains	Fuses 7.2 kv 160 amp Hub-bell CLF's	Fuses 7.2 kv 160 amp Hub-bell CLF's	Westinghouse	CO-11	Westinghouse	CO-11	.83 seconds tap - .8 time dial - 1.5	.43 seconds tap - .5 time dial - 1.5	UV Trip
182 crosscut	Ensign	M-1157	North-east Mains	2 South-east	Fuses 7.2 kv 200 amp Hub-bell CLF's	Fuses 7.2 kv 200 amp Hub-bell CLF's	Westinghouse	CO-11	Westinghouse	CO-11	.78 seconds tap - .5 time dial - 1.5	.73 seconds tap - .5 time dial - 1.5	UV Trip

* OCB shunt trip mechanism was inoperative

Appendix M-9

MINE ELECTRICAL SYSTEMS BRANCH

PITTSBURGH TECHNICAL SUPPORT CENTER

Location: Scotia Mine, Blue Diamond Mining Co., Oven Fork, Ky.

Investigative Report No. C042877

Investigator: William J. Helfrich

Subject: Scotia Mine Power System Investigation

This report details tests made to the 7.2 kV power system which supplies power to the Scotia Mine of the Blue Diamond Mining Co., Oven Fork, Ky. Those participating in the tests were George Fesak, MESA, Arlington, Va.; Cecil Lester, Aaron Jones, and Ralph Rinehart, MESA, Beckley, W. Va.; Andy Lycans, MESA, Pikeville, Ky.; Richard Reynolds and William Helfrich, MESA, Pittsburgh, Pa.; and Bo Simpson, Scotia Mine, Oven Fork, Ky.

The intent of the tests were to determine the reason for the 7.2 kV oil breaker being tripped after each explosion at the mine. One theory for the breaker being tripped was that during the fault the ground and monitor wires had a current induced into it out of phase by 180° with the monitor current. This would cause the monitor relay to drop out, tripping the 7.2 kV oil breaker.

The procedure for testing the system was to fault each phase of the 7.2 kV feeding the mine from phase to ground through a 25-amp fuse. During the faulting of the system, various parameters of the system would be monitored with high speed recording equipment. The various parameters to be monitored were to be ground field current, ground wire monitor current, ground wire current, ground monitor wire to ground wire voltage, ground monitor relay coil voltage, ground monitor relay contacts, and two 7.2 kV phase currents.

The calibration on the recordings is as follows:

Channel #1 - Ground Field Current: 1.13 inches P-P = 25 amps.
Channel #2 - Monitor Current: 5 volts/inch.
Channel #3 - Ground Wire Current: 1.13 inches P-P = 25 amps.
Channel #4 - Ground Monitor to Ground Volts: 100 volts/inch.
Channel #5 - Ground Monitor Relay Coil Volts: 500 volts/inch.
Channel #6 - Monitor Relay Contact Volts: 500 volts/inch.
Channel #7 - Phase Current: 1.13 inches P-P = 40 amps.
Channel #9 - Phase Current: 1.13 inches P-P = 40 amps.

Channel #1 and #3 currents were measured using Gould current transformers with a 1 volt = 25-amp calibration. Channel #7 and #9 phase currents were measured off a 0.1-ohm resistor in series with 40:1 current transformer; therefore, a 1-volt signal would equal 400 amps.

High-Voltage Distribution Tests

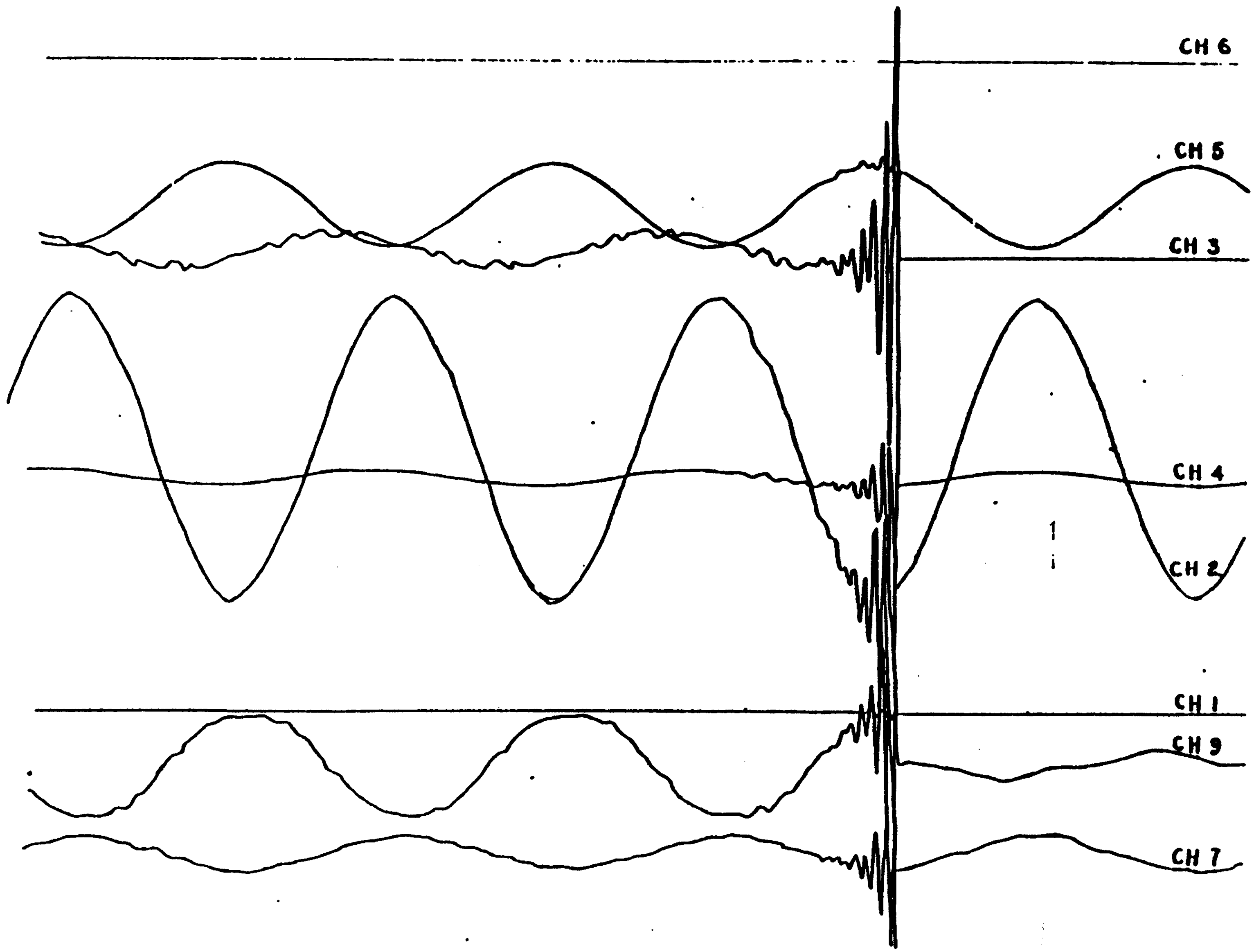
Attached is a recording showing the different parameters which were recorded. This recording shows the time period before the phase to ground fault and after the phase to ground fault. As can be seen from this recording, no current was induced into the ground wire to cause the ground wire monitor relay to drop out. During the course of this investigation, it was found that the 13.8 kV recloser feeding this substation did trip before the 7.2 kV oil circuit breaker tripped, which feeds the mine. This would explain why the "Y" boxes and the 7.2 kV oil circuit breaker were tripped after each explosion.

Equipment Used

Honeywell Visicorder
Model 1858
Frequency response dc to 5,000 Hz.

Gould High Voltage Amplifiers
Model 134215 92
Frequency response dc to 20.000 Hz.

William J. Helfrich


CH 6
CH 5
CH 3
CH 4
CH 2
CH 1
CH 9
CH 7

Appendix M-10

United States Department of the Interior

MINING ENFORCEMENT AND SAFETY ADMINISTRATION
4800 FORBES AVENUE
PITTSBURGH, PENNSYLVANIA 15213

July 12, 1977

Memorandum

To: James D. Michael, Coal Mine Safety Specialist, Coal Mine Health and Safety, Arlington, Virginia

From: Chief, Industrial Safety Branch, Division of Safety Technology, Pittsburgh Technical Support Center
Chemical Engineer, Industrial Safety Branch, Division of Safety Technology, Pittsburgh Technical Support Center

Subject: Deformation of dust collector box on Scotia Mine roof bolter from explosion pressures

Introduction

A dust collector box was removed from a roof bolter in the Scotia Mine and sent to the Industrial Safety Branch laboratory for special evaluation. The bolter was located in the 2 Left Panel off 2 Southeast Mains and the box had been deformed and damaged by explosion pressures generated during the disaster occurring in March 1976. The dust box had deformed by implosion pressures and studies were proposed to determine and/or estimate the maximum forces imposed on the box by surface gallery tests.

Test Procedures

Figure 1 is a sketch of the box and shows the deformation of the base and ends of the enclosure. Prior to testing, the box was straightened and returned as near as possible to its original configuration and fitted with a gasketed 1/4-inch steel cover plate to provide a seal.

The 64 cubic-foot steel gallery, designed to withstand pressures to 40 psi, was modified to accomodate methane-air ignition. Gas inlet and sampling lines were installed in one chamber wall and a small fan was anchored inside to provide a homogeneous gas-air mixture. Adjustable steel plates were fabricated on a wall for the purpose of providing variable vent size openings. The main hinged door was gasketed and attached with special shear-type brass bolts to offer protection against development of excessive pressures. The dust collection box was bolted securely to an interior wall of the gallery.

Methane mixtures, a 9.4 percent concentration, was used in all tests and the vent opening was utilized to control the magnitude of explosion pressures. Gas was ignited by a remotely actuated electric match located near the center of the chamber. Two 60 psi range pressure transducers measured pressure buildup within the gallery. The dust box was examined after each test and damage was noted prior to restraightening the box for additional tests.

During final tests, both sealed and unsealed empty one-gallon cans were placed inside the gallery with the dust box. The cans were introduced into the test chamber to observe possible implosion and explosion effects on capped and uncapped containers.

Conclusions

Since the gallery was designed for pressures not exceeding 40 psi, additional testing was not performed at higher pressures. Tests indicate that the dust collection box had been subjected to pressures of at least 30 psi as judged by the relative deformation of the enclosure. Information obtained on the change in volume of the cans indicate only reduction in volume for the capped units and an increase in volume for the uncapped cans. These data are given in Tables 1 and 2.

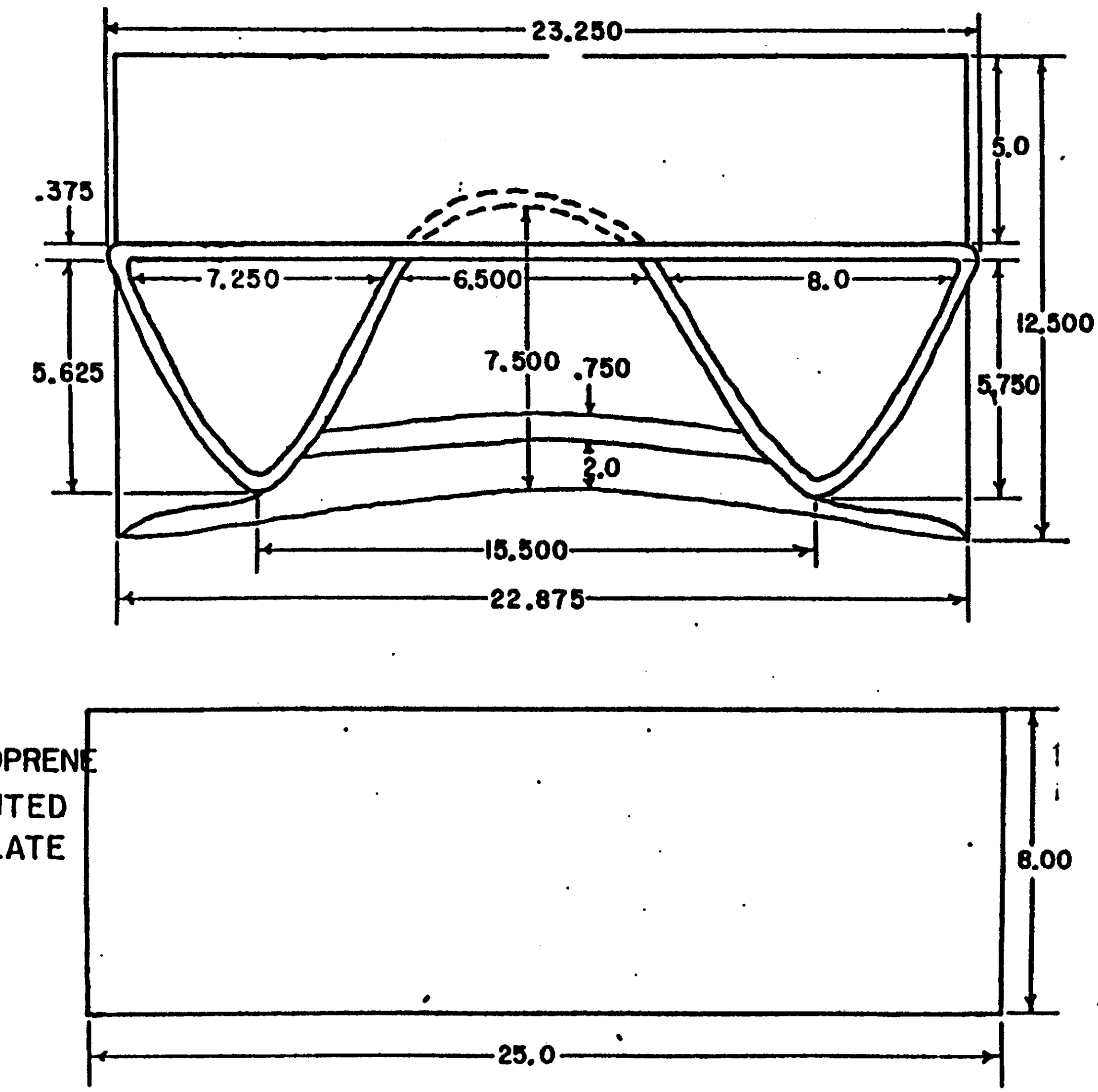
Edward M. Kawenski

Edward M. Kawenski

Steven J. Luzik

Steven J. Luzik

Enclosures



NOTE: .125 NEOPRENE
GASKET MOUNTED
ON COVER PLATE

FIG. 1
7-7-77

TABLE 1. - Test Results

DATE	TEST	TEMP.	% RH	VENT SIZE	% CH_4	MAX. PRESSURE (PSIG)	COMMENTS
6/23/77	1	65	68	12" x 18"	9.4	2	—
6/23/77	2	65	68	6" x 18"	9.5	11.5	—
6/23/77	3	65	68	3" x 18"	9.2	28	Base bent inward 2-1/8"
6/27/77	4	78	65	1" x 18"	9.4	38*	Base bent inward 2-1/2"
6/30/77	5	72	62	3" x 18"	9.3	24**	Base bent inward 2-5/8"
6/30/77	6	85	42	3" x 18"	9.4	14	Box from Test 5 not restraightened

* Explosive forces blew door off changer, shearing brads bolts. Chamber tipped over on its side opposite door.

** Could not be determined accurately because of technical problems with transducers. This value is estimated.

TABLE 2. - Test Results

Test	Can	Original Volume	Final Volume	
4	1	4.07	3.88	capped
4	2	4.10	3.75	capped
5	1	4.10	4.32	uncapped
5	2	4.12	4.52	uncapped

United States Department of the Interior
GEOLOGICAL SURVEY
RESTON, VIRGINIA 22092

June 27, 1977

Mr. John Nagy
Mine Enforcement and Safety Administration
400 Forbes Avenue
Pittsburgh, Pa. 15213

Dear John:

Here is Dick Volckmann's report on his examination of the samples from the Scotia Mine. I think he has done a commendable job and I hope that it meets your need. Please feel free to contact either Dick or me if we can be of further help.

Sincerely yours,

Jack

John C. Reed, Jr., Chief
Office of Environmental Geology

Enclosure

Appendix M-11

Analysis of Rock Specimens from the Scotia Mine, Scotia Coal Company, Letcher County, Kentucky

1/ by R. P. Volckmann

Introduction

The report is in response to a request from the Mining Enforcement and Safety Administration (MESA) for detailed analyses of a suite of nine rock samples taken from the Scotia Coal Mine, Letcher County, Kentucky - the site of two explosions in March, 1976. The samples (Table 1) were collected in March, 1977, following recovery of the mine in 1976. Collections were made by Michael Elliot and John Nagy of MESA in areas of the mine designated 2- Southeast and 2- Left Section of 2- Southeast.

The specimens are from the roof and from slabs fallen from the roof above the Imboden coal bed within the Breathitt Formation of Pennsylvanian age. The rock-types are generally siltstone, silty-shale and sandstone.

Included in the report are the results of petrographic (Table 2) and X-ray analyses (Table 3) of all nine samples. Chemical analyses (rapid rock analysis (Table 4) and semiquantitative spectographic analysis (Table 5)) were made on samples 1, 4, and 5. Petrographic studies were done by the writer. X-ray data was provided by Melodie Hess and Janet Hoffman,

1/ Abstract prepared by MESA; full report is available from the Administrator, Mining Enforcement and Safety Administration and chemical analyses were made by the Branch of Analytical Laboratories, U. S. Geological Survey.

Petrographic Analyses

Detailed petrographic analyses were made on thin sections of each of nine samples. Grain size determinations were based on measurements of long dimensions of detrital quartz grains. Mineral percentages were determined from point counts. These may be viewed as typical percentages, but not absolute percentages, as the composition and texture of the rocks vary both laterally and vertically. Where indicated, quartz can be assumed to be detrital unless further qualified, such as silica cement, etc. Except as noted muscovite and sericite are treated together as it generally is not possible, in such fine-grained rocks, to distinguish microscopically between very fine-grained muscovite and sericite. Many of the descriptions are repetitious as it was thought to be advantageous to describe each sample separately rather than make a general statement about the suite as a whole.

Microscopic examination of the thin sections reveals significant amounts of quartz in each sample but little or no feldspar. However, X-ray data show from 3 to 7 percent feldspar in the samples. Also, in some samples, X-ray data show lower quartz percentages than were obtained by point count. The discrepancies are probably due to inhomogeneity of the samples which results from lateral compositional variation along stratigraphic planes, and vertical compositional variation between laminations such as quartz-rich versus quartz-poor laminations. In order to be certain that quartz was not being misidentified as untwinned feldspar several of the thin sections were stained for feldspar. The mineral grains originally identified as quartz remained unstained. It is, therefore, considered that the quartz percentages obtained from point counts are representative for that part of each sample which was thin-sectioned. Feldspar is undoubtedly present in all the samples but is probably represented in the clay-size matrix.

Clay minerals could not be identified in thin-section. X-ray data show that some kaolinite is present in most samples and is included in the layer silicate percentages. In addition, petrographic determination of siderite probably includes some clay which accounts for part of difference between X-ray and point count percentage of siderite.

Finally, it should be noted that the point-count percentages include carbon which, in some samples is a significant constituent. The X-ray data do not include carbon, thus the percentages of the other constituents (quartz, layer silicates, feldspar and siderite) are inflated relative to those percentages obtained by point count.

The following are details of the petrographic analyses of sample No. 1:

<u>Principal components</u>	
quartz	48%
muscovite	45%
<u>Accessory components</u>	~7%
siderite	
epidote	
zircon	
carbonaceous material	

Quartz grains are angular; many are sliverlike; spehericity is very low; sorting is poor; average grain size is 15 microns (medium silt); size range is 2-72 microns (clay-size to very fine sand).

Muscovite flakes show subparallel orientation and are commonly warped or broken by compaction around quartz grains.

Siderite occurs as isolated rounded grains which are probably micro-concretions, and as minor dust around quartz grains.

The rock is well indurated due to the combination of poor sorting and high degree of compaction which results in a fabric of interlocking quartz and muscovite grains. Chemical cement is absent. Muscovite flakes and quartz slivers show subparallel orientation but because of the high degree of induration the rock tends to fracture subchoncoidally, without respect to mineral alignment. A second, less pronounced, subparallel alignment of muscovite flakes lies at an angle of about 25° to the bedding. This alignment is thought to be a tectonically induced foliation.

Table 1. - ROCK SAMPLES FROM SCOTIA MINE, LETCHER COUNTY, KENTUCKY

Specimen Number	Date Collected	Collector	Description
1	3/2/77	J. Nagy	from rock on top of roof bolter, No. 2 entry, 2-Left
2	3/22/77	M. Elliot	from roof 24-inches outby cavity above roof bolter, No. 2 entry, 2-Left
3	3/9/77	J. Nagy	from roof, near face of No. 2 entry (straight), 2-Left
4	3/22/77	M. Elliot	from fall at No. 3 crosscut outby bolter, No. 2 entry side, 2-Left
5	3/22/77	M. Elliot	from roof at fall 10-feet into crosscut, No. 1 entry side, 2-Left
6	3/22/77	M. Elliot	from fallen material 25-ft. from face of No. 1 entry, 2-Left
7	3/9/77	J. Nagy	from roof at face of No. 2 entry, 2-Southeast
8	3/22/77	M. Elliot	from fall in No. 4 entry, outby side, 2-Southeast
9	3/22/77	M. Elliot	from fall in No. 2 entry, inby side, 2-Southeast

Table 2. - SUMMARY OF PETROGRAPHIC OBSERVATIONS RELATIVE TO QUARTZ IN SAMPLES

Sample Number	Quartz Content, %	Quartz Grain Range	Size, Microns Average
1	48	2-72	15
2	—	—	—
3	26	4-24	13
4	43	4-24	14
5	29	3-58	16
6	15	1-35	—
7	46	90-1200	530
8	28	1-140	20
9	63	30-270	153

Table 3. - X-RAY DATA (Normalized for the four components listed; layer silicates include micas and clays)

Sample No.	% quartz	% layer silicate	% feldspar	% siderite
1	23	68	6	4
2	15	79	5	1
3	21	65	6	8
4	25	61	6	8
5	27	61	7	5
6	9	84	5	2
7	not run			
8	32	58	7	3
9	53	37	3	7

Table 4. - Rapid rock analyses of samples 1, 4, and 5 from the Scotia Mine, Letcher County, Kentucky

	1	4	5
SiO_2	55.7	40.3	54.6
Al_2O_3	22.4	15.1	18.6
Fe_2O_3	1.3	1.0	1.2
FeO	4.6	19.1	7.8
MgO	2.2	2.0	1.4
CaO	0.42	0.95	0.60
Na_2O	0.50	0.28	0.42
K_2O	4.9	3.3	4.1
H_2O +	4.3	3.0	4.0
H_2O -	0.56	0.44	0.41
TiO_2	1.0	0.70	0.99
P_2O_5	0.15	0.19	0.17
MnO	0.07	0.40	0.18
CO_2	1.2	11.8	4.0
S	0.04	0.03	0.04
SUM	99	99	99

Note: Method as described under "single solution" in USGS Bulletin 1401.

Table 5. - Summary of Emission Spectographic Analyses

Component, %	Sample Number		
	1	4	5
Si	30	14	26
Al	13	4.4	9
Fe	4.6	10.8	6.4
SiO_2	64	30	55.5
Al_2O_3	25	8.4	17
Fe_2O_3	6.6	15.5	9.1
MgO	2.2	1.2	2.0

Appendix N

ARMED FORCES INSTITUTE OF PATHOLOGY

WASHINGTON, D.C. 20306

ADDRESS REPLY TO THE DIRECT
ATTN: AFIP- CPL

7 January 1977

Mr. Joseph Cook
Coal Mine Health and Safety
Mining Enforcement and
Safety Administration
4015 Wilson Boulevard
Arlington, Virginia 22203

Dear Mr. Cook:

Enclosed is my report concerning my investigation of the Scotia Mine explosion. Please feel free to call me if there are any questions concerning the report.

In the future if there are other problems requiring the services of a forensic pathologist, please call upon us for help.

Sincerely yours,

Robert L. Thompson

ROBERT L. THOMPSON, M.D.
Captain, MC, USN
Chairman, Department of
Forensic Sciences

AMERICAN REVOLUTION BIC... 1776-1976

Appendix N

ARMED FORCES INSTITUTE OF PATHOLOGY
WASHINGTON, D.C. 20306

ADDRESS REPLY TO THE DIRECT
ATTN: AFIP- CPL

Investigation of Scotia Mine explosion which occurred at Scotia No. 1 Coal Mine, Oven Fork, Kentucky.

At approximately 0530 hours on 19 November 1976, a team of approximately 20 individuals, including the undersigned, entered the above mentioned coal mine for the purpose of removing the bodies of 11 victims of an explosion which occurred on 11 March 1976. Members of the team included Dr. John Feegel, a forensic pathologist employed by the Scotia Mining company, Dr. George Nichols, a forensic pathologist employed by the state of Kentucky, Robert E. Barrett, Administrator of Mining Enforcement and Safety Administration (MESA), Joseph Cook, Coal Mine Safety Division of MESA, several MESA investigators, individuals from Kentucky Department of Mines and Minerals, representatives of the Scotia Mining Company, Charles Day, coroner having jurisdiction of the mine area, several funeral directors, and one individual representing the families of the deceased. The train ride to the area of the mining disaster took approximately 30 minutes. The team first preliminarily viewed the bodies and made identification, primarily by the name plates attached to the miners' belts, and tagged each body with a name and a number. Then a more detailed examination of the bodies was performed, and the personal effects were removed from the bodies and placed within containers. The coroner was responsible for documenting the personal effects, which later would be turned over to the families. As the bodies were examined in more detail, they were placed within body bags and placed on flat bed cars to be taken by railroad from the mine. The members of the investigating team and the bodies returned to the surface between 1130 and 1200 hours on 19 November 1976.

Description of the bodies in the mine:

General comment: Examination of the bodies and the area around the bodies show no evidence that the bodies had been disturbed. All of the bodies show moderate to marked postmortem decomposition and there is a moderate amount of grayish-green mold growing on the skin and the victims' clothing.

General statement: Examination of the victims' skin, hair, and clothing reveals no evidence of burning.

Body No. 1 - Identified as Richard Sammons, found at the intersection in which 2-S.E. intersects with the main passageway. The body is lying on the right side with the head facing toward the interior of the mine. There is a heavy beam lying on top of both legs. There is a fracture of both bones of the left lower leg. There are multiple fractures of the right lower leg with these involving the femur and both bones of the lower leg. There is a fracture of the right humerus and a fracture of the left wrist area.

Body No. 2 - Identified as Grover Tussey is found at the intersection in which 2-S.E. intersects with the main passageway. The body is lying face down with the head away from 2-S.E. The face area is lying on a large rock. There is a massive depressed fracture of the face area. Multiple skull fractures are noted with these being primarily in the right parietal and temporal areas. There are massive fractures and soft tissue hemorrhage of both lower legs.

Body No. 3 - Identified as Don Polly found at the intersection of 2-S.E. and the main passageway. The body is lying on the left side with head facing the direction of 2-S.E. It is noted that the victim's self rescuer is open. Within the left temple area there is a laceration measuring approximately 4 by 2 by ½ inch. The entire area of the left temple is noted to be slightly depressed.

Body No. 4 - Identified as James O. Williams is found within a train car attached to a locomotive on the track within the main passageway. The body is laying face down with the head turned slightly to the right. The head is facing toward the interior of the mine. The self rescuer is noted to have been opened and lying between the legs. After the body is turned there is noted a portable telephone beneath the body and also a hard hat beneath the body. There is pressure deformity of the face due to decomposition and the body having laid face down for a long period of time. No obvious injury is identified.

Body No 5 - Identified as Monroe Sturgill is found within the main passageway lying by the side of the train car in which body number 4 was found. The body is laying face down with the head toward the exterior of the mine. The self rescuer is on the belt and has not been opened. The face, after the body has been turned, shows pressure deformity due to postmortem decomposition and lying in this position for a long period. No obvious injury is identified.

Body No. 6 - Identified as Glen Barker is found within the main passageway on the left of the railroad track with left being oriented as an individual would be facing toward the interior of the mine. The body is lying face up with the head being toward the interior of the mine. It is noted that the third and fourth fingers of the left hand are missing, but the areas of amputation are noted to be old and well healed. The face is noted to be slightly bloated with the eyes being dry and the tongue slightly protruding. The self rescuer is lying by the victim's feet and is closed. There is noted to be no name plate on the victim's belt and identification is made by the missing fingers and recognition by friends. No obvious injury is identified.

Body No. 7 - Identified as John Heckworth is found lying between the railroad tracks in the main passageway. The body is lying face down with the head toward the interior of the mine. The victim's self rescuer is between his legs and open. After the body is turned over, there is pressure deformity of the face due to postmortem decomposition and the long period of time that the body had laid in this position. No obvious injury is identified.

Body No. 8 - Identified as James Sturgill is found within the main passageway just to the left of the railroad tracks with left having the orientation of the reviewer facing toward the interior of the mine. The body is lying face down with the head being toward the interior of the mine but at a slight angle. The self rescuer is on the belt and is not open. After the body is turned, the face shows pressure deformity due to the postmortem decomposition and the long period of time that the body had laid in the face-down position. No obvious injury is identified.

Body No. 9 - Identified as J. B. Holbrock found within the main passageway. The body is lying face down with the head being toward the exterior of the mine. The body is lying on the left railroad track with left being oriented with the reviewer facing toward the interior of the mine. The name plate on the belt has the name L. Holbrock but the victim was known to have not been wearing his own miner's belt. As the body is turned, an open self rescuer is noted beneath. The face shows pressure deformity due to postmortem decomposition and the body having laid in this position for a long period of time. No obvious injury is identified.

Body No. 10 - Identified as Kenneth Kiser is found within the main passageway. The body is lying face down with the head being toward the direction of 2-S.E. The victim's head is lying on the right rail of the railroad tracks with the right being viewed as the reviewer faces toward the interior of the mine. A self rescuer is open and lying to the right of the body. After the body is turned there is pressure deformity of the face due to postmortem decomposition and the long-time position of the body. No obvious injury is identified.

Body No. 11 - Identified as Don Creech is lying within the main passageway. The body is lying face down with the head being toward the exterior of the mine. The left arm is lying on the left rail of the railroad track with left being viewed as a reviewer would face toward the interior of the mine. After the body is turned it is noted that the self rescuer is open and within the right hand. No obvious injury is identified.

Autopsy findings:

X-rays were taken of all of the victims that had autopsies performed, and no fractures were identified.

Don Creech, Body No. 11. The autopsy is limited to the chest. No chest wall injuries are identified. There are apical lung adhesions bilaterally. The lungs are collapsed except for adhesions. The trachea is slightly darkened but no definite soot is identified. Cutting through the pectoral muscle of the chest wall reveals the muscles to be slightly pink.

John Heckworth, Body No. 7. The autopsy is limited to the chest organs. No chest wall injuries are identified. The pectoral muscles are slightly pink. Examination of the lungs reveals them to be shrunken, but there are few bullae on the surfaces. The interior of the trachea is slightly dark, but no definite soot is identified.

Kenneth Kiser, Body No. 10. Examination of the left index finger reveals is to be missing and the amputation site is well healed. No chest injury is identified and the muscles are slightly pink. In focal areas there are bilateral adhesions in the left apex. The mucosa of the trachea is slightly darkened, but no definite soot is identified. Examination of the abdominal cavity also reveals no evidenee of injury.

James Sturgill, Body No. 8. No chest wall injuries are identified and the pectoral muscles are slightly pink. The lungs are shrunken and there are slight pleural adhesions in the left apex. The mucosa of the trachea is slightly darkened, but no definite soot is identified. Examination of the abdominal cavity reveals no evidence of injury.

J. B. Holbrock, Body No. 9. The autopsy is limited to examination of the chest organs. No chest wall injuries are identified. There are a few focal pleural adhesions. The lungs are retracted. The chest wall muscles are slightly pink.

Monroe Sturgill, Body No. 5. No chest wall injuries are identified. There is slightly increased anterior-posterior diameter of the chest, and there are a few pleural adhesions. The muscles of the chest wall are slightly pink. The lungs are shrunken. Examination of the abdominal cavity reveals no evidence of injury.

Summary of autopsies. X-rays of all autopsied victims reveals no fractures. No chest wall injuries are identified. All of the victims have shrunken lungs, and this is consistent with postmortem decomposition. Focal pleural adhesions are noted in all victims. The tracheas of all victims are slightly darkened, but this is consistent with postmortem decomposition and no definite soot is identified. The muscles of the chest are slightly pink with this being compatible with carbon monoxide intoxication, but no definite determination can be made on the muscle color alone.

Toxicologic studies. Because of the postmorten decomposition, the muscle tissue removed for toxicologic studies was not suitable for examination.

Microscopic studies. Studies of microscopic slides prepared from lung and trachea tissue removed from the autopsied victims reveals the tissue to be too decomposed to make any meaningful interpretation.

Conclusion.

After review of the investigative information concerning the incident, examination of the interior of the mine, examination of the victims at the scene of the incident and viewing of partial autopsies on six of the victims it is concluded that victims 1, 2 and 3 died of traumatic injuries as a result of forces produced by the explosion. No traumatic injuries were found on the bodies of victims 4 - 11, and it is thought that these individuals died either of suffocation due to lack of oxygen as an aftermath of the explosion or due to blast injury of the lung caused by the explosion. It is certainly possible that victims 4 - 11 died due to a combination of both suffocation and blast injury. It is thought that the victims were either killed instantly or lived for a very short time following the explosion.

Robert L. Thompson

ROBERT L. THOMPSON, M.D.
Captain, MC, USN
Chairman, Department of
Forensic Sciences

Appendix O

The following violations of Part 75, Title 30, CFR, were observed during the investigation but did not contribute to the explosions:

1. Suitable connectors were not used to splice the electrical conductors of the belt line control circuit at 2 Southeast Main belt conveyor drive unit. This is a violation of Section 75.514.

2. The belt conveyor in 2 Southeast Main was not provided with stop and start controls at intervals not exceeding 1000 feet. This is a violation of Section 75.1403-5(h).

3. The motor circuit cable entering the splice box on the No. 2 Northeast Main belt drive motor did not enter the metallic splice box through a proper fitting. This is a violation of Section 75.515.

4. Adequate short-circuit and overload protection was not provided for the 2/0 cable supplying power to the No. 2 Northeast Main belt conveyor drive unit. This is a violation of Section 75.518.

5. Adequate short-circuit and overload protection was not provided for the 1-horsepower pump motor located in No. 167 crosscut and for the No. 10 cable supplying power to the motor. This is a violation of Section 75.518.

6. A ground check circuit was not provided to monitor the continuity of the grounding conductor in the resistance grounded circuit supplying power to the 440-volt pump at No. 167 crosscut. This is a violation of Section 75.902.

7. The power cable supplying power to the 1-horsepower pump located in No. 167 crosscut did not enter the metal frame of the pump motor through a proper fitting. This is a violation of Section 75.515.

8. The protective cover had been left off a cable coupler leaving the power conductors exposed in a cable supplying power to the battery charger at the mouth of Northeast Main. This is a violation of Section 75.517.

9. Three lengths of high-voltage cable were not adequate for the intended voltage in that the cable was rated at 5000 volts and was part of an energized 7200-volt circuit. This is a violation of Section 75.804(b).

10. The metallic shielding was not replaced in a splice in a high-voltage cable located at No. 205 crosscut. This is a violation of Section 75.804(b).

11. The ground check circuit had been bypassed around the high-voltage couplers connected to the Westinghouse power center at the mouth of Northeast Main in such manner so that the ground check continuity conductor would not be broken first when the coupler was uncoupled. This is a violation of Section 75.805.

12. The switches in the Ensign "Y"-box located in No. 182 crosscut were not marked for identification. This is a violation of Section 75.809.

13. The disconnecting switches in the Line Power "Y"-box located at the mouth of the 2 Left section were not marked for identification. This is a violation of Section 75.809.

14. The high-voltage coupler on the load end of the "Y"-box in No. 182 crosscut was not constructed so as to cause the ground check continuity conductor to break first when the coupler was uncoupled. This is a vi lation of Section 75.805.

15. Ground check circuits were not provided to monitor the continuity of the grounding conductors in the resistance grounded high-voltage circuits extending from the "Y"-box in No. 182 crosscut. This is a violation of Section 75.803.

16. Ground check circuits were not provided to monitor the continuity of the grounding conductors in the resistance grounded high-voltage circuits extending from the "Y"-box at 2 Left and Northeast Main. This is a violation of Section 75.803.

17. The standard drive shuttle car, Serial No. 702, in 2 Left off 2 Southeast Main was not maintained in permissible condition. This is a violation of Section 75.503.

18. The spare roof-bolting machine, Galis Model 320, in the 2 Left off 2 Southeast Main was not maintained in permissible condition. This is a violation of Section 75.503.

19. A temporary splice in the trailing cable of the standard drive shuttle car, Serial No. 702, located in 2 Left off 2 Southeast Main was improperly made. This is a violation of Section 75.603.

20. A temporary splice in the continuous mining machine trailing cable was improperly made. This is a violation of Section 75.603.

21. A ground check circuit was not provided to monitor the continuity of the grounding conductor in the resistance grounded 440-volt circuit supplying power to the belt feeder in the 2 Left off 2 Southeast Main. This is a violation of Section 75.902.

22. A ground check circuit was not provided to monitor the continuity of the grounding conductors in the resistance grounded 440-volt circuit supplying power to the battery charger in Southeast Main three crosscuts inby Northeast Main. This is a violation of Section 75.902.

23. Adequate short-circuit and overload protection was not provided for a 5-KVA control transformer in a power center located at No. 84 crosscut. This is a violation of Section 75.518.

24. Excessive levels of alternating current existed between the frames of the opposite standard shuttle car, serial No. 130, and the Lee-Norse continuous mining machine in 2 Left section off 2 Southeast Main in that 140 milli-volts was measured across a 0.1 ohm resistor connected between the machine frames while the shuttle car motor was being started. This is a violation of Section 75.524.

25. Approximately one-half box of explosives was stored in the original container in the No. 169 crosscut, Left Panel, Northeast Main. This is a violation of Section 75.1306.

26. Two boxes of detonators were stored in the original container in the No. 157 crosscut, Right Panel, Southeast Main. This is a violation of Section 75.1306.

27. Six sticks of explosives were stored in a rock dust bag in the No. 4 entry, Left Panel, South Main, between the Nos. 109 and 110 crosscuts. This is a violation of Section 75.1306.

28. Deteriorated explosives, approximately one-half box, and one box of detonators, were stored in the original containers near the section storage boxes in the 2 Southeast Main. One box of detonators were stored in the original container near a stopping in 1-1/2 Right off Northeast Main. This is a violation of Section 75.1306.

29. Approximately 25 sticks of deteriorated explosives were stored in the original container 75 feet inby survey station 9119 in 2 Left off Northeast Main. This is a violation of Section 75.1306.

30. One box of explosives was stored in the original container in the No. 194 crosscut and approximately 50 sticks of explosives were scattered along the No. 3 entry, Northeast Main, between the Nos. 197 and 198 crosscuts. This is a violation of Section 75.1306.

31. Approximately 30 sticks of explosives were stored in the original container near the overcast across the No. 4 entry at No. 217 crosscut, Left Panel, Northeast Main. This is a violation of Section 75.1306.

32. The section explosives storage box in 1 West was 11 feet, 6 inches from the section electrical distribution box. This is a violation of Section 75.1306.

33. Metal nail heads were exposed on the inside of the car used for transporting explosives in the mine. This is a violation of Section 75.1305.

34. Explosives, in an explosive carrying bag, were stored on the mobile coal drill in the 1 West section. This is a violation of Section 75.1306.

35. Oxygen and acetylene tanks were stored within 10 feet of the section electrical power center in the 1 West section. This is a violation of Section 75.1106.

36. The chain drive on the conveyor belt drive in 3 Left off 1 West was unguarded. This is a violation of Section 75.1722.

37. A crosscut was not provided near the face of the No. 5 entry, 3 Southeast Main before the section was abandoned. This is a violation of Section 75.316.

38. Crosscuts were not provided near the faces of the Nos. 2, 3, and 4 entries, Left Panel, Northeast Main before the section was abandoned. This is a violation of Section 75.316.

39. The width of the roadway into the pillar split being mined exceeded 16 feet and turn posts had not been set in 1-1/2 Right off 2 East section. This is a violation of Section 75.200.

40. The bleeder system and ventilation controls in the pillar section of 1-1/2 Right off 2 East did not insure that return air flow from the gob area did not enter the active working places along the pillar line. This is a violation of Section 75.316.

41. There was an excessive accumulation of float coal dust deposited on rock dusted surfaces for a distance of about 2,500 feet along the conveyor belt entry in 1 West Section.

APPENDIX P

SCOTIA MINE
SCOTIA COAL COMPANY
OVENFORK, LETCHER COUNTY, KENTUCKY

Notices and Orders issued and sections violated at Scotia Mine, Ovenfork, Letcher County, Kentucky, from May 13, 1970, to March 9, 1976.

TOTAL NUMBER OF NOTICES ISSUED:	854
TOTAL NUMVER OF ORDERS ISSUED:	109
TOTAL NUMBER OF NOTICES AND ORDERS ISSUED:	963
TOTAL INSPECTION MANDATES:	1,050
NUMBER OF NOTICES AND ORDERS ISSUED PER MANDAY:	0.92

NOTICES ISSUED

104(i)

Section Violated	Number Issued
70.100	37
Total	37

104(c)(1)

Section Violated	Number Issued
75.302	1
75.400	1
75.403	1
75.603	1
Total	4

104(b)

Section Violated	Number Issued	Section Violated	Number Issued	Section Violated	Number Issued
70.100	1	75.517	2	75.1710	15
70.210	1	75.518	2	75.1712	8
70.220	1	75.520	2	75.1713	2
70.230	4	75.521	2	75.1715	1
70.246	5	75.523	9	75.1718	6
70.250	15	75.601	6	75.1722	22
75.200	28	75.602	1	75.1725	10
75.201	1	75.603	27	77.202	9
75.202	2	75.605	5	77.205	3
75.300	1	75.607	1	77.206	1
75.301	71	75.700	7	77.208	4
75.302	32	75.701	10	77.213	1
75.303	1	75.703	1	77.215	2
75.304	2	75.800	2	77.312	1
75.307	2	75.803	1	77.313	1
75.308	3	75.807	9	77.314	1
75.313	7	75.810	1	77.400	1
75.316	29	75.902	3	77.408	2
75.326	1	75.903	1	77.410	2
75.400	106	75.904	3	77.412	1
75.401	3	75.1100	38	77.504	2
75.402	8	75.1101	14	77.505	6
75.403	27	75.1102	3	77.509	1
75.500	2	75.1103	3	77.511	1
75.503	43	75.1104	3	77.513	1
75.505	21	75.1105	20	77.701	2
75.506	1	75.1106	4	77.1101	1
75.507	5	75.1107	2	77.1104	1
75.509	2	75.1202	2	77.1109	2
75.510	3	75.1306	4	77.1605	1
75.511	1	75.1403	12	77.1710	1
75.512	19	75.1404	2	77.1900	1
75.514	5	75.1405	1	77.1905	1
75.515	6	75.1704	21	77.1907	1
75.516	12				

TOTAL 104(b) NOTICES ISSUED: 813

ORDERS ISSUED

1975 NOTICE AND ORDER DATA

Notices

104(b) Notices	201
104(i) Notices	13
104(c)(1) Notices	0
Total	214

Orders

104(a) Orders	9
104(b) Orders	6
104(c)(1) Orders	0
104(c)(2) Orders	6
103(f) Orders	2
Total	23

Total Notices and Orders issued in 1975: 237

Mandays: 251

1976 NOTICE AND ORDER DATA

Notices

104(b) Notices	91
104(i) Notices	1
104(c)(1) Notices	0
Total	92

Orders

104(a) Orders	0
104(b) Orders	2
104(c)(1) Orders	0
104(c)(2) Orders	1
103(f) Orders	0
Total	3

Total Notices and Orders issued in 1976: 95

Mandays: 44

1973 NOTICE AND ORDER DATA

Notices

104(b) Notices	108
104(i) Notices	7
104(c)(1) Notices	1
Total	116

Orders

104(a) Orders	9
104(b) Orders	8
104(c)(1) Orders	1
104(c)(2) Orders	6
103(f) Orders	0
Total	24

Total Notices and Orders issued in 1973: 140

Mandays: 239

1974 NOTICE AND ORDER DATA

Notices

104(b) Notices	87
104(i) Notices	15
104(c)(1) Notices	1
Total	103

Orders

104(a) Orders	5
104(b) Orders	5
104(c)(1) Orders	0
104(c)(2) Orders	8
103(f)	0
Total	18

Total Notices and Orders issued in 1974: 121

Mandate: 198

1971 NOTICE AND ORDER DATA

Notices

104(b) Notices	94
104(i) Notices	0
104(c)(1) Notices	0
Total	94

Orders

104(a) Orders	7
104(b) Orders	0
104(c)(1) Orders	0
104(c)(2) Orders	16
103(f) Orders	0
Total	23

Total Notices and Orders issued in 1971: 117

Mandays: 101

1972 NOTICE AND ORDER DATA

Notices

104(b) Notices	155
104(i) Notices	0
104(c) Notices	1
Total	156

Orders

104(a) Orders	4
104(b) Orders	0
104(c)(1) Orders	1
104(c)(2) Orders	8
103(f) Orders	0
Total	13

Total Notices and Orders issued in 1972: 169

Mandays: 180

104(a)

Section Violated	Number Issued
75.200	5
75.301	3
75.400	5
75.403	1
75.512	2
75.603	1
75.1403	1
No section cited	21
Total	39

104(b)

Section Violated	Number Issued
75.301	1
75.316	1
75.400	8
75.403	2
75.1101	1
75.1102	1
75.1105	1
75.1405	1
75.1704	2
75.1710	2
75.1722	1
75.1905	1
Total	22

104(c)(1)

Section Violated	Number Issued
75.400	2
Total	2

104(c)(2)

Section Violated	Number Issued
75.200	12
75.301	11
75.302	4
75.307	1
75.308	1
75.316	1
75.400	4
75.503	1
75.505	4
75.518	1
75.603	3
75.1106	1
Total	44

103(f)

Section Violated	Number Issued
No section cited	2
Total	2

1970 NOTICE AND ORDER DATA

Notices

104(b) Notices	77
104(i) Notices	1
104(c)(1) Notices	1
Total	79

Orders

104(a) Orders	5
104(b) Orders	1
104(c)(1) Orders	0
104(c)(2) Orders	0
103(f) Orders	0
Total	6

Total Notices and Orders issued in 1970: 85

Mandays: 37 —