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DEVELOP AND TEST  
AN AUTOMATIC FIRE CONTROL SYSTEM  
FOR  
SURFACE MINING MACHINERY

PREPARED FOR

UNITED STATES DEPARTMENT OF THE INTERIOR  
BUREAU OF MINES

BY



**THE ANSUL COMPANY, MARINETTE, WISCONSIN, 54143**

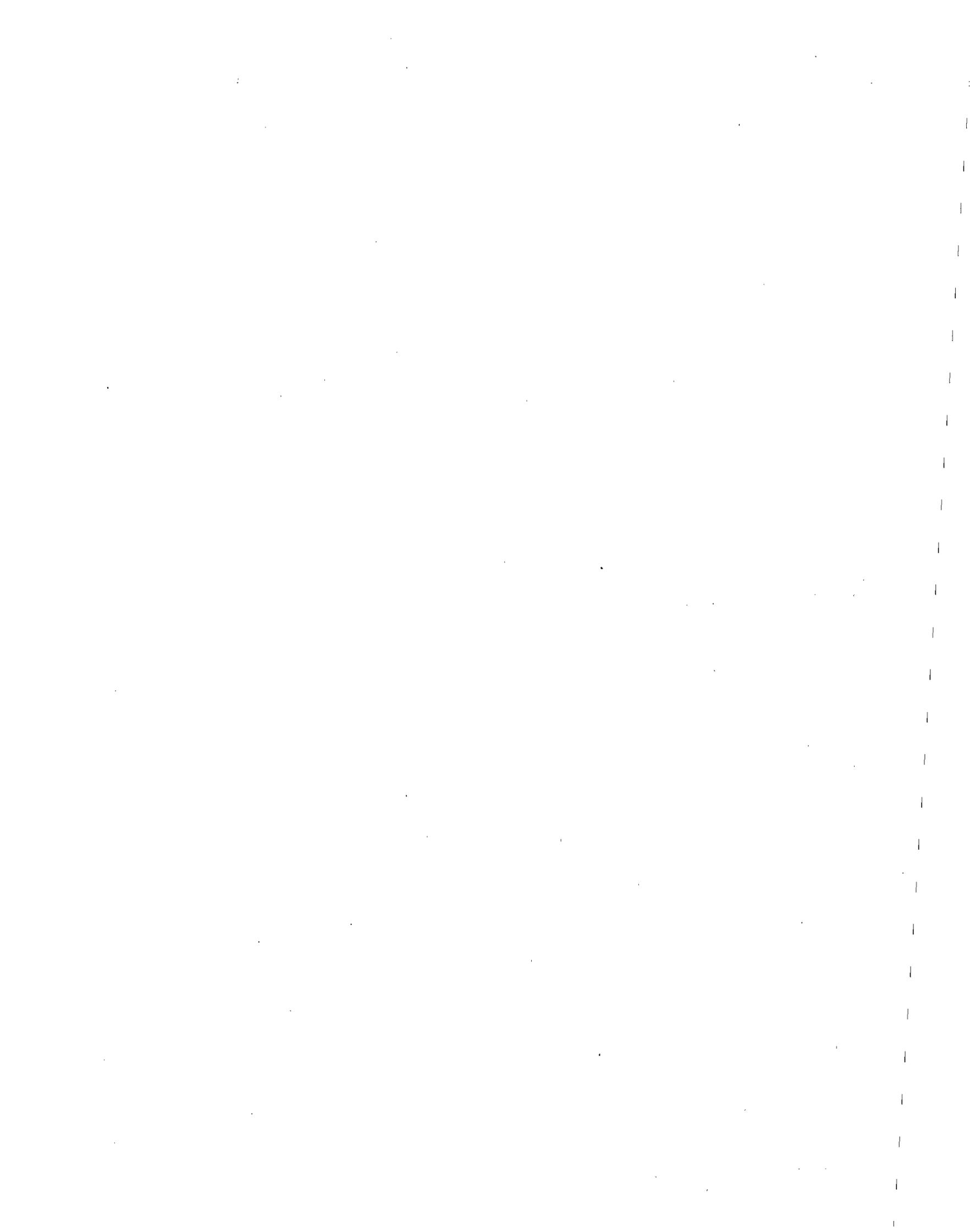
FINAL REPORT, VOLUME I  
ON  
CONTRACT NUMBER H0272013  
DEVELOP AND TEST  
AN AUTOMATIC FIRE CONTROL SYSTEM  
FOR SURFACE MINING MACHINERY

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16. Abstract (Limit: 200 words) The objective of this investigation was to develop and test automatic fire control systems for large surface machinery in surface coal mines. The effort described covers the period from January 31, 1977 to November 11, 1977, and accomplished the following tasks: (1) Data accumulation, mainly from visits to the major manufacturers and mine sites. (2) Hazard analysis of blast-hole drill, mining shovel, and dragline. (3) Recommended design concepts for automatic fire control systems for each of these vehicles. (4) Detail system designs for each of these vehicles. (5) Procurement of prototype systems for the blast-hole drill and mining shovel. (6) Installation of the prototype systems on machines at a surface mine and demonstration of performance by fire tests on the machines.		13. Type of Report & Period Covered Contract research 1/77 - 11/77	
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## FOREWORD

This report was prepared by The Ansul Company of Marinette, Wisconsin, under USBM Contract No. H0272013. The contract was initiated pursuant to the Federal Coal Mine Health and Safety Act of 1969. It was administered under the technical direction of TCMRC, with Mr. Bill Pomroy acting as the Technical Project Officer. Mr. W. Battle was the Contract Administrator for the Bureau of Mines.

This report is a summary of the work recently completed as a part of this contract during the period January 31, 1977 to November 11, 1977. This report was submitted by the authors on November 11, 1977.

The program was performed at The Ansul Company under the direction of Mr. Gene R. Reid, Program Manager; Mr. Alan E. Kasten, Systems Project Engineer; and Mr. Richard J. Plog, Electronics Engineer. Special acknowledgement should be given to the following groups for their efforts towards the successful completion of this program:

- The cooperation and assistance of the Peabody Coal Company, Lynnville, Indiana Mine, during the performance of the field demonstration, particularly Mr. Alan Cook, Area Safety Supervisor.
- The assistance of the Brunswick Company, through Mr. Emory Thomas, for their work with the early warning system.
- The assistance of the Bucyrus-Erie Company, through Mr. Len Hansson, Staff Engineer, for their assistance in obtaining surface machinery information. However, the views and conclusions are those of the authors and should not be interpreted as necessarily representing the policies of Bucyrus-Erie.



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EXECUTIVE SUMMARY  
OF  
FINAL REPORT, VOLUME I

U.S. BUREAU OF MINES CONTRACT H0272013  
"DEVELOP AND TEST AN AUTOMATIC FIRE CONTROL SYSTEM  
FOR SURFACE MINING MACHINERY"

THE ANSUL COMPANY  
MARINETTE, WISCONSIN 54143

The work under USBM Contract H0272013 was divided into three distinct phases. Phase I consisted of hazard analyses for large surface mining machinery and development of suppression system design concepts. In Phase II, suppression systems were designed in detail for a crawler-mounted blast-hole drill, a loading shovel, and a walking dragline. The work under Phase III consisted of installing and testing the blast-hole drill and loading shovel suppression systems under actual mine working conditions.

The design concepts presented under Phase I consisted of various combinations of dry chemical and Halon 1301 intended to protect the enclosed machinery spaces of blast-hole drills, loading shovels and draglines. The agent and detection recommendations are summarized in the table below. In general, halon was recommended for areas where personnel safety was concerned and agent residue or its removal were an important consideration. Dry chemical was recommended where agent residue was of little concern or a low degree of enclosure integrity prohibited the use of a gaseous agent. The design concepts dealt with protection of blast-hole drill and loading shovel machinery enclosures, loading shovel collector ring/roller path areas, and dragline transformer enclosures, control rooms and roller paths.

<u>Protected Area</u>	<u>Agent Recommendation</u>	<u>Detection Recommendation</u>
<b>Blast-Hole Drill</b>		
Machinery Enclosures	Halon 1301	Thermal*
Transformer Enclosures	Dry Chemical	Thermal
<b>Loading Shovel</b>		
Machinery Enclosure	Halon Halon/Dry Chemical	Thermal*
Roller Path/Collector Ring	Dry Chemical	Thermal
<b>Walking Dragline</b>		
Roller Path	Dry Chemical	Thermal
Main Transformers	Dry Chemical	Thermal
Control Room	Halon 1301	Ionization

\*The recommendation includes the use of the Brunswick ionization detector as an early warning system.

Detection was generally recommended to be one of the various forms of thermal detection because of the contaminated operating environment; however, a recommendation was made advising consideration and testing of a sampling type ionization detector developed by the Brunswick Corporation for use in contaminated atmospheres. The concepts were presented to the Bureau and approved on April 26, 1977. A written report was submitted on May 12, 1977.

In Phase II, suppression systems based on the approved concepts were designed for a Bucyrus-Erie Company 61R blast-hole drill, 150-B loading shovel, and 2570W dragline. In anticipation of the installation planned for Phase III, the drill and shovel systems were designed for existing machines located at the Peabody Coal Company, Lynnville, Indiana Mine. Two important features incorporated into the drill and shovel systems were a ruggedized control unit capable of operation from line voltage or internal emergency battery power and continual supervision of critical detection and actuation circuits, and the use of an extended halon discharge intended to prolong the duration of halon protection in the presence of uncloseable ventilation openings. The plans were presented and approved on August 4, 1977.

Phase III testing began on August 4, 1977 with mock-up fire testing of the dry chemical system intended to protect the collector ring/roller path area of the 150-B loading shovel. The test consisted of successful fire testing of an Ansul SCAD/101 dry chemical system installed on a full-scale mock-up of the shovel roller path area. On October 5, 1977 through October 12, 1977 the drill and shovel halon systems, as well as the collector ring dry chemical system, were installed on their respective machines at the Peabody Mine near Lynnville, Indiana. The installations were performed jointly by Ansul and Peabody personnel. In addition to the suppression system hardware, a Brunswick detector and recording equipment were installed on the drill to test its long-term performance. On October 13, 1977 fire and operational tests of both systems were conducted. Both systems successfully performed the necessary equipment shutdown and alarm functions and rapidly extinguished the test fires.

All fires were extinguished in less than 10 seconds. Because of damage to one of the control units during installation, the shovel test was conducted using the system's standby batteries. In both tests the measured initial halon concentrations were in the 5-7% design range; however, during the subsequent extended discharge, the concentration decay was more rapid than expected. The most probable causes for the lower readings was settling of the halon following the initial discharge and a higher leak rate than calculated due to the overlooked cumulative effect of the smaller cracks and openings in the machine enclosures.

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## 1.0

### INTRODUCTION

The objective of U.S. Bureau of Mines Contract H0272013 is to develop automatic fire suppression systems for the enclosed machinery spaces of large surface mining equipment, specifically blast-hole drills, loading shovels and draglines.

This final report presents suppression system design concepts for the indicated equipment types, detailed system design plans for a Bucyrus-Erie Company 150B loading shovel, 61R blast-hole drill, and 2570W dragline, and a description of the installation and testing of the shovel and drill systems at the Peabody Coal Company, Lynnville, Indiana mine.

2.0

DATA ACQUISITION

2.1

Visitation Program

The data acquisition program consisted of visits to the ten operating mines and four equipment manufacturers listed below. The location and types of mines visited represent an attempt to gather knowledge of the working conditions of both coal and hard rock mining operations, as well as the environmental considerations imposed upon mining in the northern regions of the US. Ten blast-hole drills, eleven loading shovels, and six draglines (the total representing five different manufacturers) were inspected during the visits.

As a supplementary information source, members of the International Electrical Commission's committee which is currently preparing a standard for mine vehicle protection, were contacted.

Mines

U.S. Steel Company  
Mountain Iron, Minnesota  
(Taconite)

Hibbing Taconite Company  
Hibbing, Minnesota

Erie Mining Company  
Hoyt Lake, Minnesota  
(Taconite)

Reserve Mining Company  
Babbitt, Minnesota  
(Taconite)

Peabody Coal Company  
Lynnville Mine & Squaw Creek Mine  
Lynnville, Indiana

Amax Incorporated  
Ayrshire Mine

Old Ben Coal Company  
Mine No. 1  
Evansville, Indiana

Consolidated Coal Company  
Burning Star Mine  
Pinckneyville, Illinois

Manufacturers

Harnischfeger Corporation  
Milwaukee, Wisconsin

Bucyrus-Erie Company  
Milwaukee, Wisconsin

Marion Power Shovel  
Marion, Ohio

Page Engineering Company  
Chicago, Illinois

Fire Histories

Figure 1 shows the machinery enclosure of a Bucyrus-Erie 50R blast-hole drill which experienced a fire in December 1976. When the drill was examined, the roof and sidewall of the enclosure had been removed along with the damaged machinery. Although the fire did occur during operation of the drill and is known to have originated in the machinery enclosure, the cause of the fire is unknown. Damage to the drill is estimated to be in excess of \$70,000. This is just one of several fire incidents related by the mine safety personnel and machine operators interviewed during the field investigations. Other pertinent fire incidents are listed below:

- In February 1977, a minor fire of unknown origin occurred in the operator's enclosure of a BHD. Damage was confined to insulation in the enclosure wall. An important note is that the drill had been extensively field-modified using Class A construction materials.
- In 1976, while a BE-61R BHD was in transit, overheated compressor drive belts ignited some flammable materials. The fire was extinguished with hand portable extinguishers. Damage was minimal.
- In March 1976, a minor fire occurred in the collector ring area of a Marion 5900 Stripping Shovel. Factors reportedly related to the cause of the fire were an accumulation of grease and dust, along with defective electrical insulators.
- Approximately 1½ years ago, a fire occurred in the machinery space of a BE-61R BHD while it was in operation. Extensive damage was done to the compressor and electrical equipment. The cause is unknown.
- Approximately two years ago, mast welding repairs on a Marion Mark V BHD resulted in a fire. Damage to the drill was extensive.

Additional information on surface mining equipment fires is contained in the Final Report for USBM Contract H0122053.



Figure 1 - Fire Damaged Blast-Hole Drill

Current Fire Protection Methods

Current on-vehicle fire protection is primarily limited to portable and semi-portable extinguishers. Hand held dry chemical extinguishers were present on all the equipment inspected. In addition, several draglines inspected were equipped with hand hose line dry chemical units.

Conversations with the major manufacturers indicated that their experience with fire suppression systems is also limited to hand hose line dry chemical or carbon dioxide units and, in one instance, a manually-operated fixed extinguishing system. In general, the manufacturers prefer that any specialized fire protection systems be installed by the mine operator.

However, a trend toward automatic fire protection is indicated by several system installations on newly constructed draglines. One such system protects the roller path area of a BE 2570-W dragline through the use of standard water sprinkler heads connected to a pressurized water supply. A second example is the installation of small, automatic dry chemical systems in the enclosed transformer and high voltage switch rooms of a BE 1360-W dragline under construction in Indiana. We have also observed halon systems installed in the enclosed high voltage switch rooms of the draglines of two mine operators.

In addition to the systems observed during our visits we are aware that several mine operators are currently proceeding with plans for the installation of automatic fire protection systems on their large surface machinery.

### 3.0

## HAZARD ANALYSIS

The machine descriptions in this section discuss the types of fire hazards which exist in the equipment. However, the degree of hazard which these pieces of equipment represent depends to a large extent on the "housekeeping" methods and control in each piece of machinery. Where excessive grease accumulations are tolerated or where fuels, oily rags, and other Class A materials are stored in open areas, the potential for fire damage may be drastically increased. It may be that "housekeeping" is the most important consideration in reviewing the need for fire protection. In general, it seems that housekeeping is related to the age of the equipment, with newer equipment having better housekeeping.

### 3.1

#### Blast-Hole Drill

#### 3.1.1

##### Functional Description

The function of a blast-hole drill in an open pit mining operation is to assist in the removal of overburden and mineral-bearing rock by providing a series of drilled holes from the surface to the mineral deposit. An explosive mixture placed into these holes and then detonated serves to loosen overburden and shatter sub-surface rock formations.

Blast-hole drills are classified by their main power source, either diesel or electric, and by the diameter of the drilled hole, measured in inches. During this investigation, the most commonly encountered drill was enclosed, electrically powered, and in the 9" to 12" size range.

#### 3.1.2

##### Machine Description

The machinery space of a typical electric blast-hole drill is illustrated by Figures 2 and 3 as having four distinct enclosed areas. The largest of these areas,

the main machinery space, houses the main air compressor and drive motor. In addition, this space contains a motor-generator set for powering electrical functions, electrical cabinets containing controls and equipment, and automatic lubrication pumps and reservoirs. During operation, this area is pressurized to approximately 0.5" of water for ventilating purposes and to help maintain a relatively clean environment. Due to noise considerations, occupancy by personnel is limited to periodic inspection only. The primary power transformers and pressurizing fan intake are housed immediately adjacent to the main machinery space. A notable feature of this enclosure is the typical use of expanded metal as flooring. Forward of the machinery space is an enclosed passageway containing a hydraulic pump unit and reservoir and an auxiliary air compressor. Egress from the operator's cab, which contains both hydraulic and electric controls, can be made either through this passageway or through an access door to the drilling platform. Variations to this arrangement would include elimination of the transformer compartment in the case of a diesel drill, and inclusion of the hydraulic pump and reservoir into the main machinery space.

Combustible materials aboard these machines appear to be limited to the various working fluids and electrical equipment. In addition to the hydraulic fluid and lubricants, these fluids include transformer oil, the compressor cooling fluid, either automatic transmission fluid or a water-glycol mixture, and an air line antifreeze during cold weather operation.

### 3.2 Mining Shovel

#### 3.2.1 Functional Description

Two functions of the intermediate mining shovel are depicted in Figure 4. In this illustration, the lead shovel is engaged in removing a coal deposit for loading into haulage trucks, while the second shovel

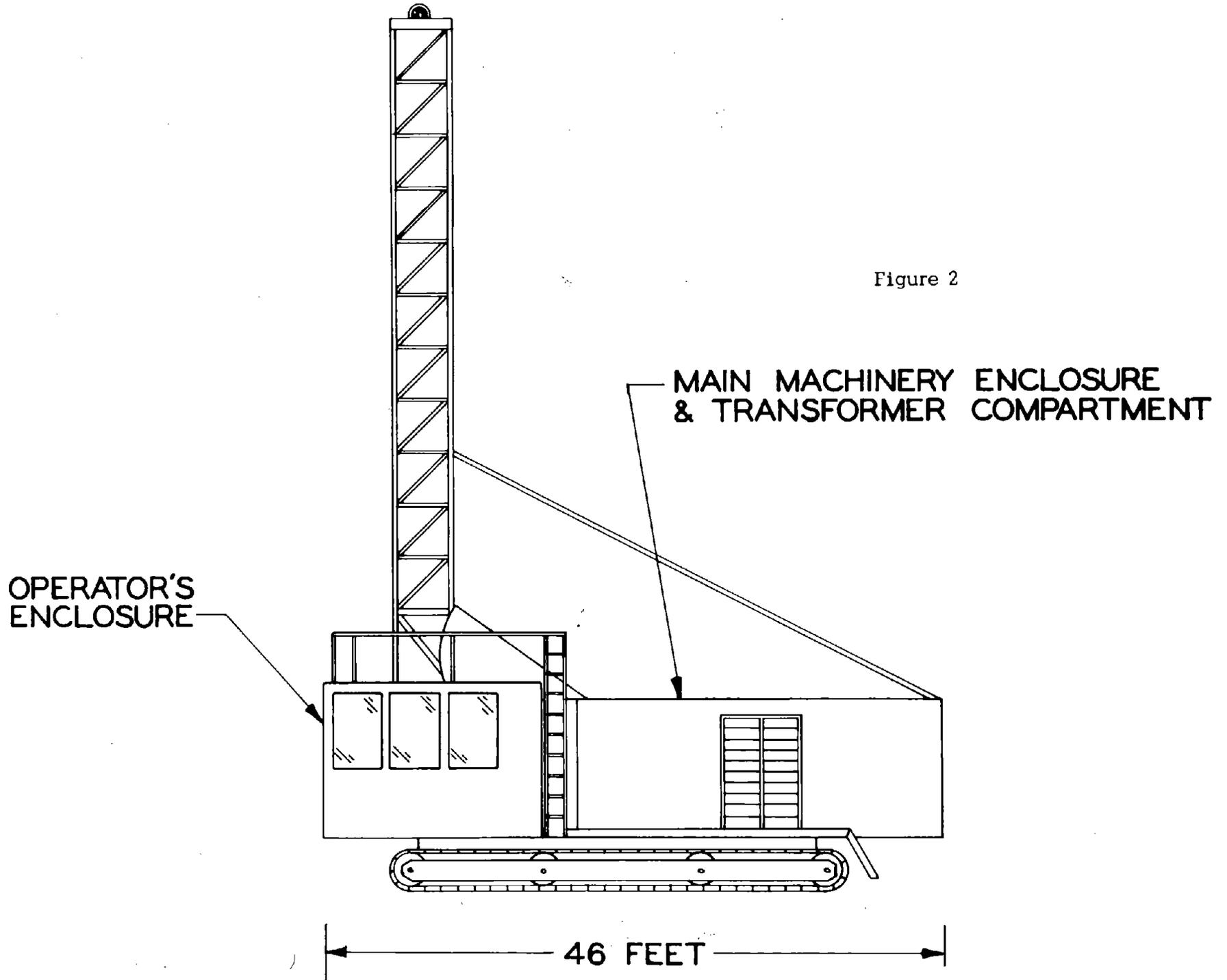
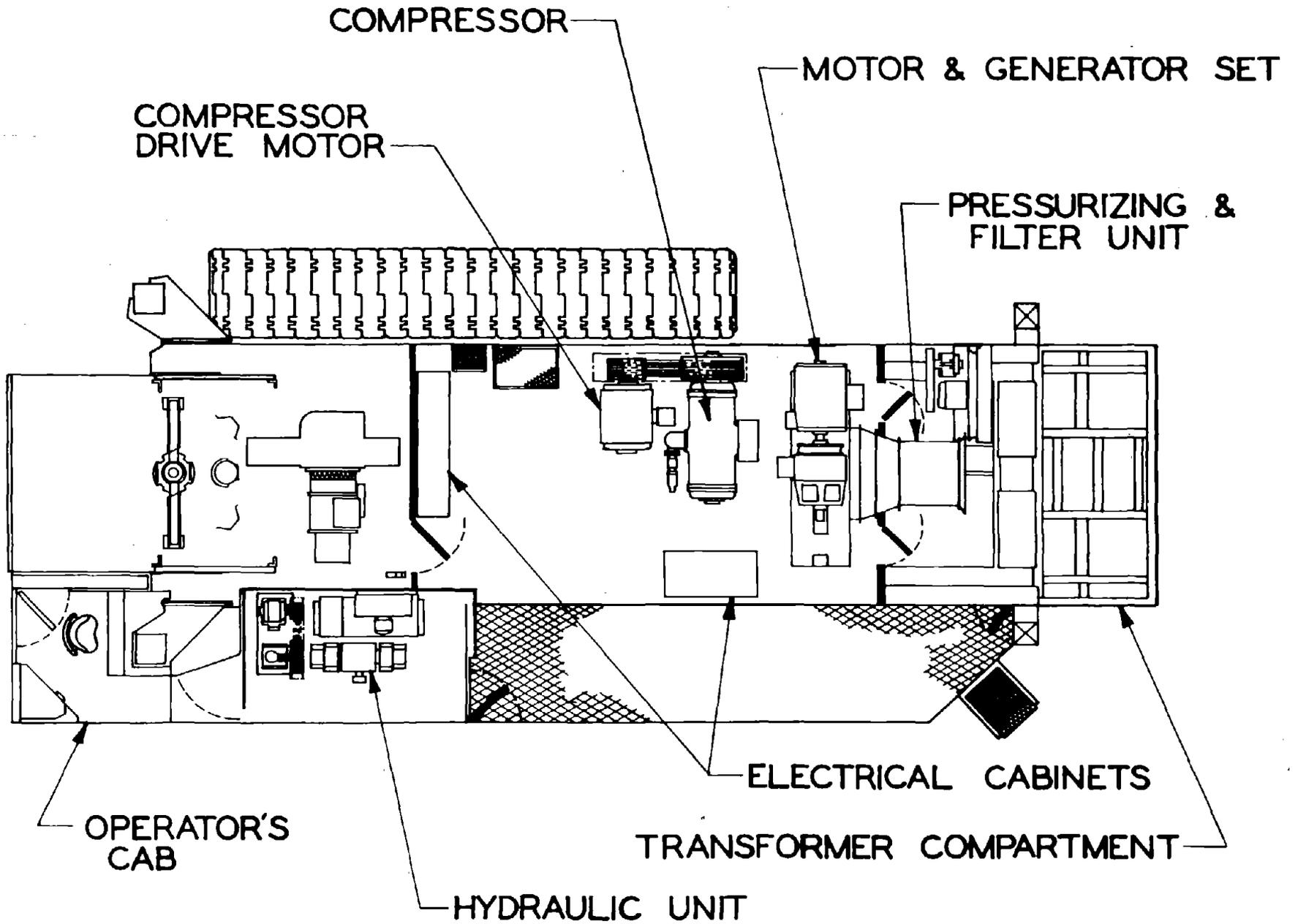


Figure 2

Figure 3



is performing a parting operation by removing a burden layer covering a second coal seam. Loading is the more common use of the intermediate shovel and is a function common to both coal and hard rock mining.



Figure 4

Shovels are primarily classified by bucket capacity. Commonly encountered capacities range from seven to 40 cubic yards. The primary power source is electric.

### 3.2.2

#### Machine Description

A typical shovel machinery space is illustrated by Figures 5 and 6. Centrally located in this space are the main hoist drum and drive motor. To the rear of the enclosure are the motor-generator sets

and ventilation fan intakes. As in the case of the blast-hole drill, the ventilation system is most often designed to pressurize the machinery space. Forward of the hoist drum and to either side of the rope opening are the shovel swing motors. To the left of the rope opening is the operator's enclosure, which is ventilated separately. Access to the operator's enclosure is normally through the machinery space and there is an emergency exit directly to an exterior walkway. Also housed in the machinery space are the electrical transformers and controls, an air compressor, and automatic lubrication pumps and reservoirs.

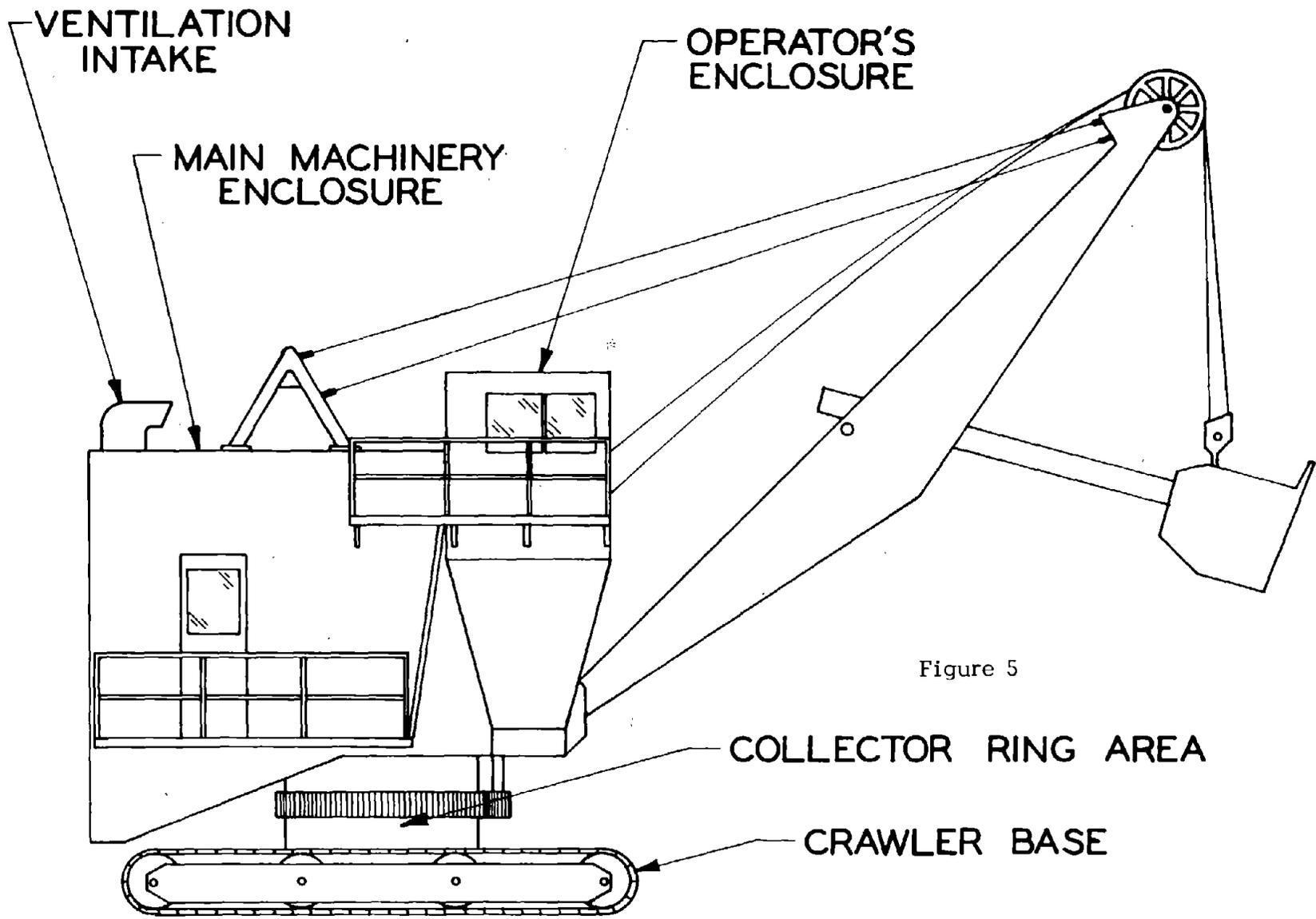
Directly beneath the machinery space deck and surrounding the center journal of the machine are the electrical collector rings which transfer power from the relatively stationary crawler base during the shovel swing motion. The rings are enclosed in a confined circular area, bounded by the shovel roller path and swing gear, and accessible only through the machine base. Due to its inaccessibility, this area tends to accumulate a measure of dust and lubricants which, as demonstrated by the minor fire in the equivalent area of a Marion 5900 stripping shovel, can become a fire hazard.

While the previously described motor-generator arrangement is common to most shovels, there exists a type in which the motor-generator sets are replaced with solid state controls. The most notable features of this arrangement are the inclusion of liquid dielectric capacitors in the control circuitry and the use of recirculated transformer fluid to cool certain of the solid-state devices.

### 3.3 Dragline

#### 3.3.1 Functional Description

The function of a walking dragline in a mining operation is large volume removal of overburden.

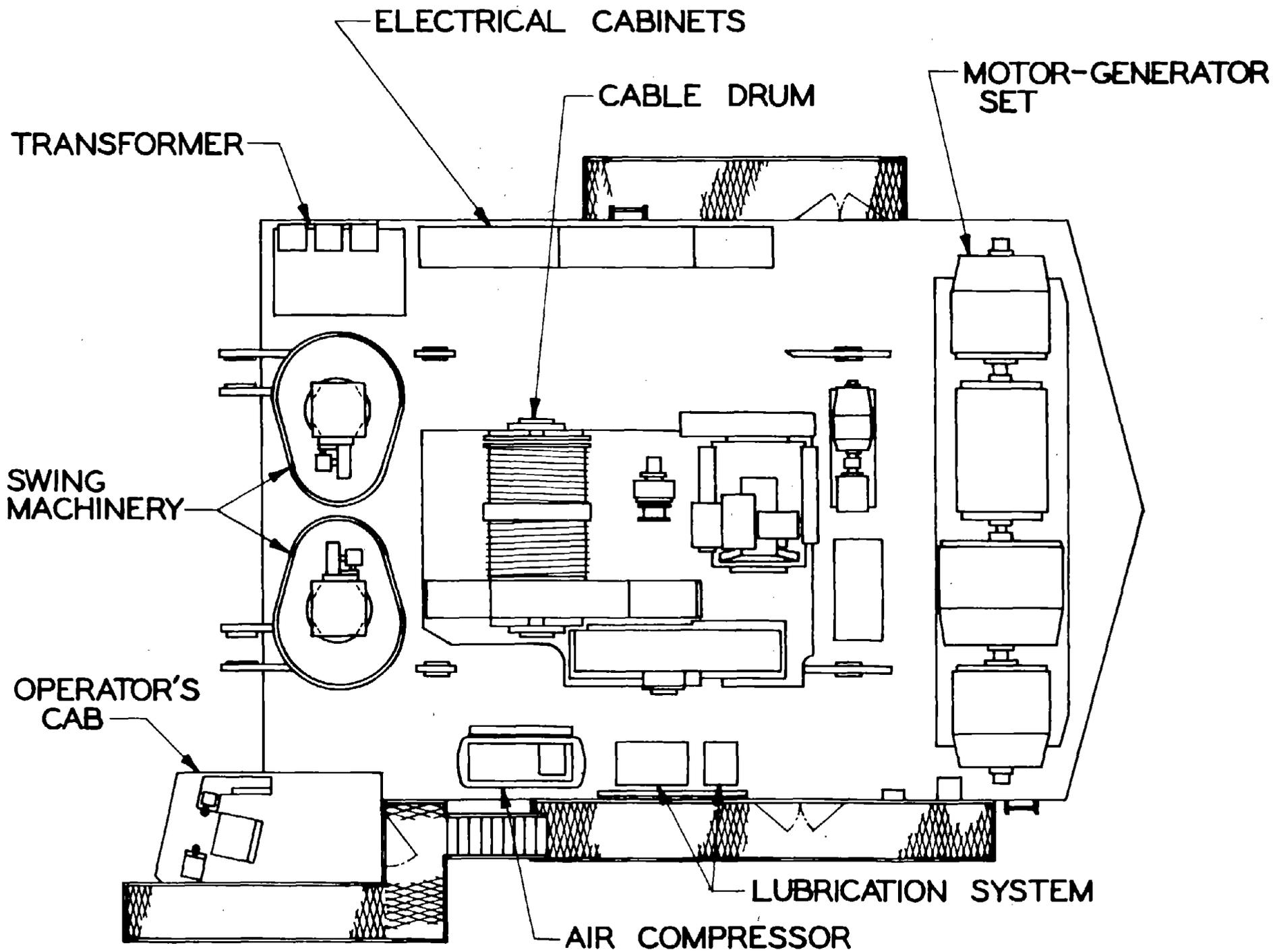


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Figure 5

60 FEET

Figure 6



Its typical use in a coal mining operation would be to expose the mineral deposit by removing the overburden layer, as depicted in Figure 7. In a phosphate mining operation the dragline may be used for direct removal of the phosphate material.

### 3.3.2

#### Machine Description

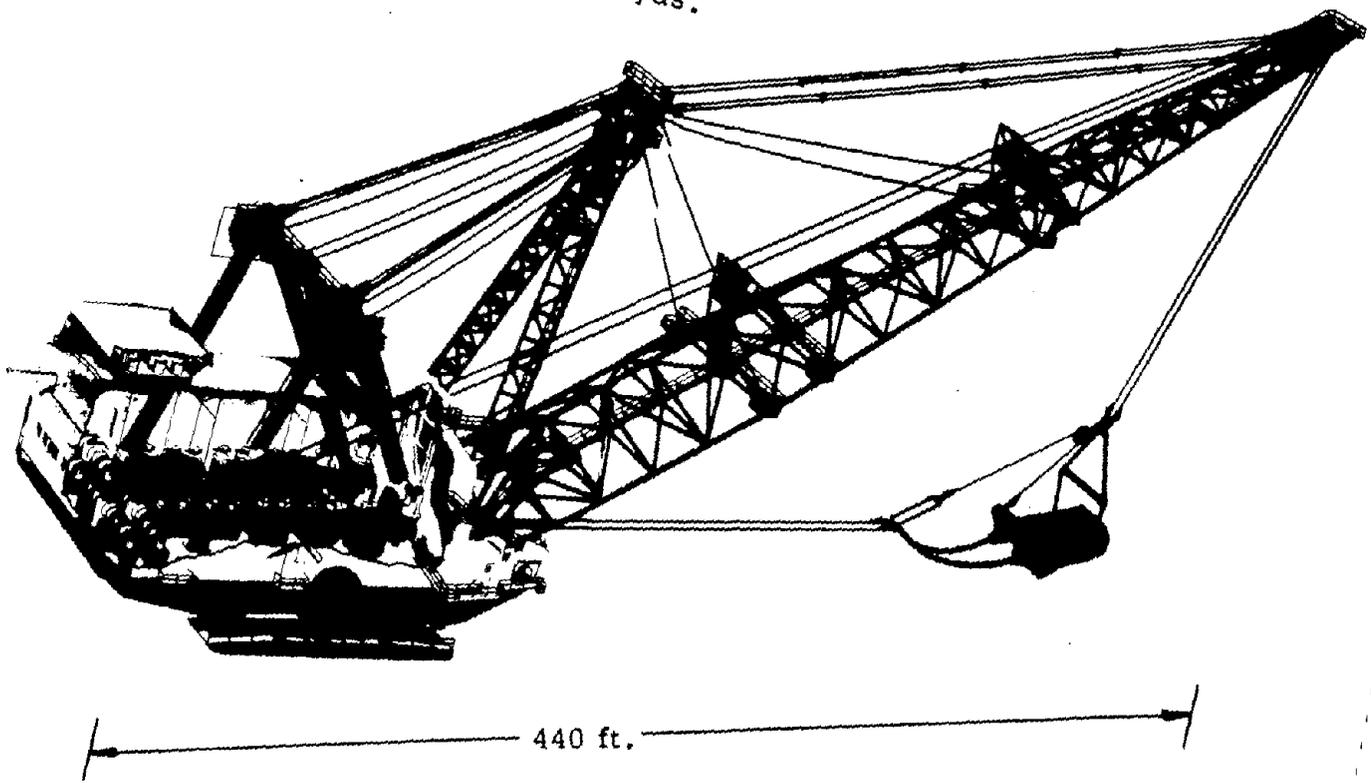
The dragline is by far the largest of the equipment types under consideration. The dragline illustrated in Figure 7 could typically have a boom 350' long, a 100 cubic yard bucket, and a 5000 sq.ft. main machinery deck. The corresponding height of the machinery enclosure could be 30'.

In a typical machine configuration, the dragline is supported by a circular base which contains the machine's center journal, swing rack, and roller path. Depending on machine size, the base could be 60' or more in diameter and approximately 6' high. The revolving frame is immediately above the base and supported by the swing rollers. The revolving frame is a compartmented structure of heavy construction forming the lower portion of the machinery enclosure. The boom and boom support frame are attached to the revolving frame. Within the revolving frame compartments are the walking mechanism, the electrical collector rings and, in some instances, high voltage electrical switching equipment. In some cases the collector rings are located in the roller path beneath the lower deck of the revolving frame.

The bulk and balance of the dragline machinery is mounted on the upper deck of the revolving base in the large volume main machinery enclosure. This

Figure 7

Bucket Capacity: 100 - 115 cu.yds.



Typical Modern Walking Dragline

includes the motor-generator sets , rope handling equipment, the automatic lubrication system, and the main electrical transformers and power control equipment. In a modern machine configuration the electrical control equipment would be housed in self-ventilated control rooms located near the operator's cab, with the main transformers located in compartments along the outside walls of the main enclosure. The lubrication center would be merely a centralized open area containing the lubrication drums and pumps. The operator's enclosure (or enclosures) would be located forward of the main machinery house on either one or both sides of the machine. As with the smaller types of equipment, the ventilation system is designed to pressurize the machinery enclosure. However, due to the size of the enclosure, the ventilation rate can equal hundreds of thousands of cfm.

Fire sources aboard the vehicles consist of the electrical transformers and control equipment and the various areas of grease accumulation, including the roller path area.

## 4.0

## SUPPRESSION SYSTEM DESIGN CONCEPTS

### 4.1

#### Design Approach

Many similarities of equipment design and operation exist among the manufacturers. However, within each of the equipment categories there are minor variations of construction which could directly affect or limit the design of a fire suppression system for a specific piece of equipment. These variations, typically related to the degree of enclosure integrity or access to a specific area, eliminate the possibility of an agent/detection combination that could be universally applied to all or each of the equipment types.

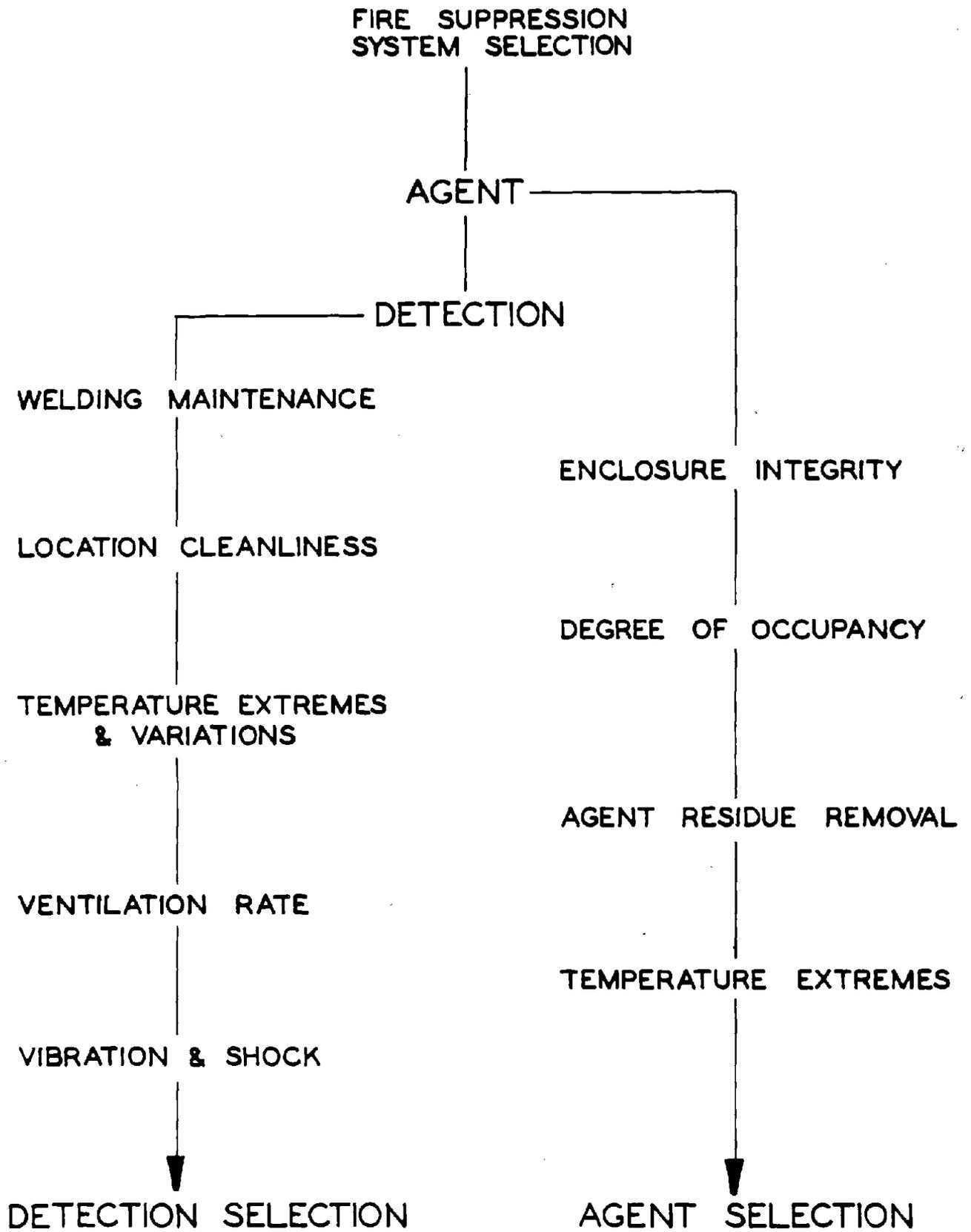
Based on this observation, a list was made of the machine construction and mine environmental considerations having greatest affect on suppression system design. Factors affecting agent selection are the machinery space enclosure integrity, the degree of human occupancy, and agent residue removal. Factors pertaining to choice of detection are location cleanliness, welding maintenance, vibration/shock, temperature variations, and machinery space ventilation. Figure 8 summarizes these items in the form of a flow chart leading to agent/detection selection.

Suppression system design would be based on evaluation of these considerations with regard to the properties of the various agents and characteristics of the detection alternatives. Sections 4.1.1 and 4.1.2 list the available agents and detection methods and briefly summarize their pertinent characteristics.

The design concepts presented in the following sections are based on consideration of these items in regard to "typical" machine configurations. Application of the concepts would require a second review of these design considerations regarding the specific piece of equipment.

The proposed concepts, as described, are limited to automatic fixed systems in accordance with the contract objective. However, these systems do not negate the

Figure 8



need for hand portable extinguishers and, in some cases, the wheeled extinguishers, which may be currently installed. This equipment will continue to be required for effective fire protection and may be the only protection provided for parts of the machinery not covered by the proposed automatic systems. In some applications consideration should be given to the use of automatic detection devices to provide a warning to the operator where suppression systems may not be practical.

#### 4.1.1

#### Agent Alternatives

- Dry Chemical  
Multipurpose dry chemical is effective on Class A, B and C fires in both local and total flooding applications. Agent residue removal can be a significant factor, primarily in the presence of electrical control equipment. Although non-toxic, personnel visibility can be impaired during discharge.
- Carbon Dioxide  
Carbon dioxide is also effective on Class A, B and C fires. However, being a gaseous agent, its effectiveness, especially on Class A fires, is limited by the system's ability to maintain a prescribed concentration for a minimum length of time. Since carbon dioxide functions as an agent by oxygen exclusion, its use can be hazardous to personnel.
- Halon 1301  
Halon 1301 is a gaseous agent used primarily for total flooding applications in closed spaces. A distinct advantage is that extinguishing concentrations of 5 to 7 percent are considered by NFPA to be not harmful to personnel. It is used effectively on Class A surface fires, Class B and Class C fires. Deep-seated Class A fires require considerably higher concentrations and longer exposure times.

- Water  
Water is effective primarily on Class A fires, but can control and extinguish certain flammable liquids by the cooling effect. Relative to other agents, a large supply is generally required. Use of water on live electrical equipment can endanger operating personnel.
- Foam  
The various foam agents are most effective for Class B fires and are also used for Class A fires. However, the low expansion foams are not effective for three dimensional fires of the type expected in machinery spaces. The foams are water derivatives and as with water their use on live electric equipment can endanger operating personnel.

#### 4.1.2

#### Detection Alternatives

- Thermal  
Thermal detectors respond to radiated heat energy and are generally slow in response. They are of rugged construction and are insensitive to high humidity and dirt build-up. Minimum maintenance is required.
- Smoke  
Smoke detectors respond to particulate matter during early combustion stages of fire. They are particularly sensitive to humidity, temperature and air velocity changes and are normally used in a clean, controlled environment. A medium amount of maintenance is required for cleaning and for sensitivity adjustment.
- Flame  
Flame detectors have a high-speed response to an open flame and are suitable for explosion suppression. Generally they are of rugged construction and are capable of operating in hazardous locations. A high level of maintenance is required due to optical lenses.
- Special Applications of Smoke Detectors  
Varying special applications are possible with some sampling systems which allow a high degree of reliability. These include ionization chamber and pressure chamber principles to determine the presence of combustion products.

### System Design Concept for Blast-Hole Drill

Referring to the blast-hole drill description (Section 3.1.2), it is apparent that three of the four enclosed areas are similar. The main machinery space, the hydraulic room, and operator's cab all have a high degree of enclosure integrity and have varying degrees of human occupancy. The fourth area, the transformer enclosure, is little more than a protective covering due to the open floor construction. Presence of personnel in this area is practically non-existent due primarily to the mine safety practice of locking access to electrical equipment.

Considering the potential presence of personnel in the main enclosure, hydraulic room and operator's cab, the optimum agent choice would be Halon 1301. An additional factor supporting the selection of Halon 1301 is the elimination of agent residue which, because of the electrical controls and equipment present, could demand a significant clean-up effort. Due to the manner of construction of the transformer enclosure, a gaseous agent such as Halon 1301 would prove an ineffective means of protection. Based on the relative effectiveness of the remaining agent alternatives to rapidly extinguish a transformer fire, the selected agent would be dry chemical.

In the selection of detection devices, drill operating conditions support the use of fixed temperature thermal detectors. Vibration, dust, shock and maintenance operations, such as welding, would pose obstructions to the use of optical or standard ionization detectors. Rate of temperature rise thermal detectors, while being insensitive to normal environmental temperature changes, would probably be adversely affected by temperature fluctuations occurring during the ventilation system start-up and shut-down.

Figure 9 describes the BHD suppression system design concept by listing the system components and illustrating its application on a typical drill configuration.

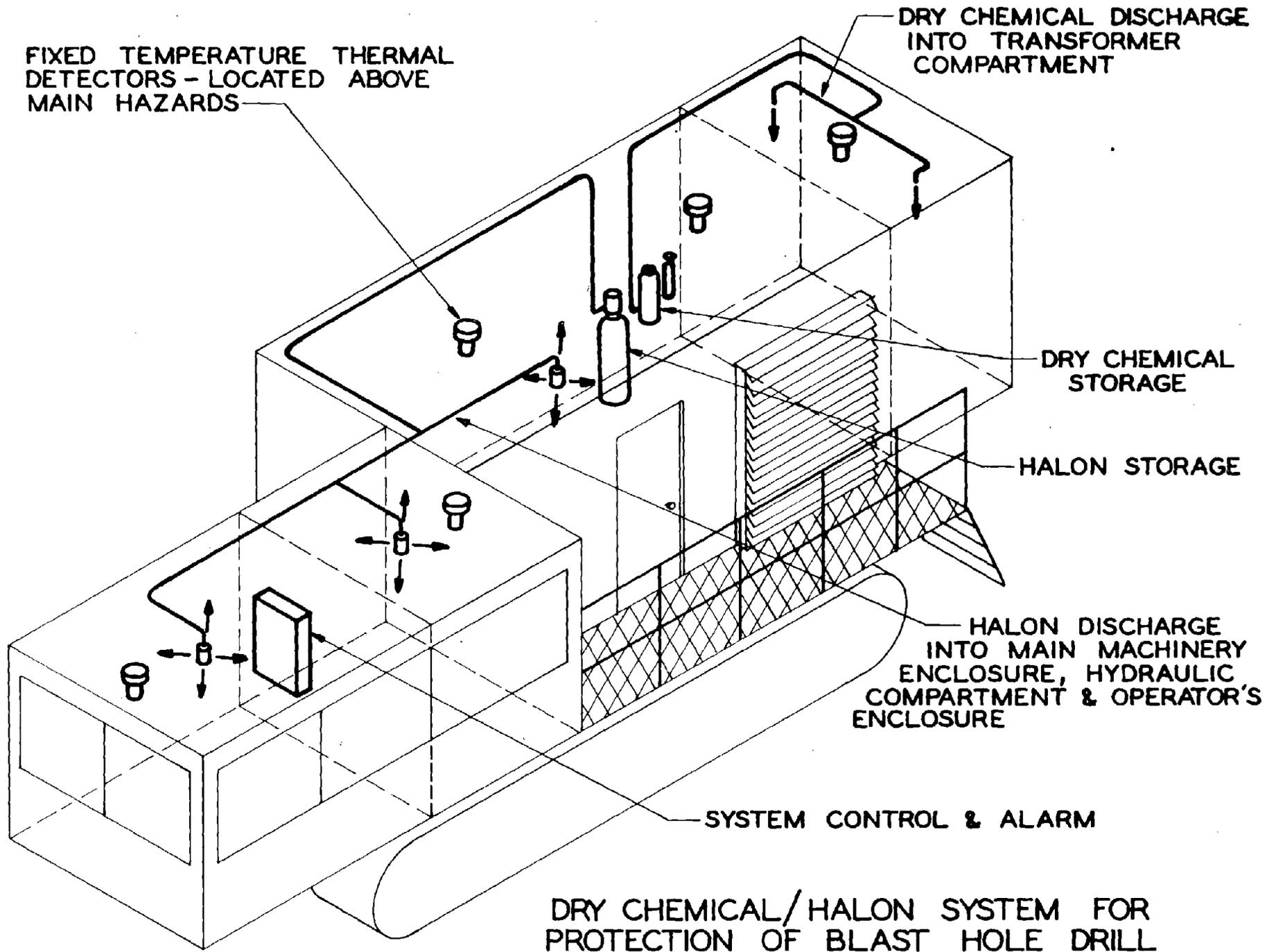


Figure 9

Detection of a fire condition in any of the four enclosures would initiate an audible alarm signal and disconnect the main power via the power supply ground fault disconnect system. Following a brief delay period to allow personnel evacuation and the ventilating air movement to subside, the system would flood the operator's cab, hydraulic room, and main machinery enclosure with appropriate concentration of Halon 1301. Simultaneously, dry chemical would be applied to the transformers in the rear enclosure. An auxiliary power supply capable of actuating the system in the event of a power failure would continue to sound the alarm until disconnected. Agent tanks are shown located within the main enclosure, but could be located externally if necessary. The system control is shown located within the operator's enclosure and would be capable of indicating the system status and would allow manual system actuation.

In the proposed system concept, fixed temperature detection is recommended because of its overall reliability in this type environment, but it is characterized as a slow-response system. We are proposing consideration of a sampling type ionization detector, such as the Brunswick Mark 2 smoke detector, as an alternate possibility in cases where a faster response to a fire condition is desired. The standard on-the-shelf ionization pick-ups would not be suitable in the dust environment of the blast-hole drill. However, there is data to indicate that the Brunswick system can tolerate these levels of air contamination.

#### 4.3 System Design Concept for Mining Shovel

##### 4.3.1 Main Machinery Enclosure

Analysis of the suppression system design considerations for the machinery enclosure of a mining shovel is similar to that of a blast-hole drill. As with the BHD, the possibility of human occupancy exists during maintenance work and periodically during machine operation. The presence of electrical controls and

equipment (in some instances solid state controls), also demands consideration of agent residue removal. However, significant differences do exist in the degree of enclosure integrity, not only with respect to a BHD, but also among the various shovel types and sizes. The rope opening, the major unclosable opening in the machinery enclosure, can vary from a four or five sq. ft. area to an area several feet wide and extending the height of the enclosure.

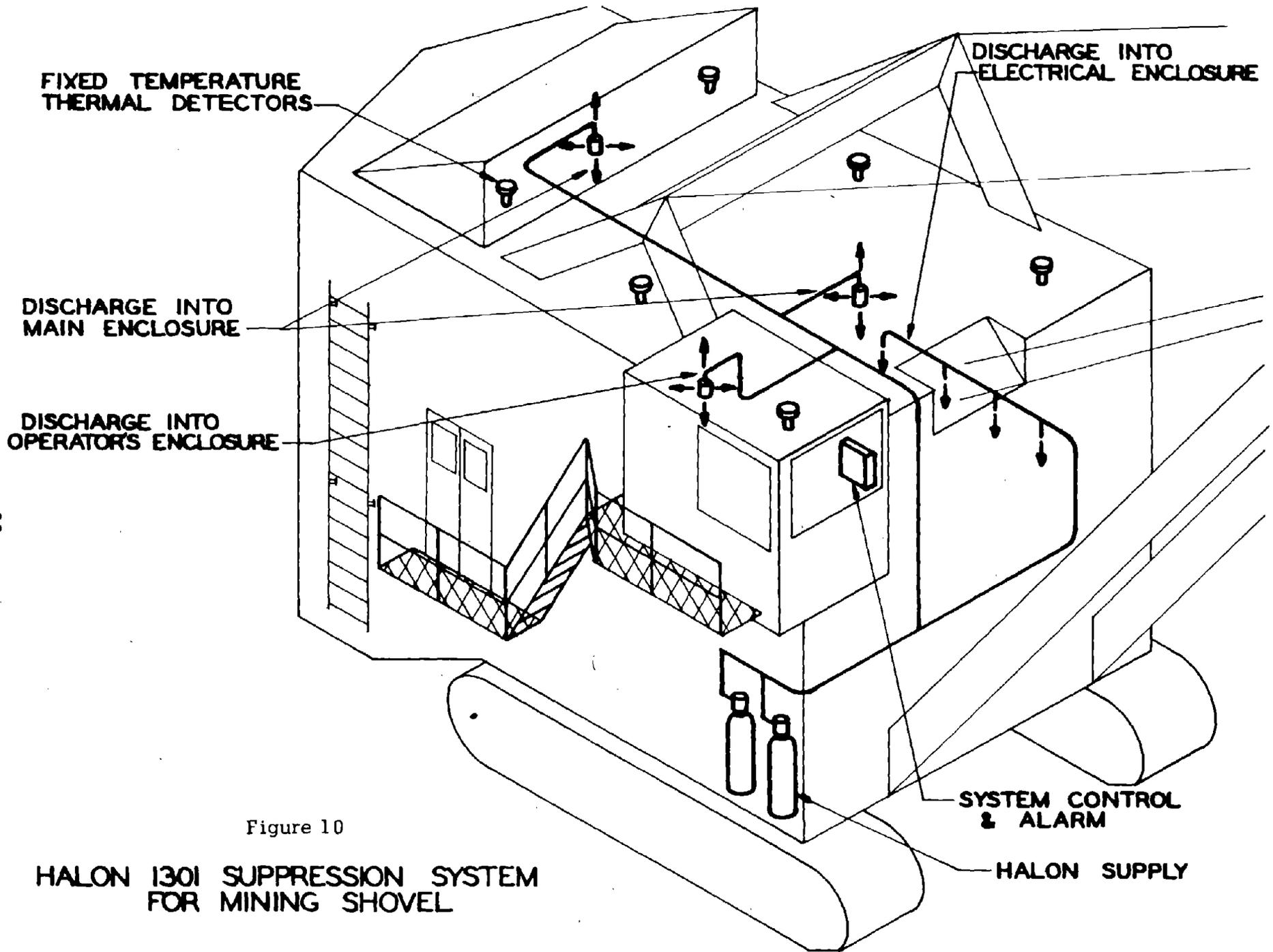
Two alternatives for protection of a mining shovel machinery space are shown in Figures 10 and 11. Figure 10 describes a Halon 1301 system designed to flood the operator's cab, machinery space and electrical enclosures. Figure 11 describes a combination dry chemical/Halon 1301 system intended for use where the cable opening size prohibits use of a gaseous agent alone. In the combination system, dry chemical protects the main enclosure, while Halon 1301 protects the operator's cab and electrical enclosures. The use of Halon 1301 in the electrical enclosures will insure complete penetration of agent into the enclosures and, in the combination system, would prevent dry chemical from entering, thus eliminating a significant portion of the clean-up effort. Environmental and operating conditions identical to those experienced in a BHD again support the use of fixed temperature thermal detectors or possibly the Brunswick system.

In operation, both systems would shut down the ventilation system and sound an audible alarm upon detection of a fire situation. Following a delay to allow the operator to safely stop the motion of the shovel and evacuate the machine, power would be removed via the ground fault system and the agents released. The alarm would continue to function until disconnected from the emergency power supply.

#### 4.3.2

##### Collector Ring Area

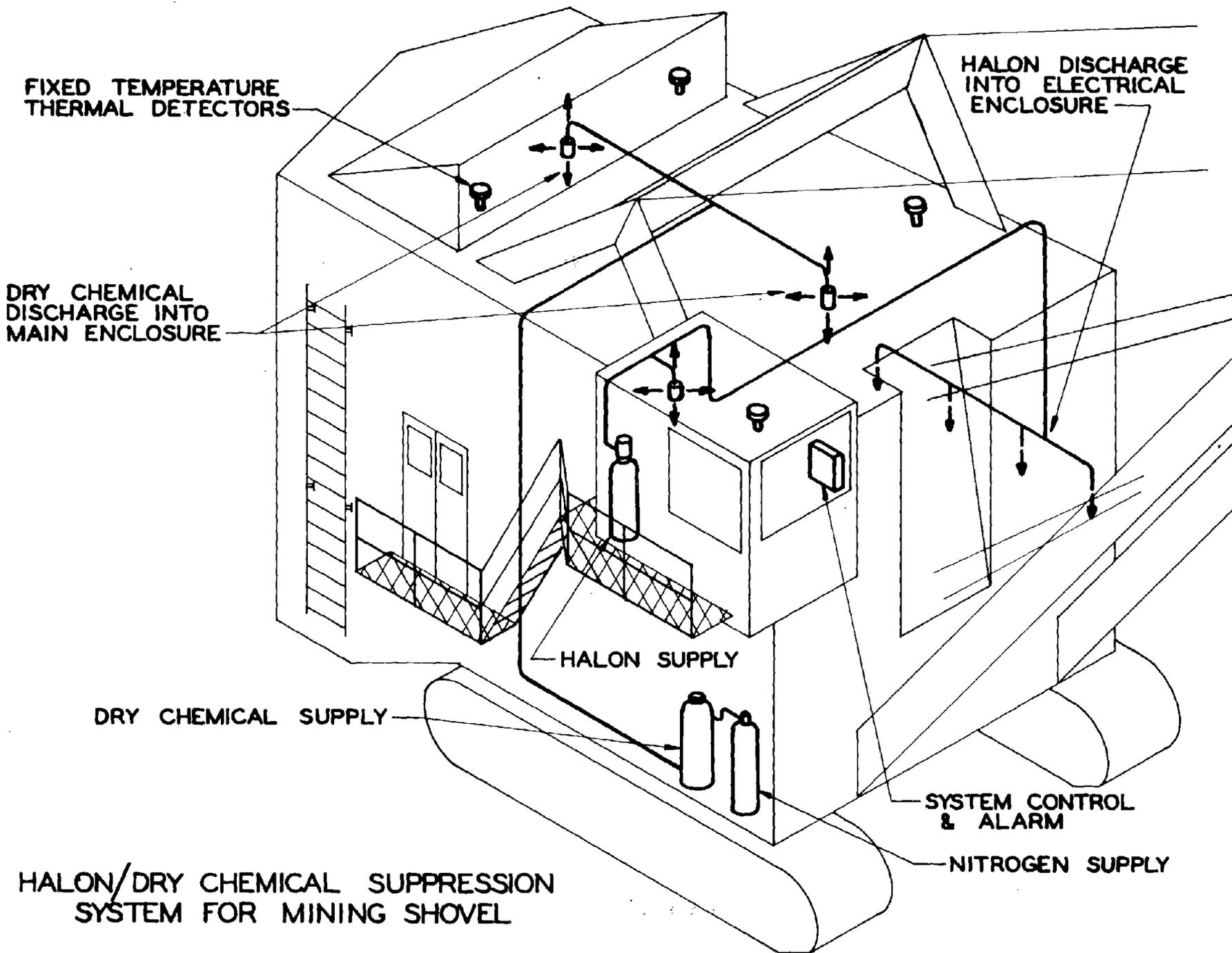
Protection of the collector ring area beneath the machinery deck would best be accomplished with dry chemical due to this area's open construction. Detection, agent storage



39

Figure 10

**HALON 1301 SUPPRESSION SYSTEM FOR MINING SHOVEL**



**HALON/DRY CHEMICAL SUPPRESSION  
SYSTEM FOR MINING SHOVEL**

Figure 11

and incorporation into the main suppression system will depend on access to the collector ring area and the power (if any) available in the crawler base.

Figure 12 depicts a dry chemical system applied to a crawler base configuration which has allowed external access to the collector ring area from above the roller bearings. Agent tanks are shown mounted within the machinery enclosure and piped to the four access points. Fixed temperature detection is provided by thermistor cable suspended from the underside of the machinery deck. The detection circuitry would provide the same alarm/delay/power cut-off and actuation sequence as described for the main machinery enclosure suppression system.

Figure 13 depicts a second crawler base configuration in which access to the collector ring area can be obtained only from the underside of the crawler base. The agent tanks are shown mounted on the base and piped to discharge nozzles within the collector ring area. The presence of low voltage electrical power would permit use of the thermistor wire detection system and the power cut-off delay. The absence of electrical power would necessitate the use of a self-contained system such as the type employing pressurized pneumatic tubing for detection. The application of the system components would be identical to the thermistor wire system. However, due to the lack of electrical power, discharge would be immediate with no alarm, power cut-off or delay options.

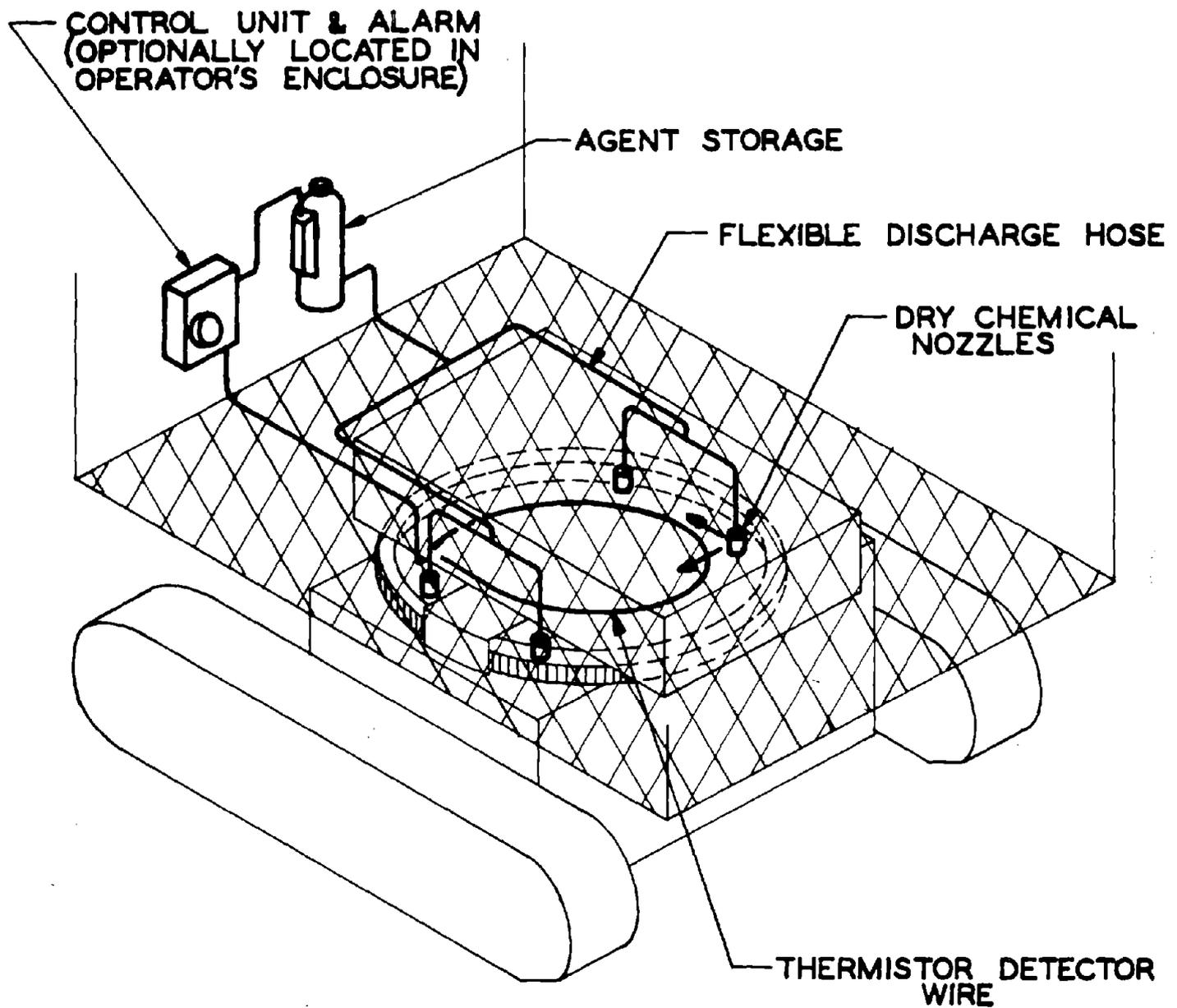


Figure 12

**MACHINERY ENCLOSURE MOUNTED DRY CHEMICAL  
SYSTEM FOR PROTECTION OF COLLECTOR RING AREA**

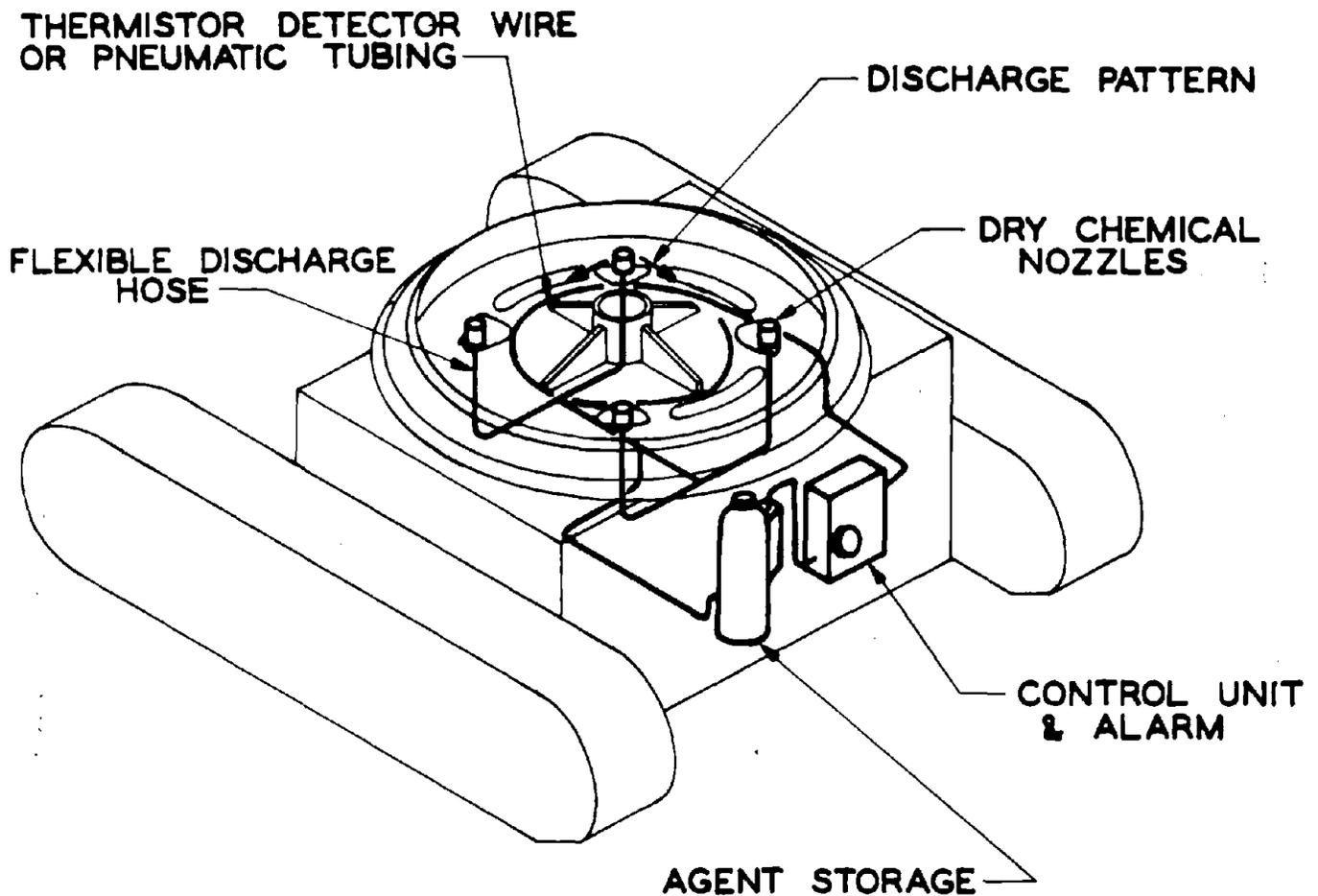


Figure 13

**CRAWLER BASE MOUNTED DRY CHEMICAL SYSTEM  
FOR PROTECTION OF COLLECTOR RING AREA**

System Design Concept for Walking Dragline

Due to the large physical size of a dragline, a suppression system designed to total flood the main machinery enclosure would not be justified from either a cost or effectiveness viewpoint. An alternate approach would be to provide a series of systems, each designed to independently protect a specific area within the enclosure, yet be integrated into a single fire control system via a master control located within the operator's enclosure. In a system of this type, each area to be protected would be analyzed independently for selection of agent and method of detection.

In general, the areas of a dragline that warrant protection would include the electrical equipment, specifically the transformers and control equipment, and the various areas in which an accumulation of lubricants may be present. Figures 14, 15 and 16 depict systems protecting three such areas.

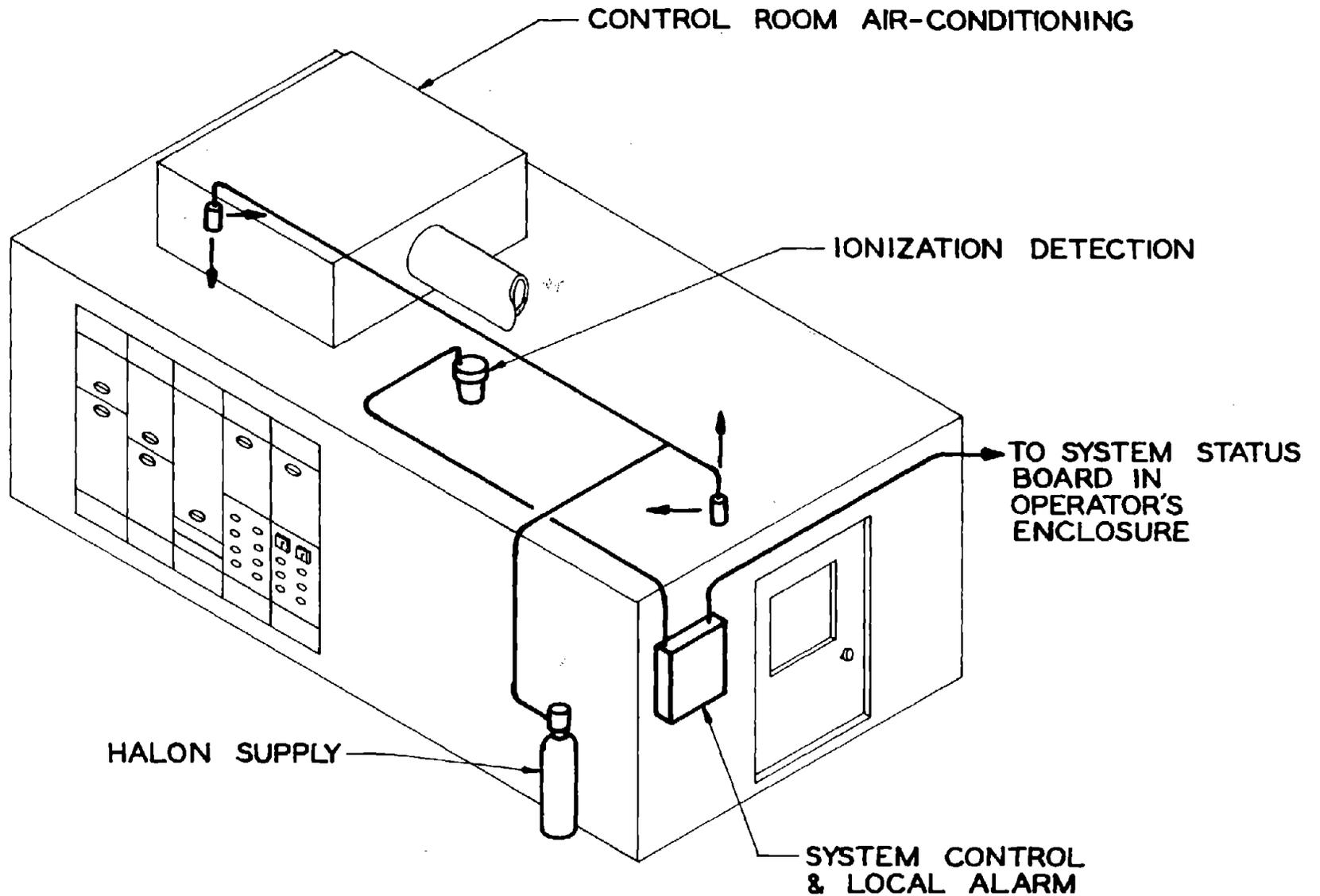
Figure 14 depicts a Halon 1301 suppression system protecting a dragline power control room. The agent choice is based on a high degree of enclosure integrity, the possibility of human occupancy and the presence of delicate electrical equipment which could be damaged by an agent residue. The indicated type of detection is ionization. Due to the "computer room" atmosphere of this area, factors such as the high ventilation rate and location cleanliness, which would adversely affect normal ionization detection elsewhere on a dragline, are not governing considerations. This condition, along with the basic desire to limit fire damage by rapid detection, has promoted selection of ionization detection. Upon activation, the system would immediately shut down the control room's ventilation, sound a local alarm, and notify the operator that a fire exists in the room. Following a brief time delay to allow the ventilation effects to subside, the agent would be released.

Figure 15 depicts a dry chemical/fixed temperature detection/suppression system to protect a main power transformer. Dry chemical is the specified agent due to the typical use of expanded metal ventilation openings

which would not allow containment of a gaseous agent. Fixed temperature detection is indicated as acceptable, however, since the enclosure would shield the detection system from normal welding maintenance, faster reacting detection, such as ultraviolet or infrared, could be used. Additional factors would be increased system maintenance and higher initial cost. Regardless of the type of detection, in a fire situation the system would simultaneously sound a local alarm, release the agent and notify the dragline operator.

The dry chemical system depicted in Figure 16 is for the protection of the roller path area beneath the lower deck of the revolving frame. Dry chemical is again selected due to the low degree of enclosure integrity. Because of the extremely adverse operating conditions, fixed temperature is indicated as the optimum detection choice. As with the transformer suppression system, discharge and alarm would occur immediately upon detection of a fire condition.

Depending entirely on individual dragline construction, additional areas may exist that warrant protection due to the presence of electrical equipment or accumulation of combustible materials. Consideration might be given to such areas as auxiliary transformers, circuit breakers, and collector rings. Selection of automatic suppression system components for these areas would follow the examples of the previously described system components.



HALON 1301 SYSTEM PROTECTING DRAGLINE CENTRAL CONTROL ROOM

Figure 14

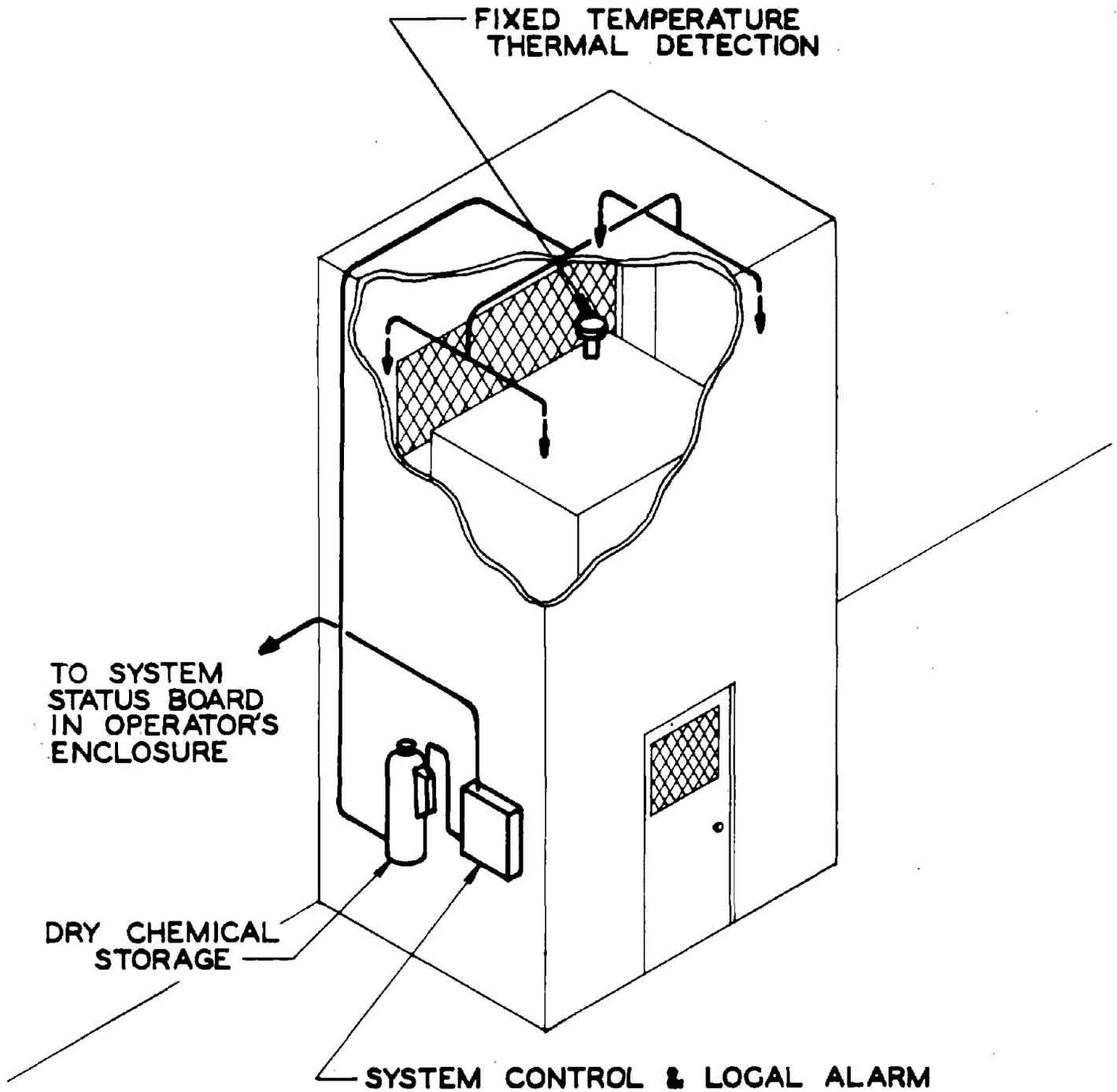
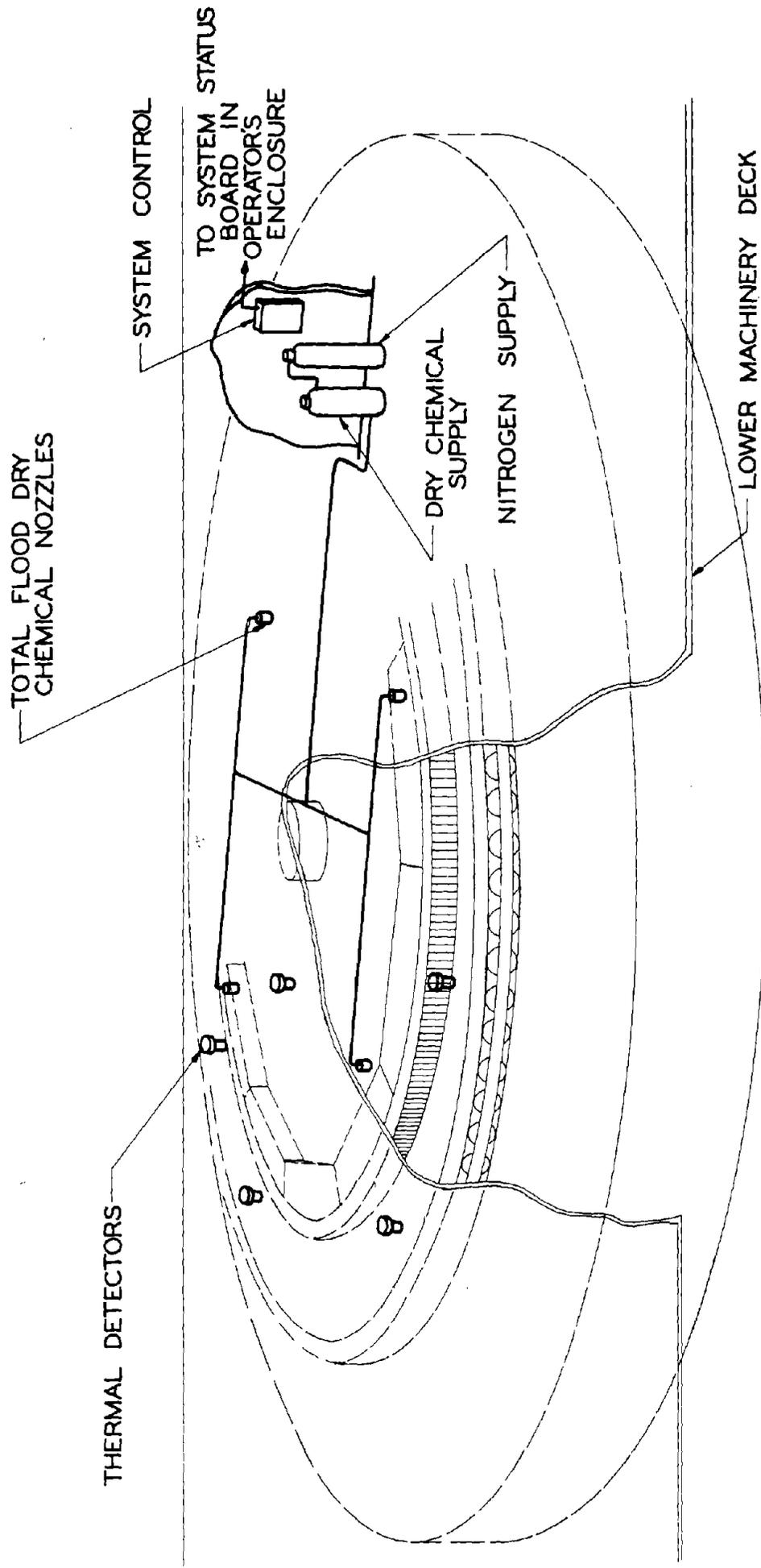


Figure 15

DRY CHEMICAL PROTECTION FOR DRAGLINE  
TRANSFORMER ENCLOSURE



DRY CHEMICAL SYSTEM FOR DRAGLINE  
 ROLLER PATH AREA

Figure 16

5.0 DESIGN PLANS FOR BLAST-HOLE DRILL FIRE CONTROL SYSTEM

The following system was specifically designed for the Bucyrus-Erie 61R drill (Serial No. 130385) located at the Peabody Coal Company Lynnville Mine. Due to the external mounting of the power transformers on this particular machine, the suppression system was limited to protection of the enclosed machinery areas with Halon 1301.

5.1 System Description

5.1.1 Design Data

The suppression system is designed to automatically flood the operator's enclosure, the hydraulic room and the main machinery enclosure with a 5% minimum concentration of Halon 1301 and to maintain an extinguishing concentration for approximately 10 minutes. To compensate for the unclosable ventilation openings, the concentration is maintained through application of the extended discharge technique described in NFPA 12A, A-2530. The table below summarizes the specific design information pertaining to the initial discharge agent concentrations and quantity requirements. Appendix C of this report contains the computer print-outs of the system's detailed design calculations.

Bucyrus-Erie 61R Drill - Suppression System Design Data

<u>Enclosure Area</u>	<u>Design Temp. (°F)</u>	<u>Total Volume (cu.ft.)</u>	<u>Design Conc. @</u>		<u>Agent Required (lbs.)</u>
			<u>Min. Temp.</u>	<u>Max. Temp.</u>	
Machinery	30 - 130	1216	5.3	6.4	29
Hydraulic	30 - 100	337	5.3	6.0	9
Operator's	30 - 100	333	5.4	6.1	<u>8</u>

Total Agent Required: 46

The extended discharge is provided by a separate halon supply connected to the distribution piping via a metering orifice. The orifice is sized to correct for the anticipated leakage at the midpoint of the design temperature range. Factors affecting the design of the extended discharge system are an unclosable opening leakage rate which decreases with the enclosure concentration and the direct relationship of the metering orifice flow rate to the storage cylinder pressure. The storage cylinder pressure is affected initially by the ambient temperature condition and, secondly, becomes a decreasing function during the time of discharge. Figure 17 shows the calculated enclosure concentration versus time for the main machinery enclosure of the 61R BHD at various ambient temperature conditions, with and without the effects of an extended discharge. The calculations were based on an unclosable ventilation opening of 2.25 sq. ft. in the machinery enclosure and a 19-pound extended discharge supply metered through a No. 69 drill size orifice. The halon is distributed to the various BHD compartments in approximately the same proportions as the initial discharge via the distribution piping.

The length of the extended discharge will vary from approximately eight to 10 minutes, depending on the initial pressure and temperature of the storage cylinder.

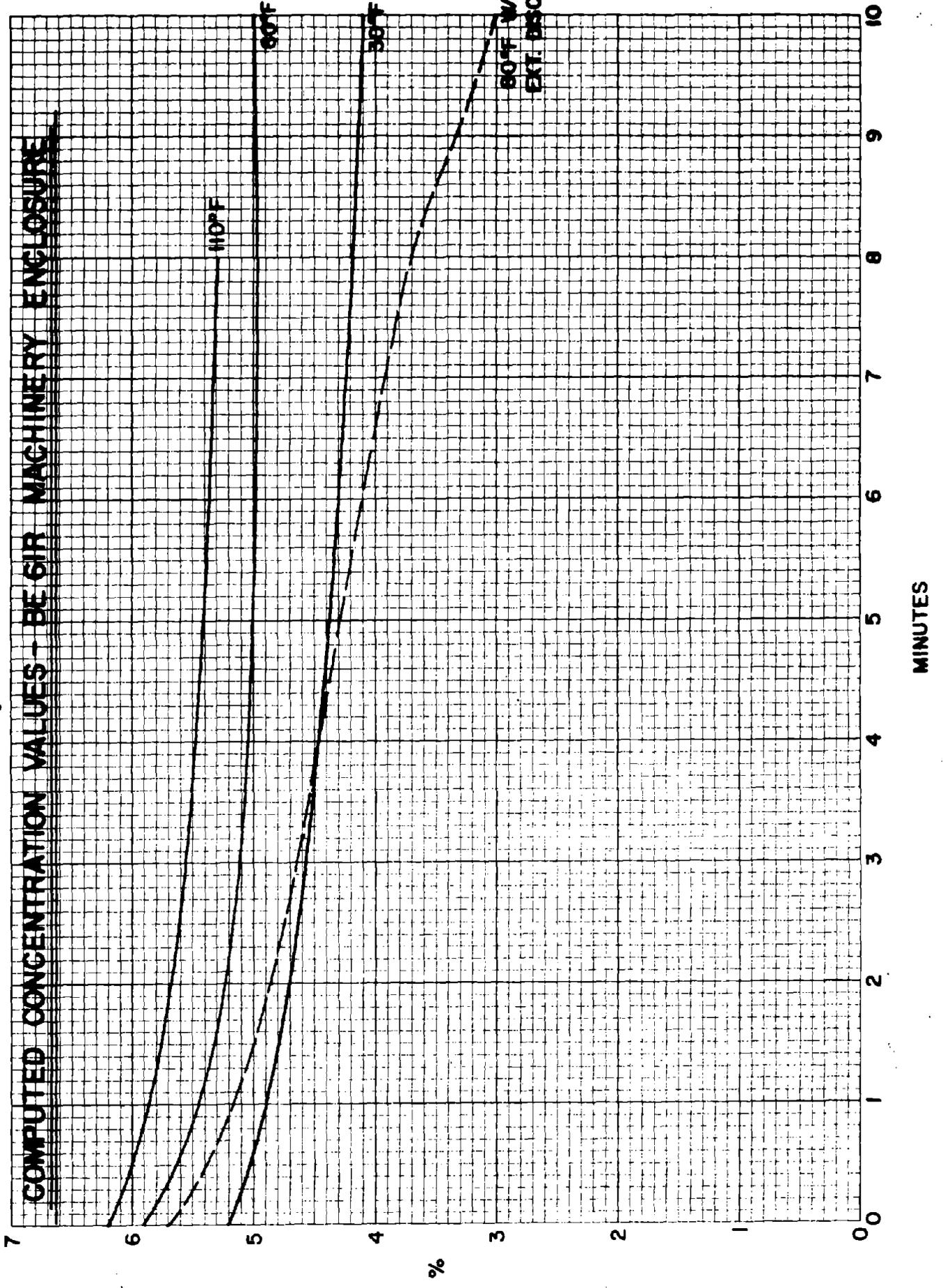
#### 5.1.2

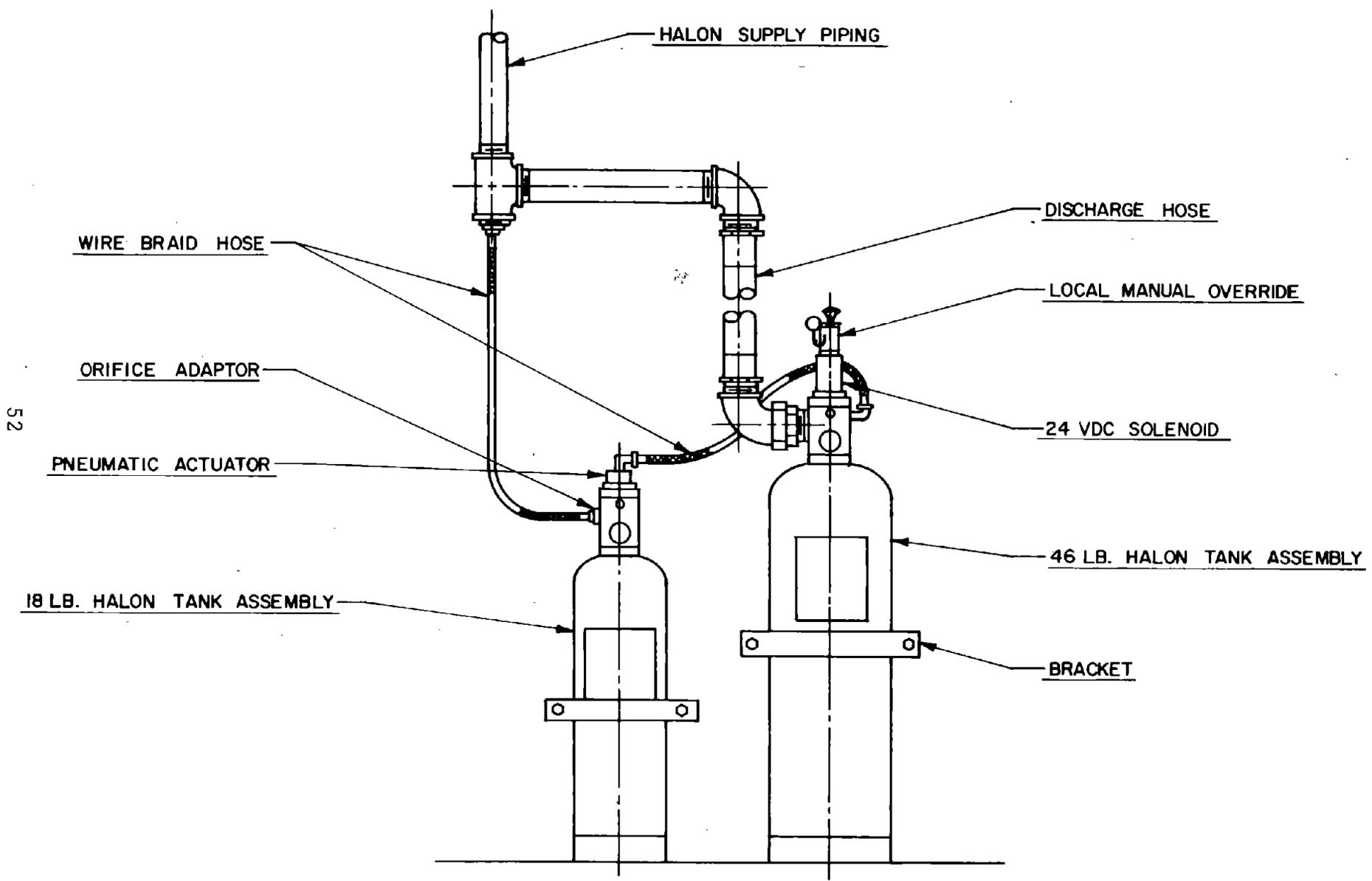
##### Agent Storage

The agent storage reservoirs (Figure 18) are DOT 4BA or 4BW-500 cylinders equipped with differential pressure Ansul cylinder valves. The main agent reservoir contains 46 pounds of Halon 1301 and is connected directly to the distribution piping. The extended discharge cylinder contains 19 pounds of Halon 1301 which is discharged into the piping network via a metering orifice located in the valve outlet. Actuation of the main cylinder is accomplished with an electrically-actuated solenoid actuation equipped with an emergency manual override. Actuation of the extended discharge cylinder is provided by a slave pneumatic actuator by the discharge pressure of the main cylinder.

Figure 17

COMPUTED CONCENTRATION VALUES - BE GIR MACHINERY ENCLOSURE





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Figure 18  
TANK DETAIL

### 5.1.3

#### Detection and Control

Detection, actuation, equipment shutdown, and alarm accessories are controlled by an Ansul prototype RCU control unit. The ruggedized control unit (RCU) circuitry is designed to be shock and vibration resistant and is mounted in a rugged, gasketed enclosure. Emergency power for approximately 24 hours is provided by standby batteries, kept continually charged by the RCU power supply. All critical circuits, including actuation, detection and the power supply, are continually monitored and, should trouble occur, the unit will provide an audible and visual signal. Automatic detection is provided by seven Fenwal Corporation thermal detectors factory set for 190°F. Figure 19 shows the relative placement of the detectors, alarms and control unit. Detectors are located above the air compressors, the motor generator set, the hydraulic reservoir and behind the hydraulic control panel within the operator's enclosure. Manual pull stations are provided at the two exit doors with an audible alarm near the operator's cab and within the main machinery enclosure. The detailed schematic of the ruggedized control unit, and the system wiring diagram are included in Appendix E.

### 5.1.4

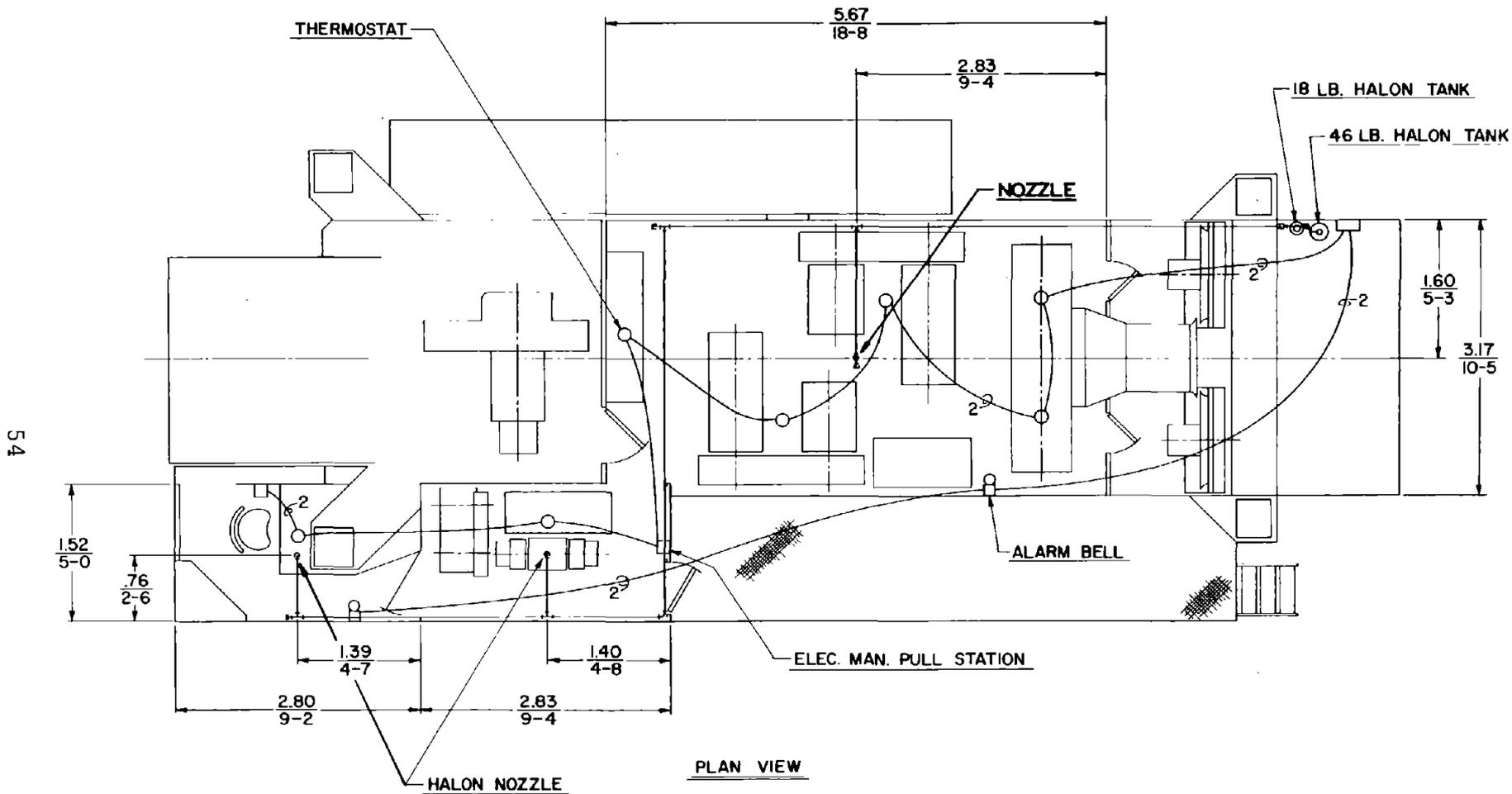
#### Distribution Piping

The distribution piping system contains approximately 62 pounds of ASTM A-53 or A-106 galvanized piping ranging in size from 1/4" to 1". Figures 19 and 20 describe the piping network and placement of the Ansul Type "V" nozzles within the enclosures. The pipe diameters and nozzle orifices are hydraulically balanced in accordance with NFPA-12A to deliver the minimum design concentrations to the various enclosures within a 10-second maximum discharge. The piping, in conjunction with an orifice plate located in the extended discharge storage cylinder valve, is used to meter and deliver the agent during the extended discharge.

### 5.1.5

#### Early Warning Detection System

A Brunswick Corporation smoke detector is included in the system detection network to provide an early warning capability. The Brunswick detector differs from



METER  
FEET-INCH ; METER / FEET-INCH

Figure 19

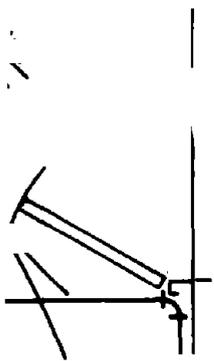
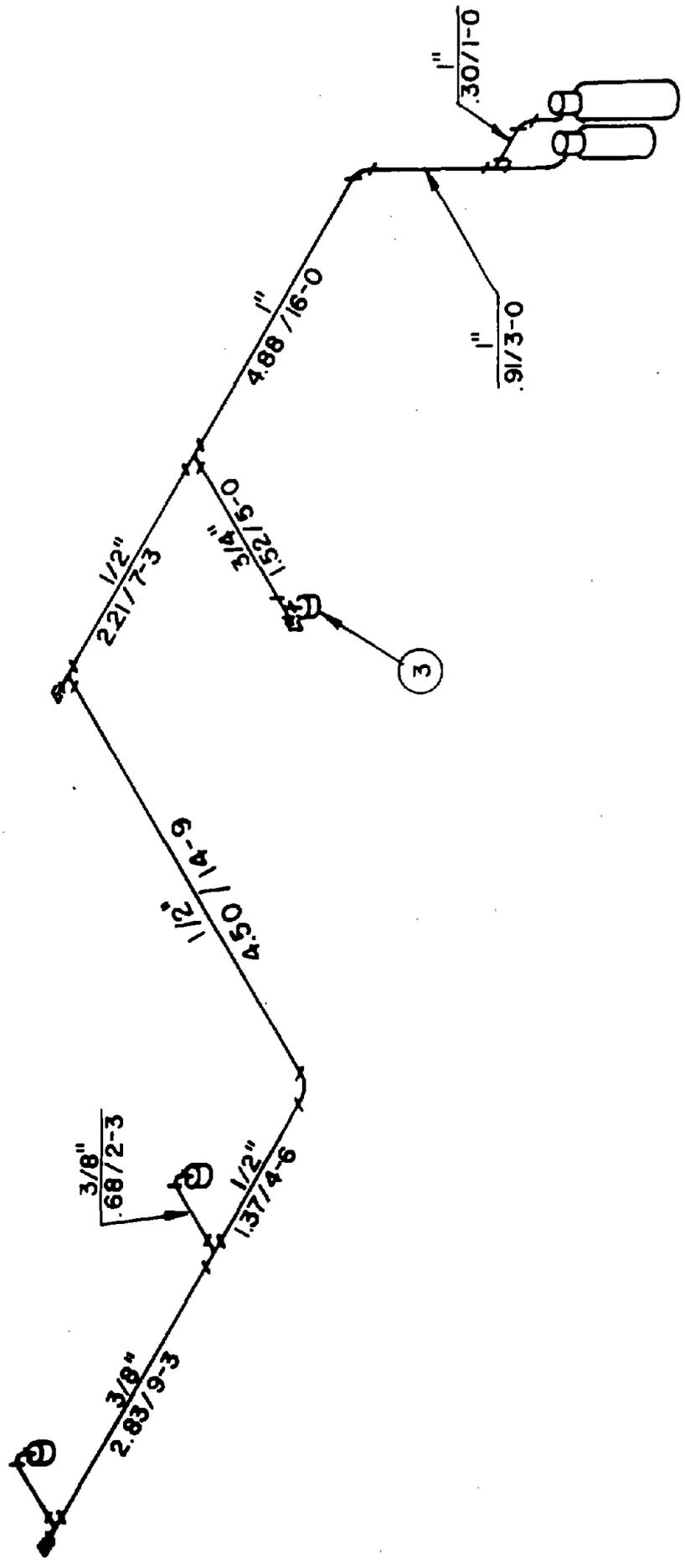


Figure 20



PIPING ISOMETRIC

NO SCALE

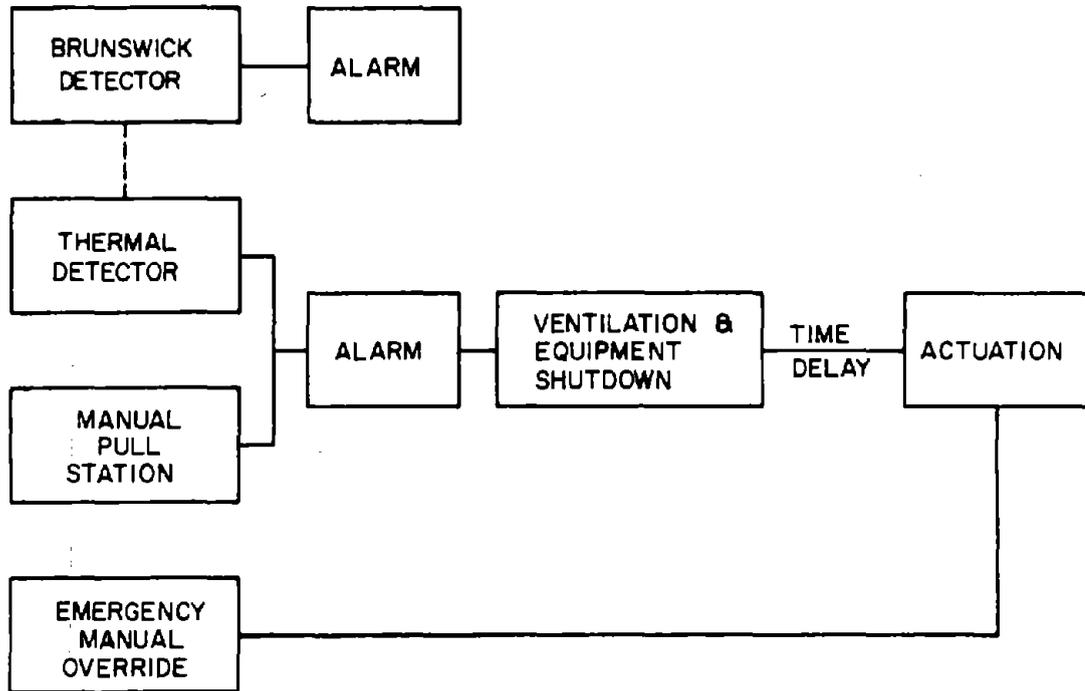
standard smoke detectors in its increased sensitivity to airborne pre-combustion particles and its decreased sensitivity to airborne contaminants and ambient condition changes such as temperature, pressure and wind velocity. The four functional components comprising the detector are the separator, sensor, pump/motor, and its electronics. The entire detector weighs approximately 1.5 pounds. In operation, the miniaturized pump/motor draws a sample of air through the separator chamber and to the sensor. Within the separator aerodynamic principles are used to cause the heavier contaminant particles to bypass the sensor inlet and the smaller (less than 2 microns in size) pre-combustion and combustion particles to enter the sensing chamber. The sensor is a modified version of a standard twin ionization chamber. The detector electronics will react to an abnormal level or rate of increase of particles less than 2 microns in size by providing a discrete alarm signal. The electronics also include alarm reset and continuous self-test capabilities. Although potentially suitable for use in several types of mining equipment, the Brunswick detector is included in the blast-hole drill fire control system because its subsequent installation and long-term testing should prove valuable in evaluating the detector's use in highly ventilated and dust contaminated environments. Appendix D of this report contains a more detailed discussion of the Brunswick detector's design and capabilities.

## 5.2

### System Operation

Per Figure 21, input from any one of the thermal detectors or manual pull stations will cause the audible alarms to sound, will shut down the rotating machinery, including the ventilation system, air compressors and motor generator set, and will initiate a 35-second time delay leading to the agent release. The main discharge will occur in less than 10 seconds, while the extended discharge will continue for approximately 10 minutes. During and following the discharge, the alarms will continue to operate, using standby battery power if required. Input from the Brunswick detector will sound an alarm only.

Figure 21  
BLAST HOLE DRILL FIRE CONTROL SYSTEM SCHEMATIC



5.3 Estimated Installed Cost

Following is a bill of materials of the control system hardware, including an estimated end-user cost for each item. Total cost of the system components is estimated at \$2,648. Following the bill of materials is an estimate of the installation cost broken down as to tradesmen requirements, piping, and some miscellaneous hardware costs. The estimated total cost of the installed system is \$3,219. The estimated costs do not include the early warning system.

Bill of Materials for 61R BHD Suppression System

System Hardware

<u>Qty.</u>	<u>Ansul P/N</u>	<u>Item</u>	<u>Est. Cost</u>
1	32273	Halon Tank, 46-Lb.	\$ 702.00
1	-----	Halon Tank, 19-Lb.	486.00
2	27421	Tank Bracket	48.00
1	32668	Nozzle, 3/4"	21.00
2	32666-4	Nozzle, 1/4"	42.00
2	33262	Entrance Warning Sign	6.00
2	33263	Exit Warning Sign	6.00
1	32094	Manual Override	67.50
1	32097	Solenoid Actuator	136.00
2	33060	Pull Station	52.50
2	33051	24 VDC Horn	106.50
1	32096	Pneumatic Actuator	39.00
2	32335	Actuation Hose, 24"	42.00
2	31810	Elbow, 1/4 NPT	3.00
1	31811	Tee, 1/4 NPT	1.50
1	-----	RCU Control Unit w/Batteries	550.00
1	-----	Extended Discharge Orifice	25.00
7	13970	190°F Thermal Fire Detector	<u>315.00</u>
		Total System Hardware Cost	\$2,648.00

Installation

<u>Item</u>	<u>Est. Cost</u>
Electrical Wiring, Flexible Conduit, and Miscellaneous Supplies	\$100.00
Pipe, Fittings, Pipe Hangers	95.00
Welding, 16 man-hours @ \$7/hr.	112.00
Electrician, 16 man-hours @ \$7/hr.	112.00
Pipefitters, 8 man-hours @ \$7/hr.	56.00
Supervision, 16 man-hours @ \$6/hr.	<u>96.00</u>
Total Installation Cost	\$571.00
Estimated Total Installation System Cost:	\$3,219.00

6.0            **DESIGNS PLANS FOR LOADING SHOVEL SUPPRESSION SYSTEM**

The following suppression systems were designed for the Bucyrus-Erie 150-B loading shovel (Serial No. 103615) located at the Peabody Coal Company Lynnville Mine.

6.1            System Description

The loading shovel suppression system consists of an extended discharge Halon 1301 system protecting the main machinery enclosure and a small dry chemical system protecting the collector ring/roller path area.

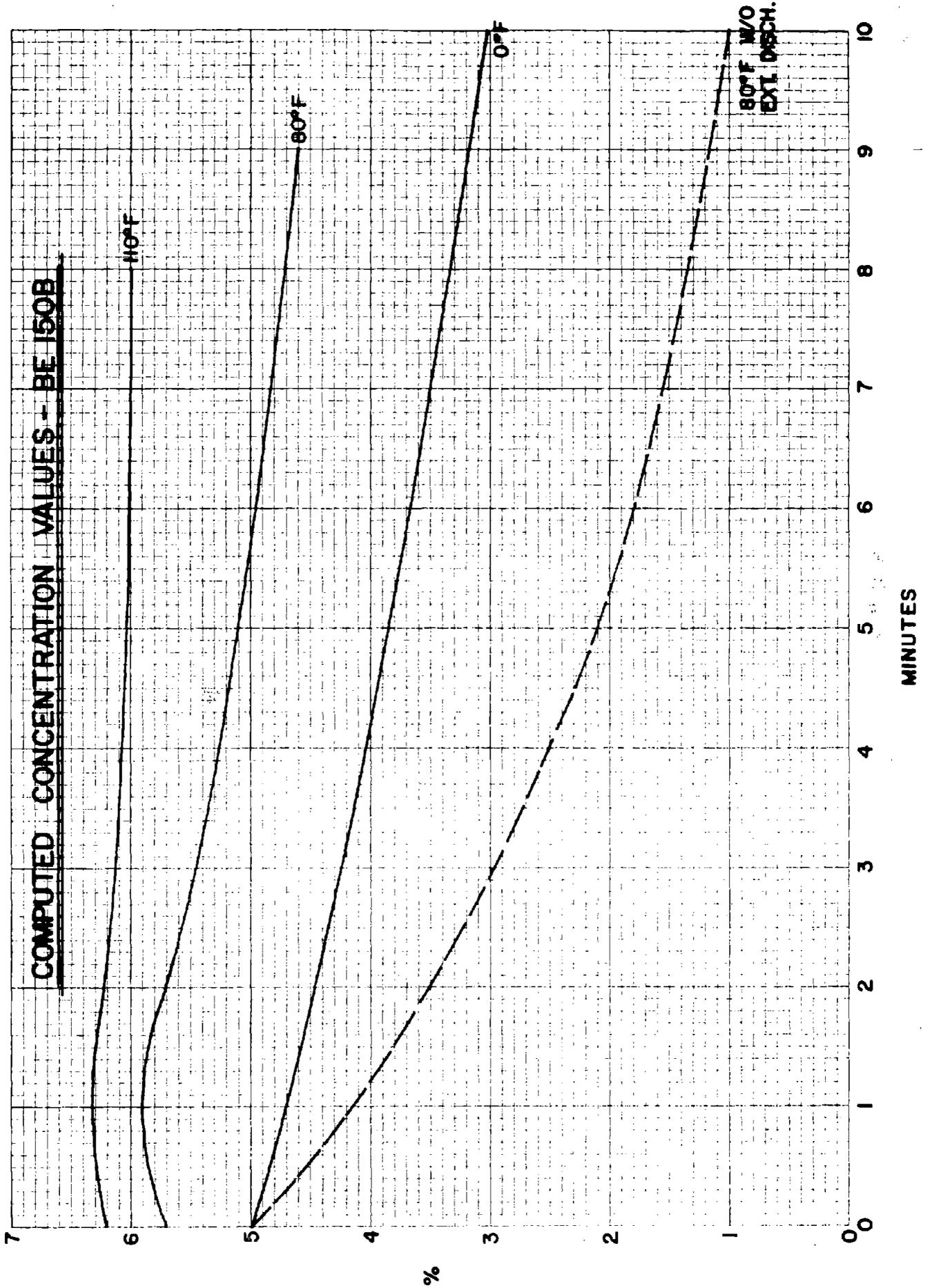
Following is the halon system design data summary and a graph describing the calculated enclosure concentrations during the extended discharge for a 36" diameter fan opening and a 35" x 12" rope opening. Computer print-outs of the design calculations are contained in Appendix C. For a more complete discussion of extended discharge design considerations, please refer to Section 5.1.

The small dry chemical system is an automatic, self-contained, pneumatic system, actuated independently of the halon system. However, the two systems are interconnected to the extent that an actuation signal from the dry chemical unit will activate the halon system alarms.

BE 150 Loading Shovel - Halon System Design Data

Enclosure Volume	3749 cu. ft.
Design Temperature Range	0° - 110° F
Initial Agent Requirement	90 lbs.
Initial Design Concentration @ Max. Temp.	6.2%
Initial Design Concentration @ Min. Temp.	5.0%
Extended Discharge Agent Requirement	150 lbs.
Approx. Extended Discharge Time @ 70°F	8 min.

Figure 22



### 6.1.1. Halon System Agent Storage

The agent storage reservoirs shown in Figure 23 are, as in the drill system, DOT 4BA or 4BW-500 cylinders equipped with differential pressure Ansul cylinder valves. The initial discharge cylinder, containing 90 pounds of Halon 1301, is equipped with a solenoid actuation. The extended discharge cylinders, containing 75 pounds each of Halon 1301, are equipped with slave pneumatic operators. Both slave cylinders discharge to a common orifice plate located in the distribution piping.

### 6.1.2 Halon System Detection and Control

System detection and control is provided by an Ansul RCU control unit, identical to that used in the BHD suppression system, equipped with six Fenwal Corporation 190°F thermal fire detectors. Figure 24 describes the locations of the detectors above the motor-generator sets, the lubrication storage area, above the main transformer cabinet, and centrally located above the rope handling machinery. Manual pull stations are located in the operator's enclosure and near the main exit from the machinery house. Alarm horns are located within both the machinery and operator enclosures. Also controlled by the RCU are the ventilation and equipment shutdown and three Edwards Company 110 VAC magnetic door holders. Because of the particular ventilation arrangement of this machine, the doors are required to be open during periods of warm weather. The function of the door holders is to hold the doors in the open position when desired. When deactivated by the RCU, the magnetic holders release the doors which are then closed by spring hinges. At all times, the doors can be manually released by simply pulling away from the magnetic holder. The detailed schematic of the ruggedized control unit and the system wiring diagram are included in Appendix E.

### 6.1.3 Halon System Distribution Piping

The Halon system distribution piping system is described by Figure 25. It contains approximately 30 pounds of A-53 or A-106 1½" piping and one centrally located Ansul Type "V" halon nozzle. The nozzle and piping are hydraulically balanced to provide an initial discharge of less than

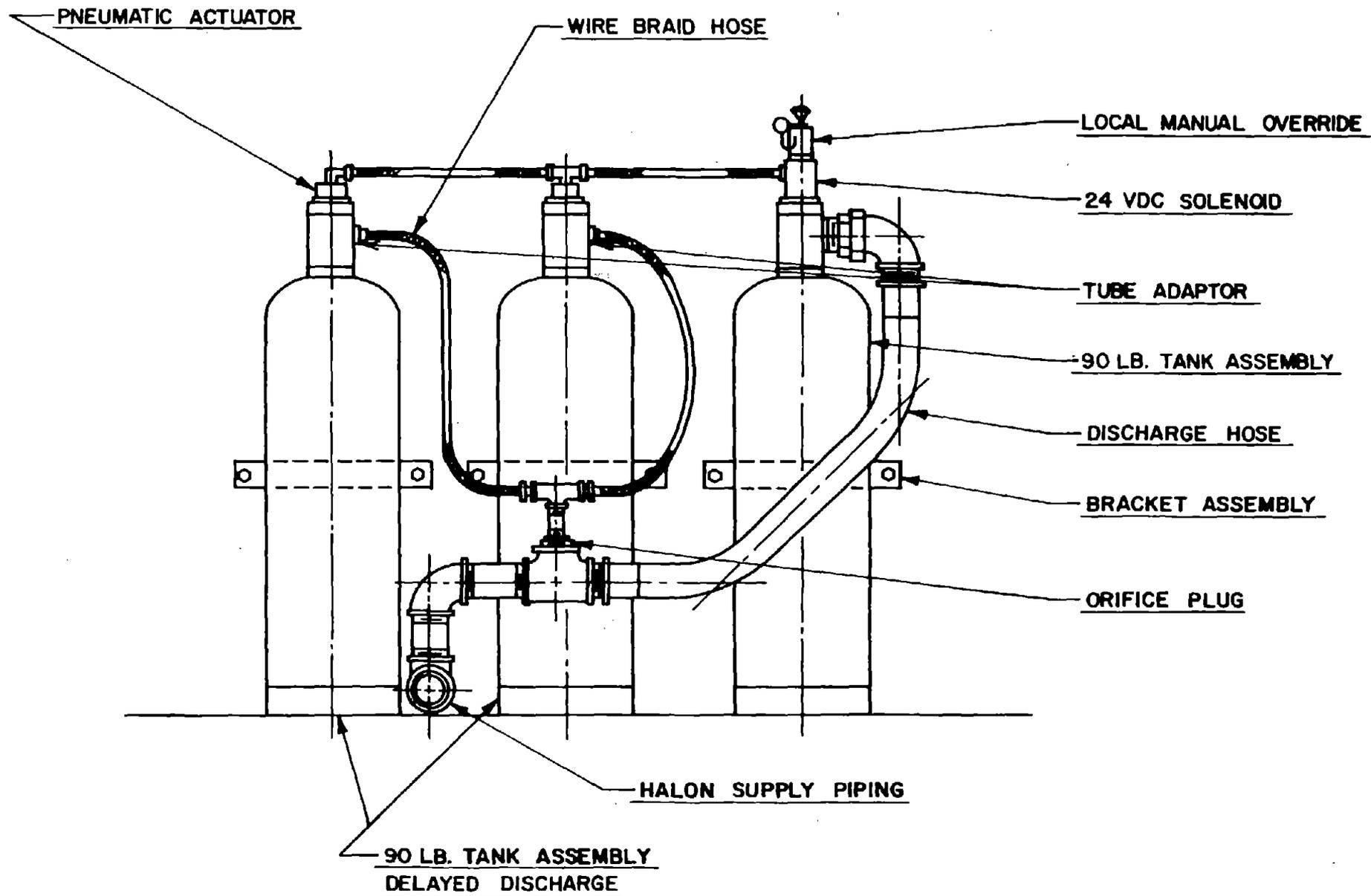


Figure 23  
TANK DETAIL

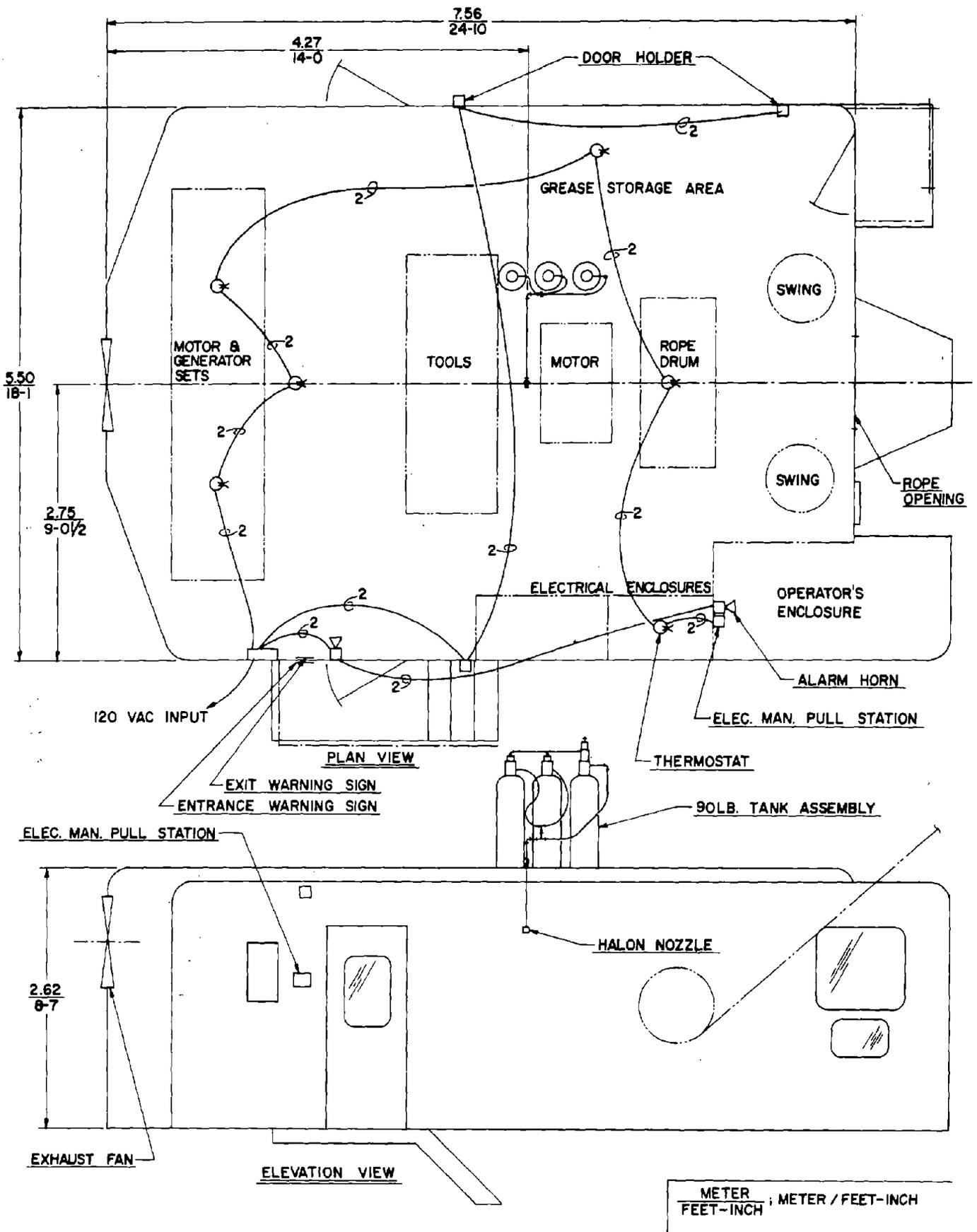
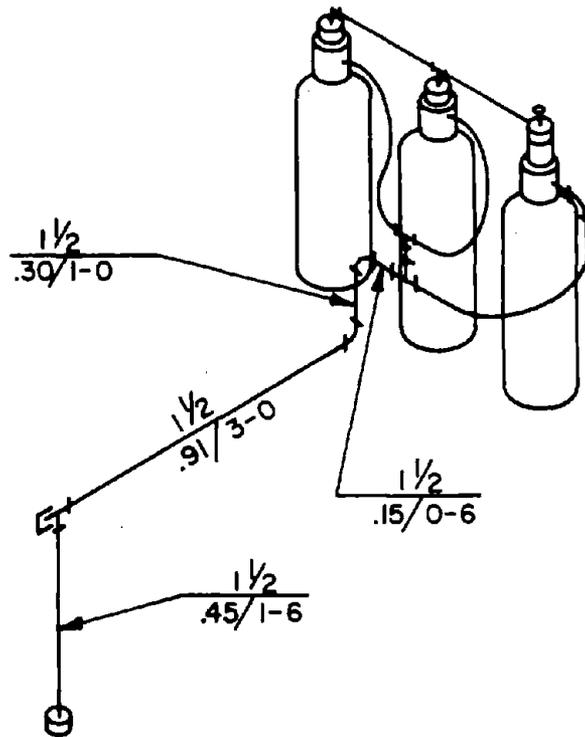


Figure 24

Figure 25



PIPING ISOMETRIC

NO SCALE

10 seconds. The piping also serves to distribute the agent during the extended discharge.

#### 6.1.4

#### Collector Ring Dry Chemical System

The collector ring dry chemical system is composed of an Ansul A-101-20 dry chemical system equipped with an Ansul SCAD automatic actuation device. The A-101-20 is a pre-engineered system supplying 20 pounds of FORAY multipurpose dry chemical to four Ansul F- $\frac{1}{2}$  nozzles through SAE 100R5 hydraulic hose. The chemical storage container, distribution hose and nozzles are mounted on the revolving frame of the shovel, as shown in Figure 26, and installed to flood the volume housing the collector rings and center pin by injecting the chemical above the shovel swing rollers. Each nozzle produces an approximately 180° flat pattern which, aimed at the center pin from the four nearly equally spaced points, assures complete coverage.

The SCAD detection and actuation device is a self-contained pneumatic unit employing heat sensitive pneumatic tubing for detection. The two main components of the SCAD, shown in Figure 27, are the pressure make-up device, used to initially pressurize and to maintain pressure in the detection tubing, and the actuation device which, upon rapid loss of pressure in the detection tubing, punctures a nitrogen cartridge and sends a pneumatic signal to the dry chemical system. A pressure operated electrical switch, installed in the detection line, will also react to a rapid pressure drop and will sound the alarm horns located in the operator and machinery enclosures.

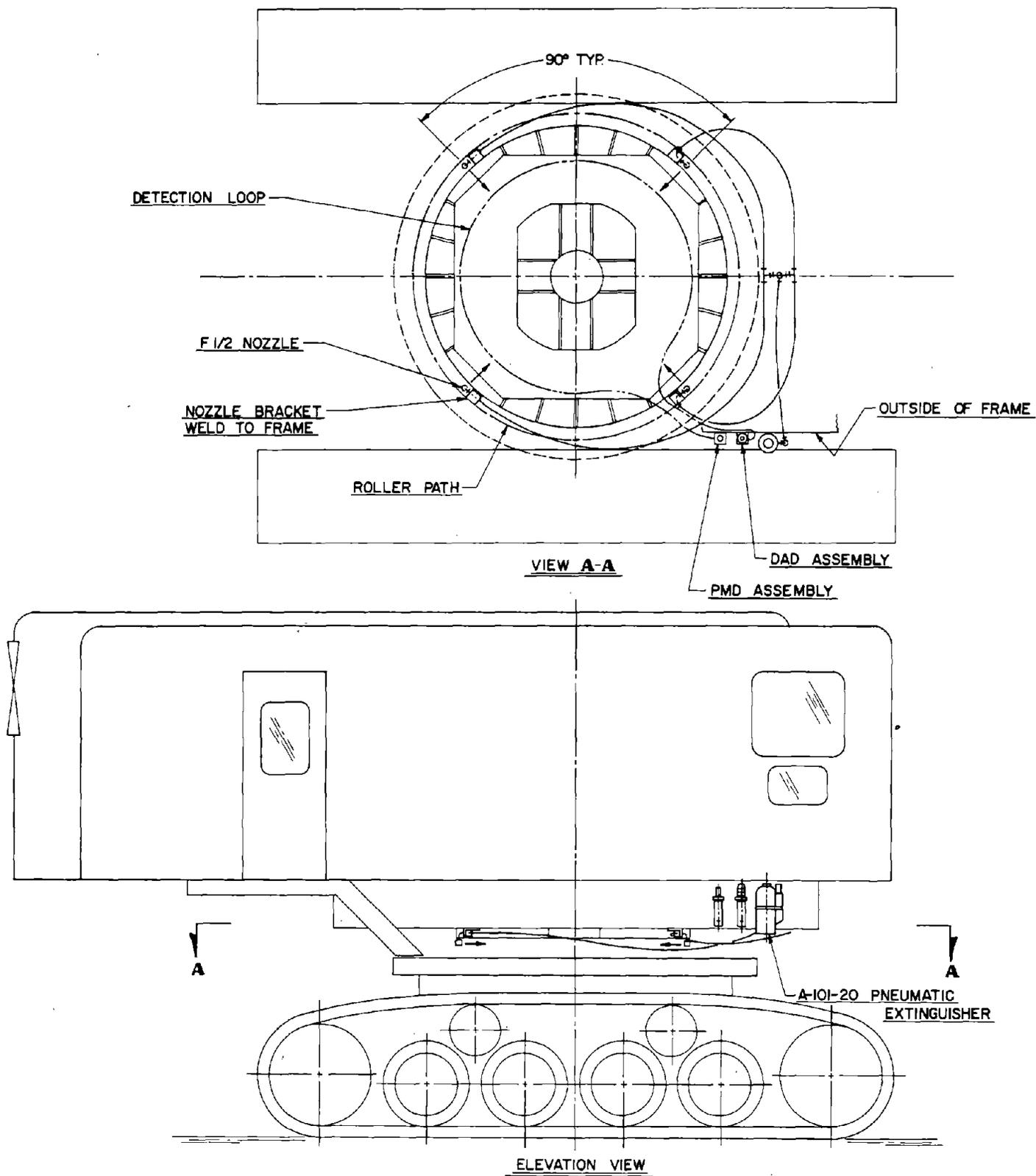
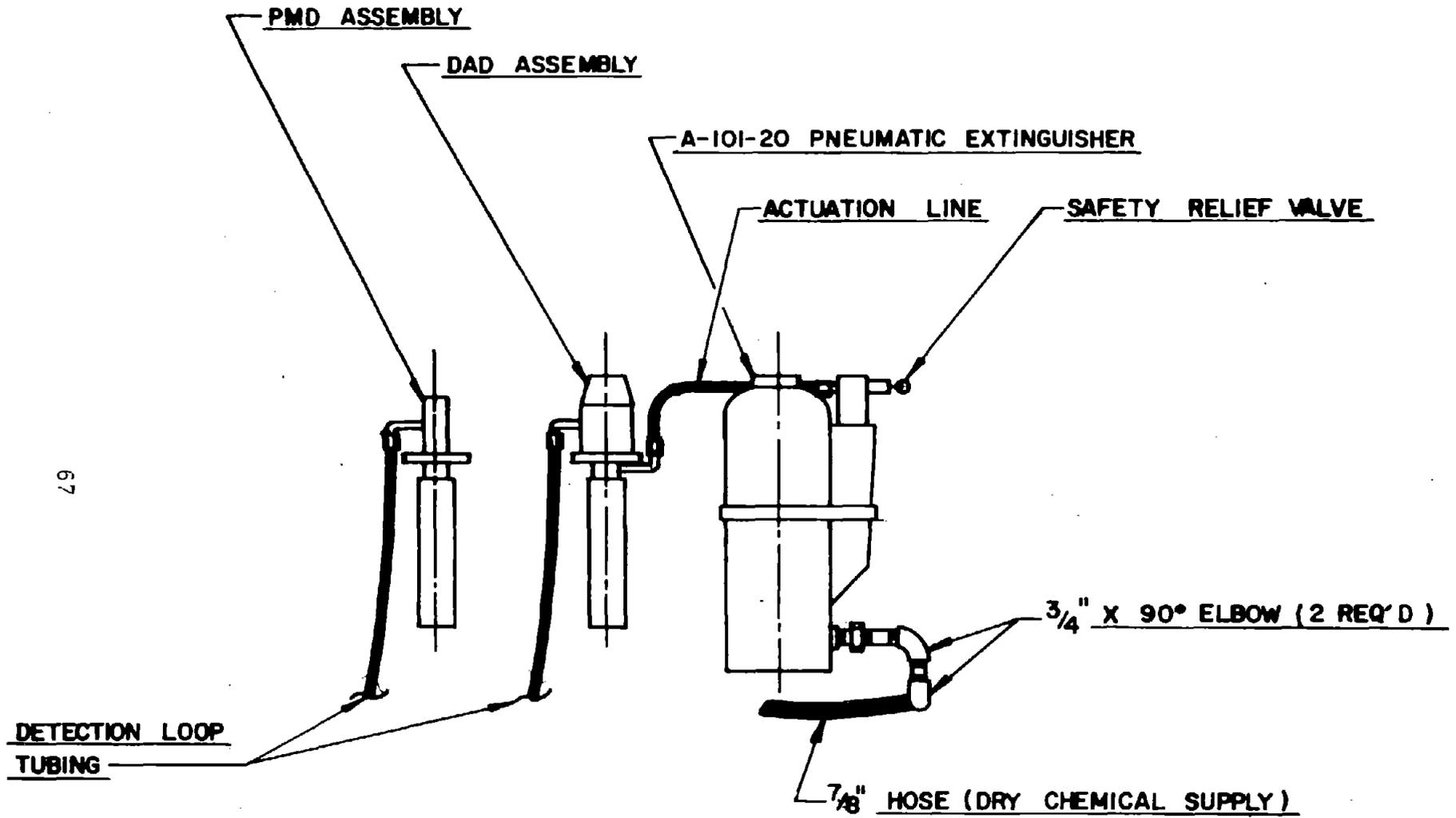


Figure 26



67

Figure 27

TANK DETAIL

6.2 Halon System Operation

Referring to the following chart, automatic or manual actuation of the halon system will result in immediate ventilation shutdown, deactivation of the door holders and sounding of the audible alarms. Following a 30- to 35-second delay, the shovel control power will be disconnected and the halon discharge begun. The initial discharge will occur in under 10 seconds, while the extended discharge will continue for approximately eight minutes. During and following the agent discharge, the alarms will continue to sound until deactivated.

6.3 Dry Chemical System Operation

When the temperature of the collector ring/roller path area reaches approximately 355°F, the SCAD tubing will burst, thus triggering the A-101-20 dry chemical system and sounding the audible alarms. Immediately upon actuation, the dry chemical system will discharge. The alarms will continue to sound until silenced.

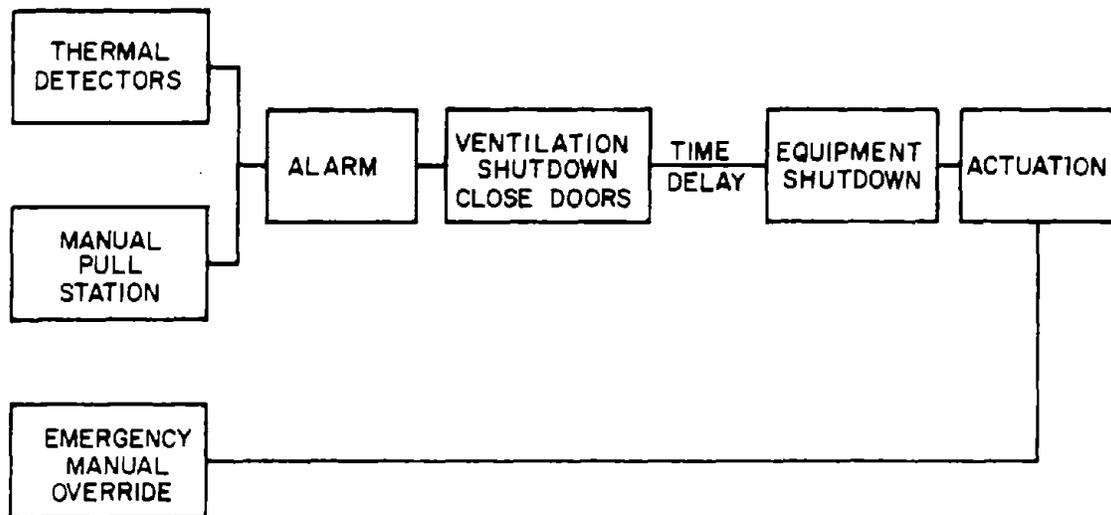
6.4 Installed Cost Estimate

An estimate of the end-user cost of the loading shovel halon and dry chemical system components is contained in the following table. Hardware cost estimates for the halon and dry chemical systems total \$5,002.50 and \$856.80 respectively. Installation costs are estimated to be \$812.00 for the halon system and \$114.00 for the dry chemical system, making the total installed cost \$5,814.50 for the halon system and \$970.80 for the dry chemical system.

Bill of Materials for BE 150-B Suppression Systems

<u>Qty.</u>	<u>Ansul P/N</u>	<u>Item</u>	<u>Est. Cost</u>
1	32303	Halon Tank, 90-Lb.	\$1,122.00
2	-----	Halon Tank, 75-Lb.	2,037.00
3	27422	Bracket	72.00
1	32671	Nozzle, 1½"	30.00

Figure 29  
LOADING SHOVEL FIRE CONTROL SYSTEM SCHEMATIC



Bill of Materials for BE 150-B Suppression System (Con't.)

<u>Qty.</u>	<u>Ansul P/N</u>	<u>Item</u>	<u>Est. Cost</u>
2	33262	Entrance Warning Sign	6.00
2	33263	Exit Warning Sign	6.00
1	32097	Solenoid Actuator	135.00
1	32094	Manual Override	67.50
2	33060	Pull Station	52.50
2	33051	24 VDC Horn	106.50
2	32096	Pneumatic Actuator	78.00
3	-----	110 VAC Magnetic Door Holder	315.00
4	32335	Actuation Hose	84.00
1	-----	RCU Control Unit w/Batteries	550.00
2	31811	Tee, 1/4" NPT	3.00
2	31810	Elbow, 1/4" NPT	3.00
6	13970	190°F Thermal Fire Detector	270.00
2	-----	Valve Outlet Adaptor, 1/4" NPT	40.00
1	-----	Extended Discharge Orifice, 1 1/2" NPT	<u>25.00</u>
		Total System Hardware Cost	\$5,002.50

Installation

<u>Item</u>	<u>Est. Cost</u>
Electrical Wiring, Conduit and Miscellaneous Supplies	\$190.00
Pipe Fittings, Hangers	30.00
Welding, 24 man-hours @ \$7/hr.	168.00
Electrician, 32 man-hours @ \$7/hr.	224.00
Supervision, 24 man-hours @ \$6/hr.	144.00
Pipefitters, 8 man-hours @ \$7/hr.	<u>56.00</u>
Total Installation Cost	\$812.00
Total Installed Halon System Cost	\$5,814.50

Dry Chemical System Hardware

<u>Qty.</u>	<u>Ansul P/N</u>	<u>Item</u>	<u>Est. Cost</u>
1	16430	A-101-20 (Less Bracket)	\$176.00
1	16461	Completor Kit	74.00
1	30759	20-E Heavy Duty Bracket	33.80
1	30804	SCAD Assembly	555.00
1	30807	Detection Tubing, 100'	17.00
10	30802	Compression Rings	<u>1.00</u>
		Total Hardware Cost	\$856.80

Installation

<u>Item</u>	<u>Est. Cost</u>
Welding, 8 man-hours @ \$7/hr.	56.00
Supervision, 8 man-hours @ \$6/hr.	48.00
Miscellaneous Supplies	<u>10.00</u>
Total Installation Cost	\$114.00
Total Installed Dry Chemical System Cost	\$970.80

## 7.0 DESIGN PLANS FOR DRAGLINE SUPPRESSION SYSTEM

The following suppression systems were designed using information and blueprints supplied by the Bucyrus-Erie Company for a typical BE 2570W dragline.

### 7.1 System Description

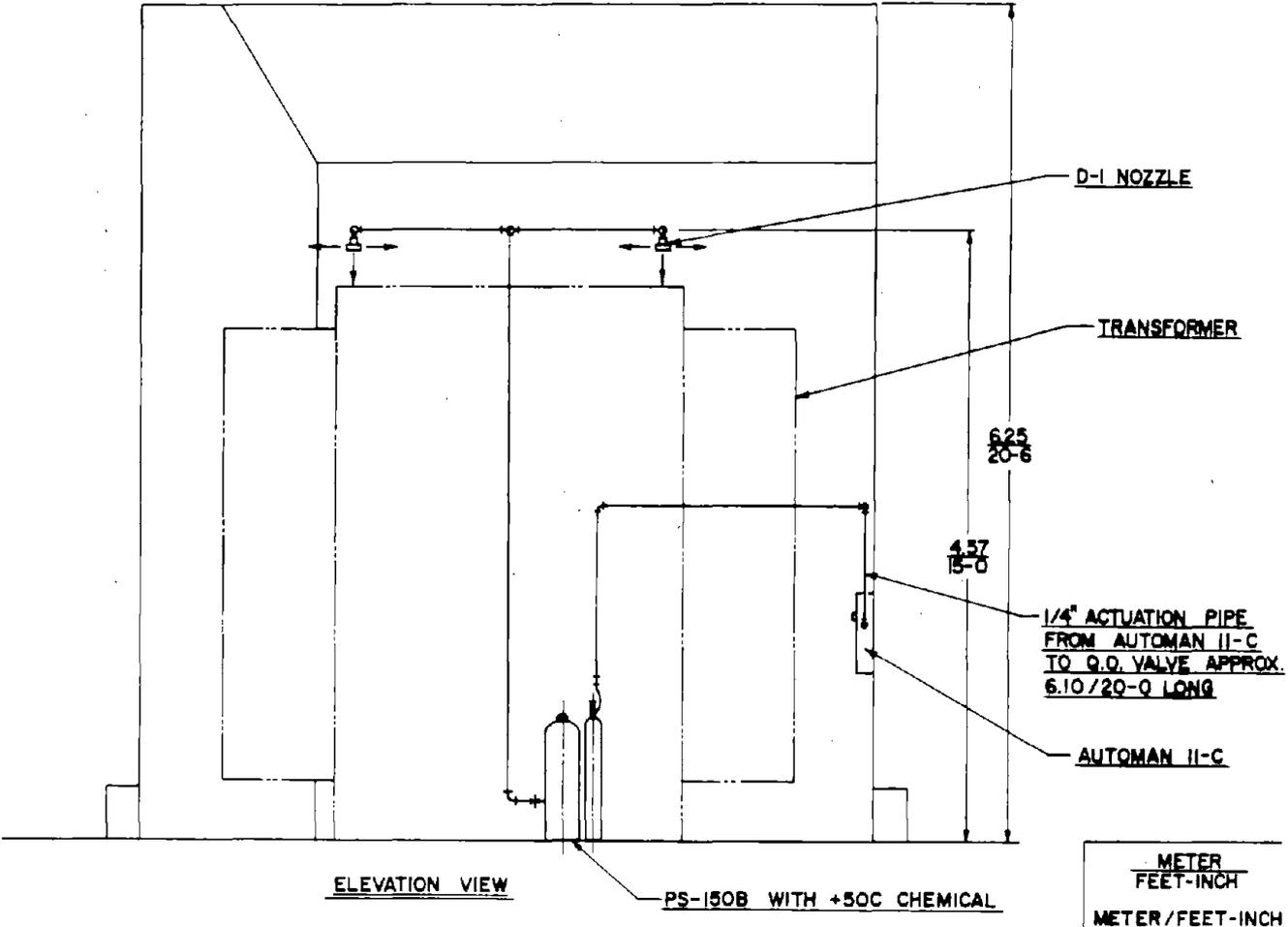
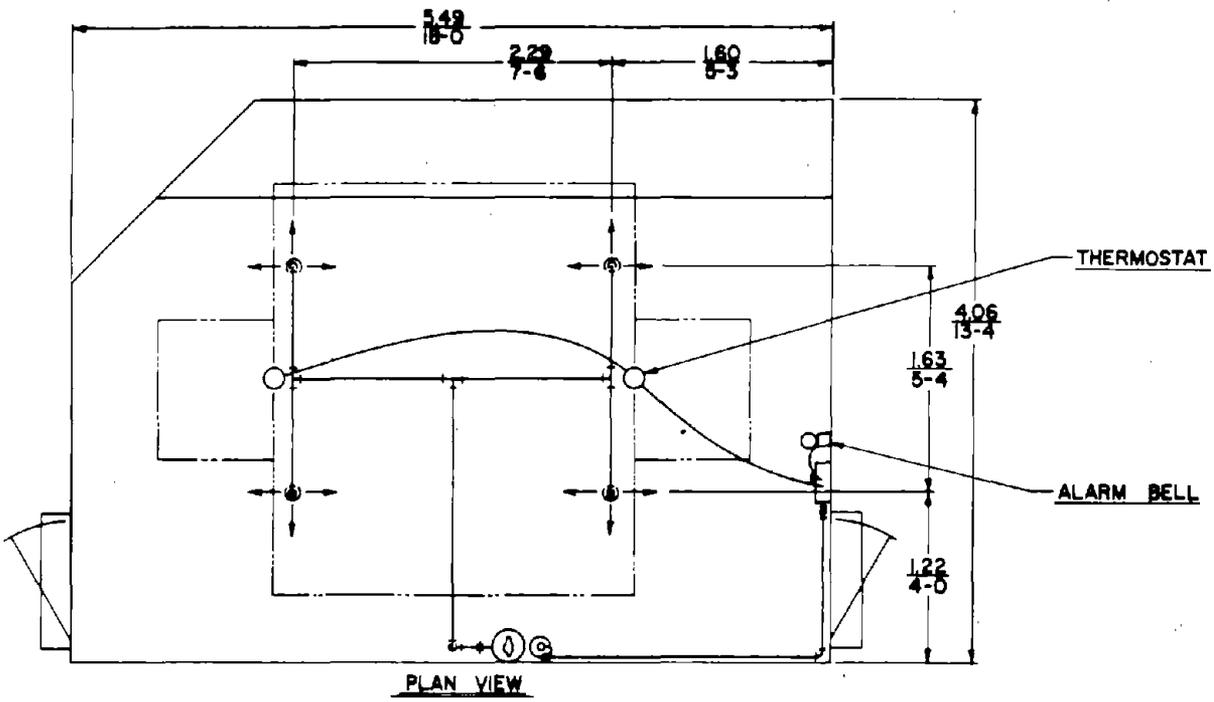
The dragline fire suppression system consists of two dry chemical systems and one halon system, each protecting a different area of the total machine. The roller path/swing gear area and main power transformer are protected by large, fixed pipe dry chemical systems. The dragline control room is protected by a Halon 1301 system. Each system is capable of independent automatic or manual actuation and is interconnected to a common alarm and indicator panel within the operator's cab.

#### 7.1.1 Transformer Room Dry Chemical System

The transformer room dry chemical system, Figures 29 and 30, consists of a 150-lb. stationary dry chemical unit designed to total flood the transformer with Ansul PLUS FIFTY C dry chemical. The chemical is dispersed throughout the enclosure by four Ansul D-1 nozzles arranged in a symmetrically balanced piping network. Each nozzle is designed to deliver 1.125 lbs./sec. for a total system flow rate of 4.5 lbs./sec. Discharge time is approximately 33 seconds. Detailed design calculations can be found in Appendix C.

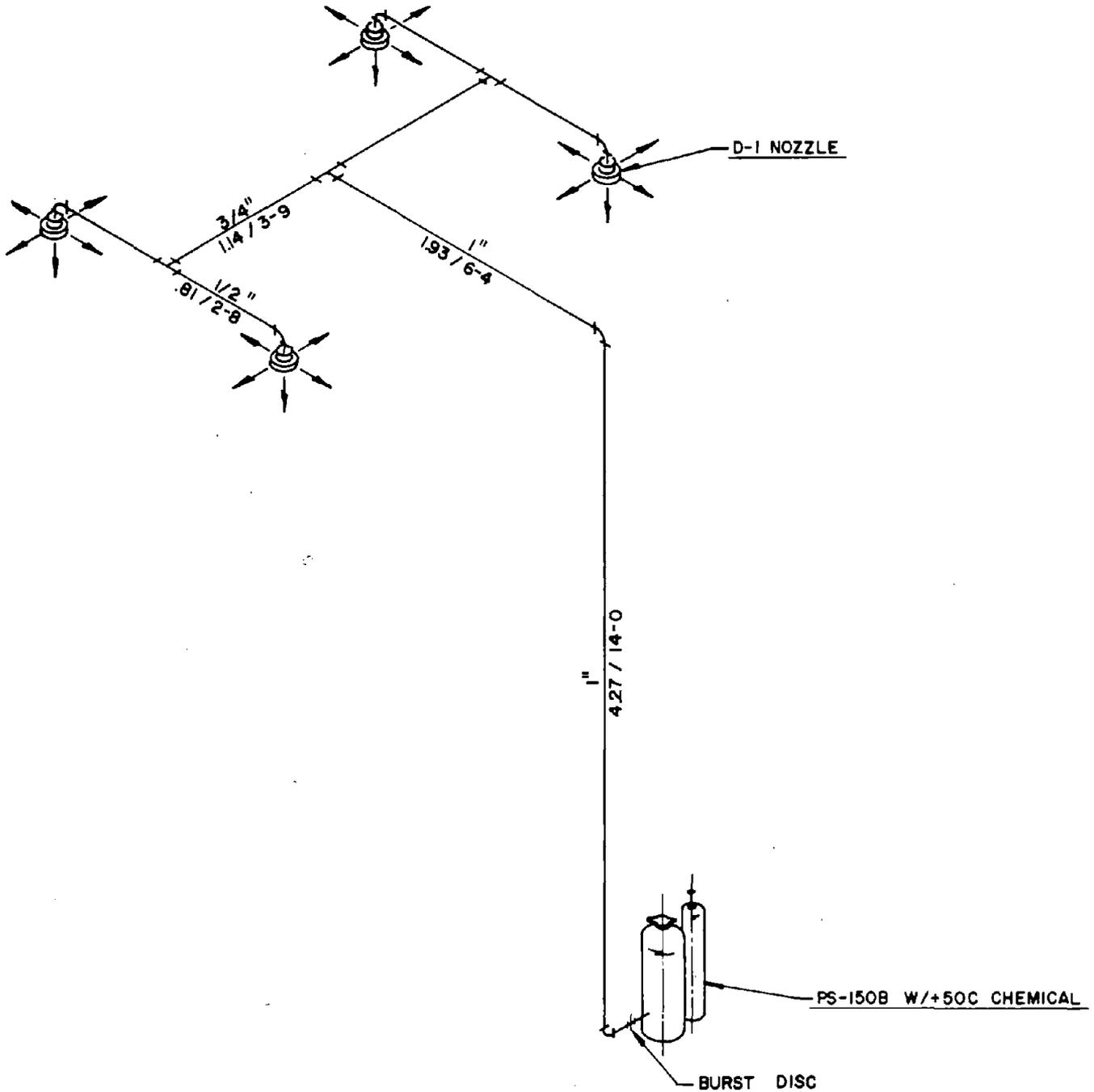
Detection and actuation is provided by two 225°F Fenwal Corporation thermal detectors and an Ansul AUTOMAN II-C releasing device. The AUTOMAN II-C is an electrically-operated pneumatic releasing device which, upon receiving a signal from the thermal detectors, punctures a nitrogen cartridge which actuates the dry chemical system. The system is equipped with a local alarm and the capability of emergency manual actuation.

Figure 29



METER  
FEET-INCH  
METER/FEET-INCH

Figure 30



PIPING ISOMETRIC

### 7.1.2

#### Control Room Halon System

The halon system described in Figure 31 is protecting a 3040 cu.ft. two-level, self-ventilated control room with 90 lbs. of Halon 1301. When delivered through the balanced piping network described by Figure 32, this quantity will provide a 6.3% concentration at 40°F and 6.8% concentration at 80°F. Computer print-outs of the detailed calculations are in Appendix C. Detection and actuation is provided by four Honeywell TC-100 ionization detectors and two manual pull stations. Two ionization detectors and one pull station are located on each of the two levels. The system is controlled by an Ansul RCU control unit equipped with standby batteries. The batteries serve not only as an emergency power source for the halon system but for both dry chemical systems as well.

Actuation of the system, either by automatic or manual means, will immediately sound alarms locally and within the operator's enclosure and will shut down ventilation to the control rooms. Following a time delay of approximately 30 seconds, the rooms will be flooded with the indicated concentrations of Halon 1301.

The entire discharge will occur in under 10 seconds. During and following the discharge the alarms will continue to sound until reset.

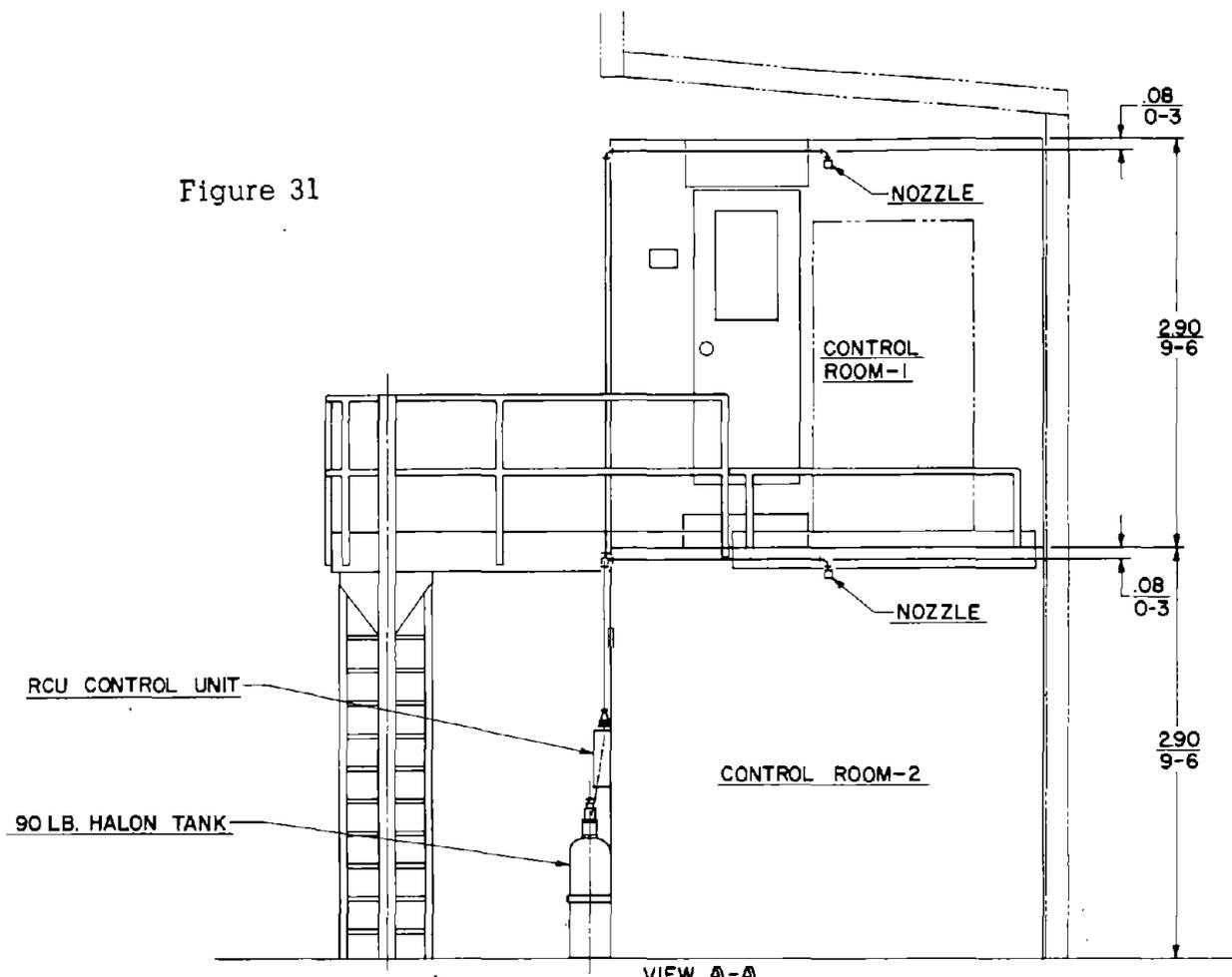
### 7.1.3

#### Roller Path Dry Chemical System

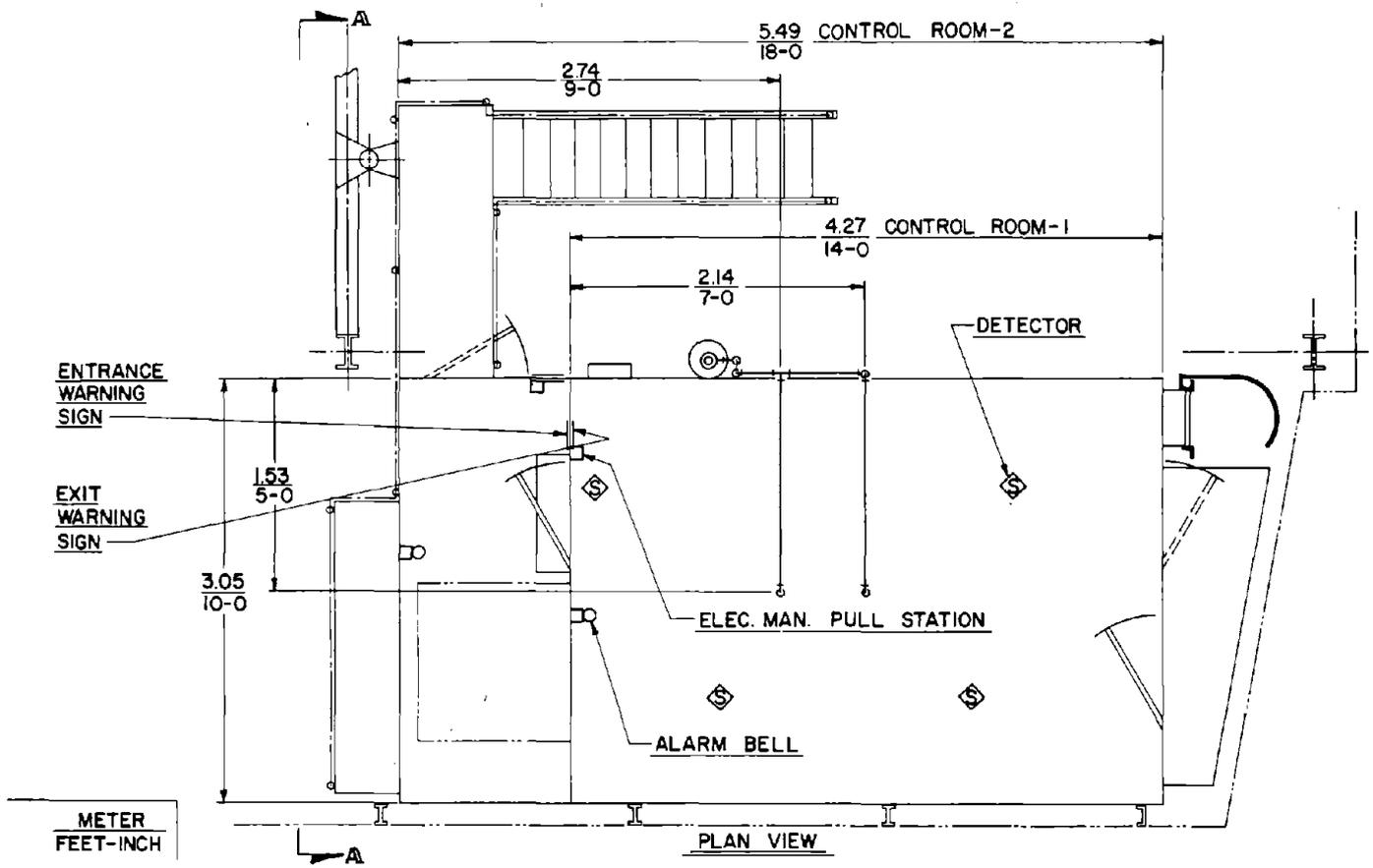
The roller path dry chemical system consists of an Ansul PS-500 skid-mounted dry chemical unit equipped with 500 lbs. of PLUS FIFTY B dry chemical.

The skid containing the dry chemical pressure vessel and the nitrogen cylinders is located on the main machinery deck, convenient for installation, inspection and recharge. The distribution piping leads from the skid through the revolving frame to the piping network described in Figures 33 and 34. The nozzle system contains 16 Ansul F-1 nozzles equally spaced along the outside perimeter of the roller path circle. Each nozzle is positioned to produce

Figure 31

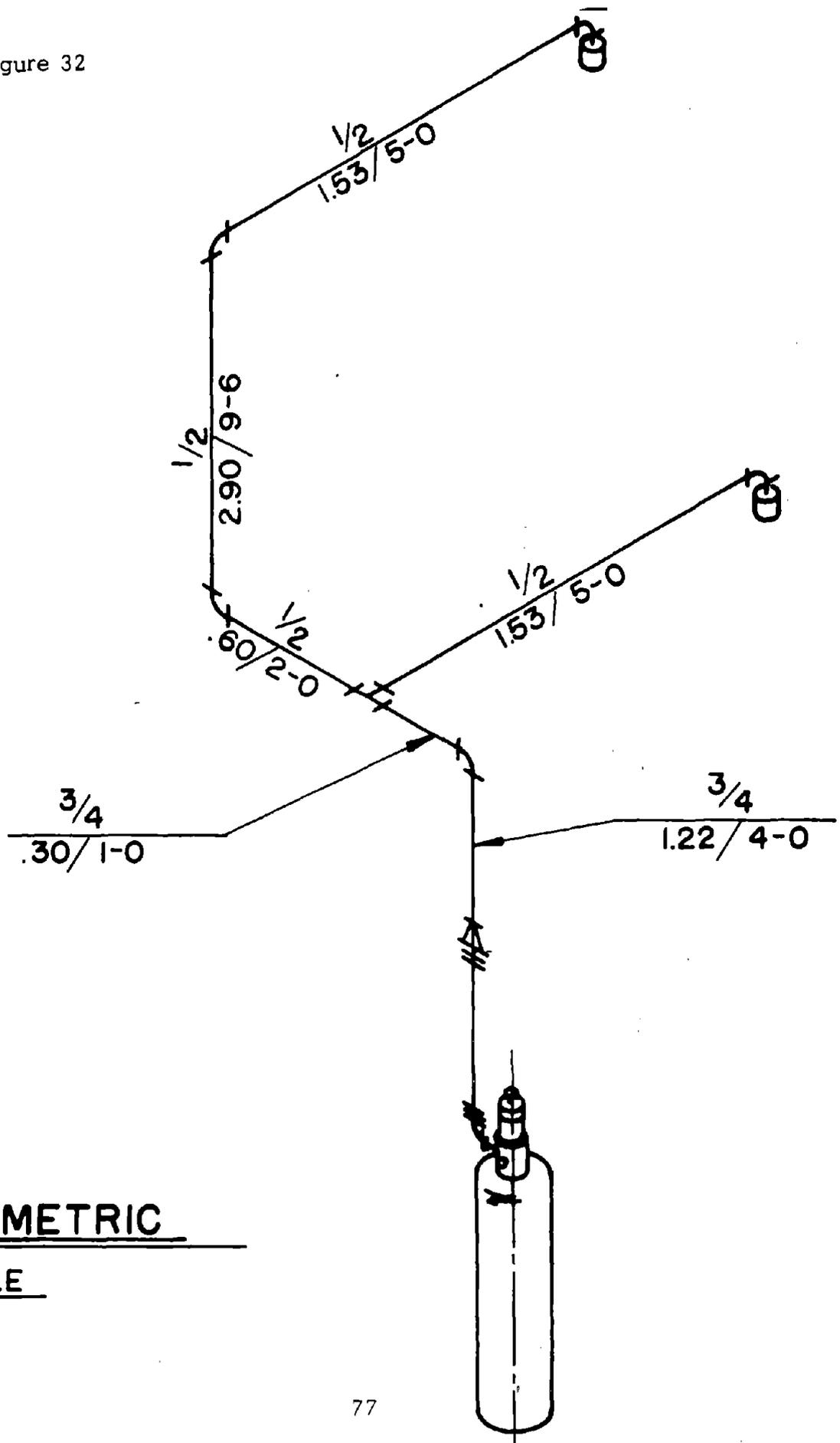


VIEW A-A



PLAN VIEW

Figure 32

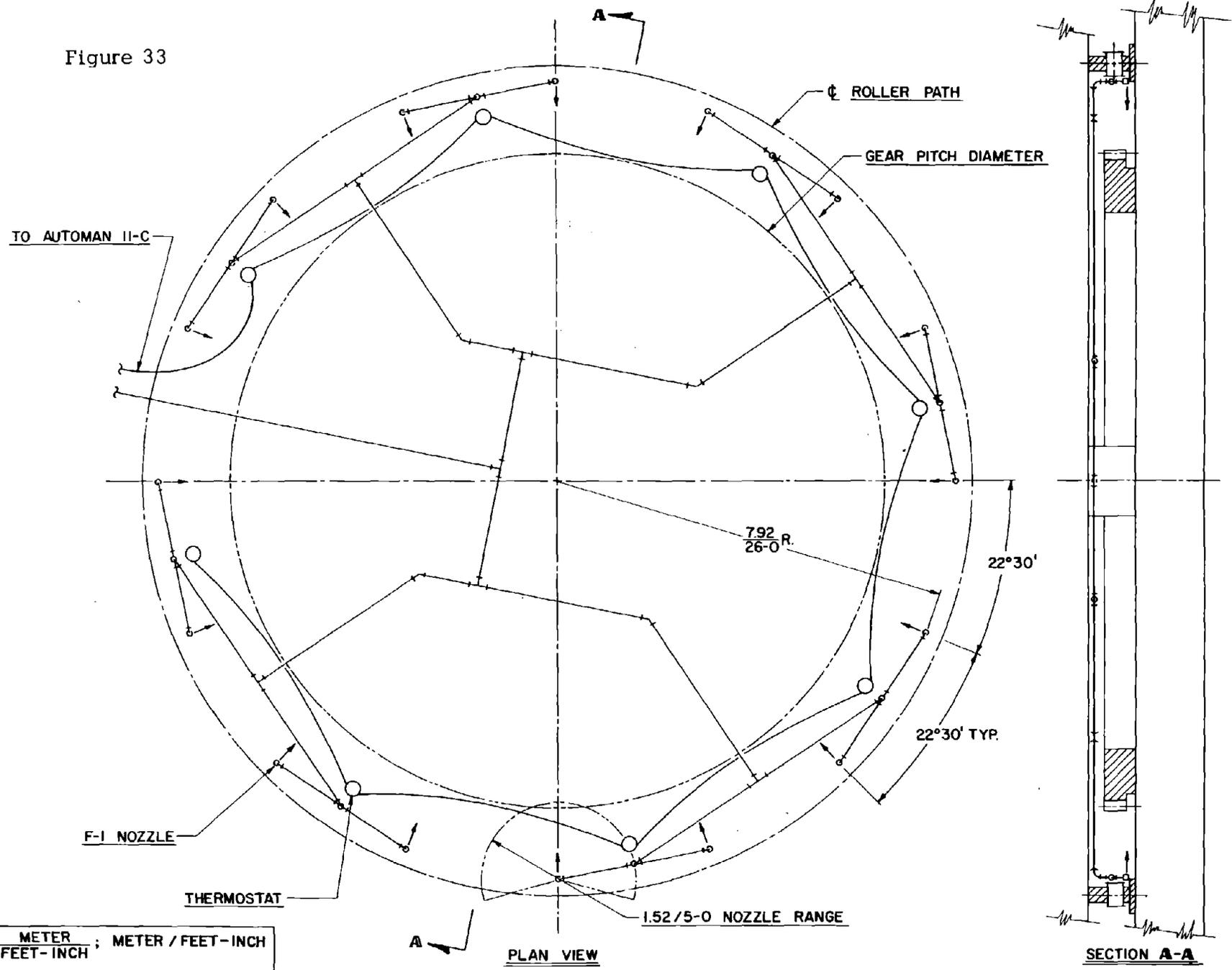


PIPING ISOMETRIC

NO SCALE

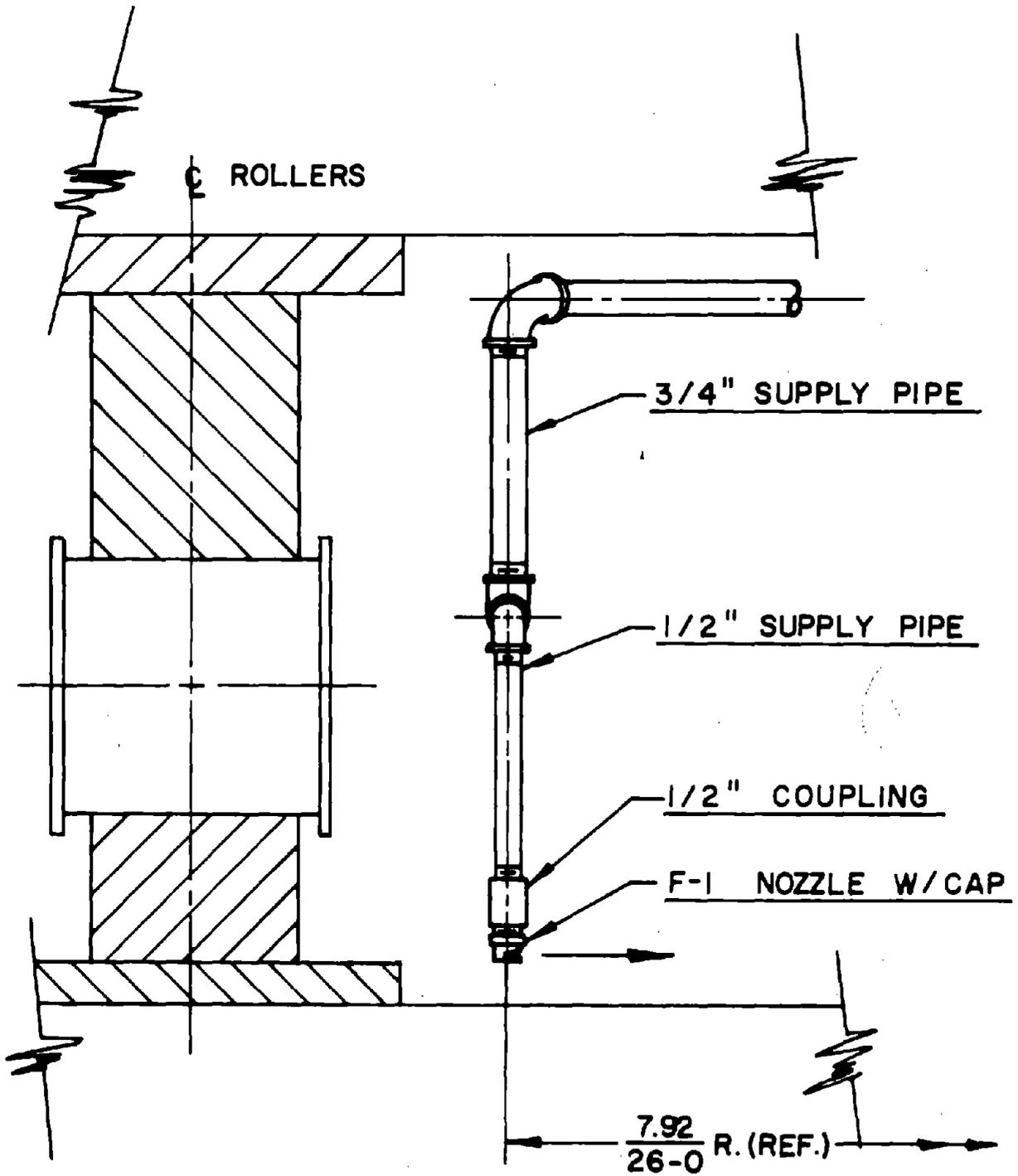
Figure 33

78



METER ; METER / FEET-INCH  
FEET-INCH

Figure 34



DETAIL A

flat, overlapping, semi-circular patterns directed from the rollers toward the swing gear, across the most probable area of grease accumulation. The piping is suspended from the underside of the revolving frame and is free to rotate with the upper portion of the machine.

The detection system is composed of eight 190°F Fenwal Corporation thermostat fire detectors equally spaced along the roller path circle. An Ansul AUTOMAN II-C control unit will provide a pneumatic actuation signal to the dry chemical skid.

Immediately upon automatic or manual actuation, the dry chemical system will discharge. Each nozzle will deliver 1.25 lbs./sec. for a system total of 20.0 lbs./sec. Discharge time will be approximately 25 seconds. During the following actuation, alarms will sound both at the skid unit and within the operator's enclosure. Appendix C contains the system's detailed design calculations.

## 7.2

### Installed Cost Estimates

The following tables contain suppression system hardware and installation cost estimates for the 2570W dragline suppression systems. System hardware costs total \$2,390.75 for the transformer room system; \$3,228.50 for the control room system; and \$3,886.30 for the roller path suppression system. Installation costs per system total \$289.00 for the transformer room system; \$539.00 for the control room system; and \$931.00 for the roller path system. The cost of the emergency battery power supply and the common alarm panel for the operator's cab are included in the control room hardware and installation estimates.

Suppression System Hardware Estimates

Transformer Room System

<u>Qty.</u>	<u>Ansul P/N</u>	<u>Item</u>	<u>Est. Cost</u>
1	-----	PS-150 w/PLUS FIFTY C Dry Chemical	\$2,000.00
1	17728	AUTOMAN II-C Release	210.00
2	13976	225°F Thermostats	90.00
1	33051	24 VDC Horn	53.25
4	3189	D-1 Nozzle	30.00
1	6335	3/4" x 3/4" x 1" Tee	2.50
2	4655	1/2" x 1/3" x 3/4" Tee	<u>5.00</u>
Total System Hardware Cost			\$2,390.75

Installation

<u>Item</u>	<u>Est. Cost</u>
Electrical Supplies	\$ 25.00
Pipe, Fittings	40.00
Electrician, 12 man-hours @ \$7/hr.	84.00
Welding, 8 man-hours @ \$7/hr.	56.00
Pipefitters, 12 man-hours @ \$7/hr.	<u>84.00</u>
Total Installation Cost	\$289.00

Control Room Suppression System

<u>Qty.</u>	<u>Ansul P/N</u>	<u>Item</u>	<u>Est. Cost</u>
1	32303	Halon Tank, 90-Lb.	\$1,122.00
1	27422	Tank Bracket	24.00
1	32156	Discharge Hose	72.00
1	32333	Union Elbow	12.00
3	33051	24 VDC Alarm Horn	159.75
4	31216	Ionization Detector	279.00
4	31218	Detector Base	81.00
2	33071	Pull Station	26.25

Control Room Suppression System (Con't.)

<u>Qty.</u>	<u>Ansul P/N</u>	<u>Item</u>	<u>Est. Cost</u>
2	33262	Entrance Warning Sign	6.00
2	33263	Exit Warning Sign	6.00
1	32097	Solenoid Actuator	135.00
1	32094	Manual Override	67.50
1	-----	RCU Control Unit	550.00
1	-----	Emergency Power Supply	<u>700.00</u>
Total System Hardware Cost			\$3,228.50

Installation

<u>Item</u>	<u>Est. Cost</u>
Electrical Supplies (Including Hardware for Common Alarm Panel)	\$150.00
Pipe, Fittings	25.00
Electrician, 32 man-hours @ \$7/hr.	224.00
Welding, 12 man-hours @ \$7/hr.	84.00
Pipefitter, 8 man-hours @ \$7/hr.	<u>56.00</u>
Installation	\$539.00

Roller Path System

<u>Qty.</u>	<u>Ansul P/N</u>	<u>Item</u>	<u>Est. Cost</u>
1	8297	PS-500 w/PLUS FIFTY B Dry Chemical	\$3,100.00
1	17728	AUTOMAN II-C Release	210.00
16	2841	F-1 Nozzle	120.00
8	13970	190 <sup>o</sup> F Thermostat	360.00
1	6110	1½" x 1½" x 2" Tee	6.25
2	6337	1" x 1" x ½" Tee	6.80
4	6335	¾" x ¾" x 1" Tee	10.00
8	4665	½" x ½" x ¾" Tee	20.00
1	33051	24 VDC Horn	<u>53.25</u>
Total System Hardware Cost			\$3,886.30

Installation

<u>Item</u>	<u>Est. Cost</u>
Electrical Supplies	\$ 75.00
Pipe, Fittings	240.00
Electrician, 24 man-hours @ \$7/hr.	168.00
Pipefitter, 48 man-hours @ \$7/hr.	336.00
Welding, 16 man-hours @ \$7/hr.	<u>112.00</u>
Installation Total	\$931.00

## 8.0 FIELD INSTALLATION AND FIRE TEST DEMONSTRATIONS

### 8.1 Plans for Field Demonstration

The field demonstration involved fire tests performed on a blast-hole drill and a mining shovel at a surface coal mine demonstrating the performance of the prototype automatic fire control systems installed on these machines.

The Ansul Company and the Peabody Coal Company of St. Louis, Missouri, began planning in March of 1977 towards a cooperative effort to perform the required field demonstration. An agreement between the two companies (see Appendix A) determined that the demonstration would be performed on machinery at the Peabody Coal Company mine at Lynnville, Indiana. The test plan, prepared in accordance with Section 4 of the agreement, is included as Appendix B of this report. It describes the procedures to be followed and the assignment of responsibilities.

The field demonstration was performed on October 13, 1977 and was witnessed by the following:

Alan Cook, Peabody Coal Company, Area Safety Supervisor  
Bill Pomroy, TCMRC, Bureau of Mines  
Dave Johnson, TCMRC, Bureau of Mines  
Mike McGuire, MESA, Denver Technical Center  
Len Hansson, Bucyrus-Erie Company  
Emory Thomas, Brunswick Company, Costa Mesa, California  
Al Kasten, The Ansul Company  
Arnie Warzon, The Ansul Company  
Rick Plog, The Ansul Company  
Ralph Strutz, The Ansul Company  
Gene Reid, The Ansul Company

### 8.2 Blast-Hole Drill Installation Description

The blast-hole drill suppression system described in Section 5.0 of this report was installed on the BE 61R drill located at the Peabody Lynnville Mine on October 17 through 19. The installation was accomplished by Ansul and the mine personnel within the time and cost indicated in the installed system cost estimate. The following is a sequence of photographs showing the system as installed:

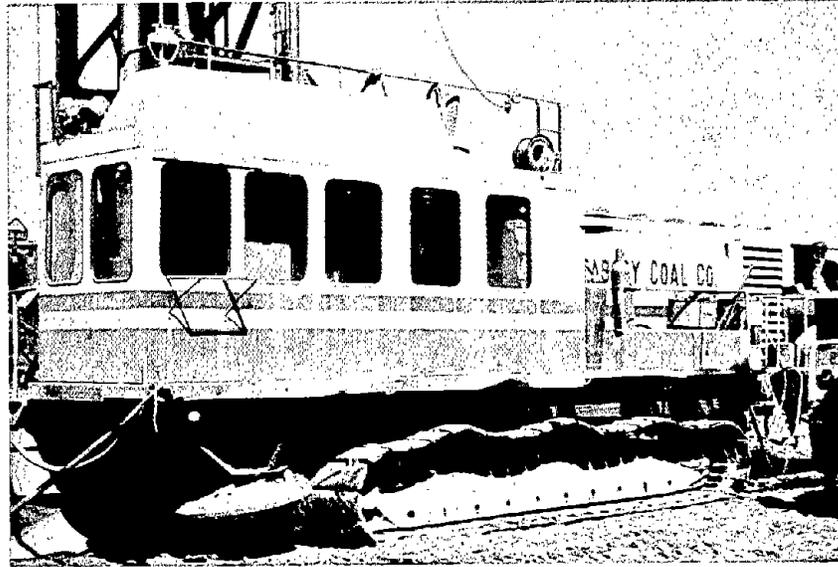


Figure 35 - Bucyrus-Erie Blast-Hole Drill



Figure 36 - Halon Tanks, RCU Control Unit,  
Brunswick Monitoring Equipment

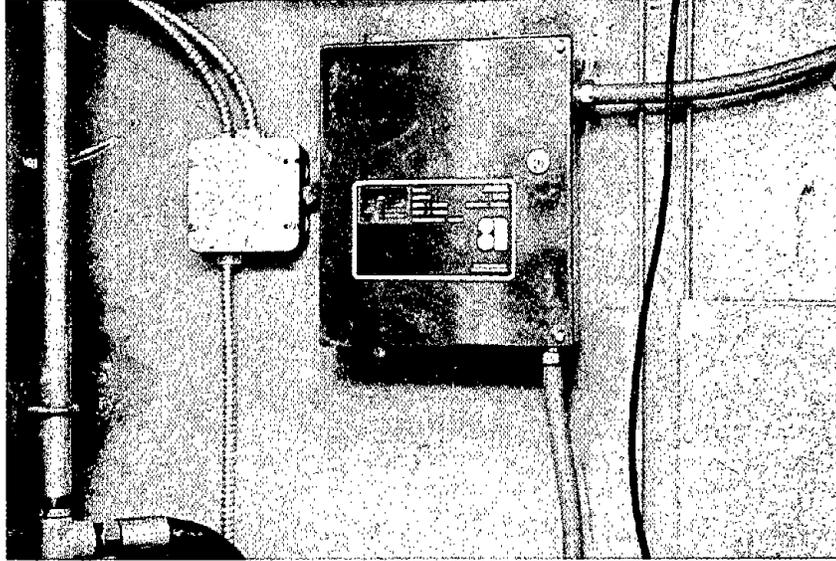


Figure 37 - RCU Control Unit

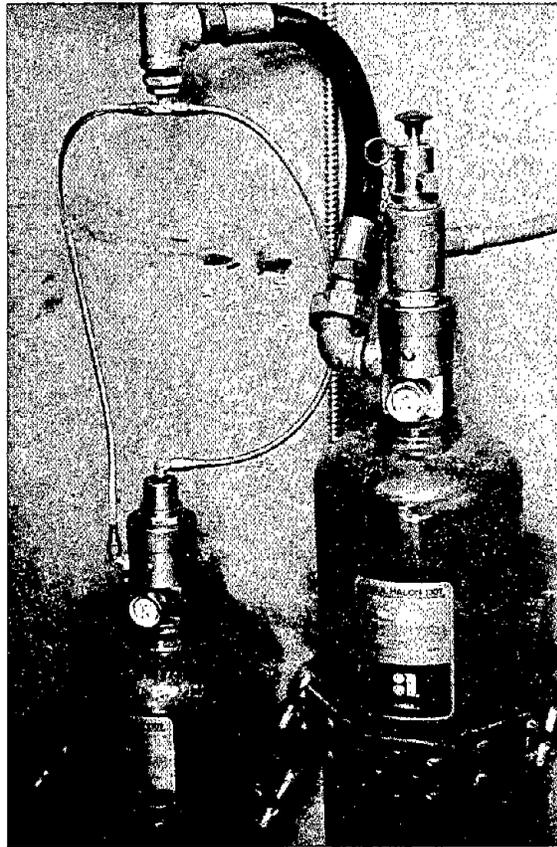


Figure 38 - Halon Tank Valves and Actuators

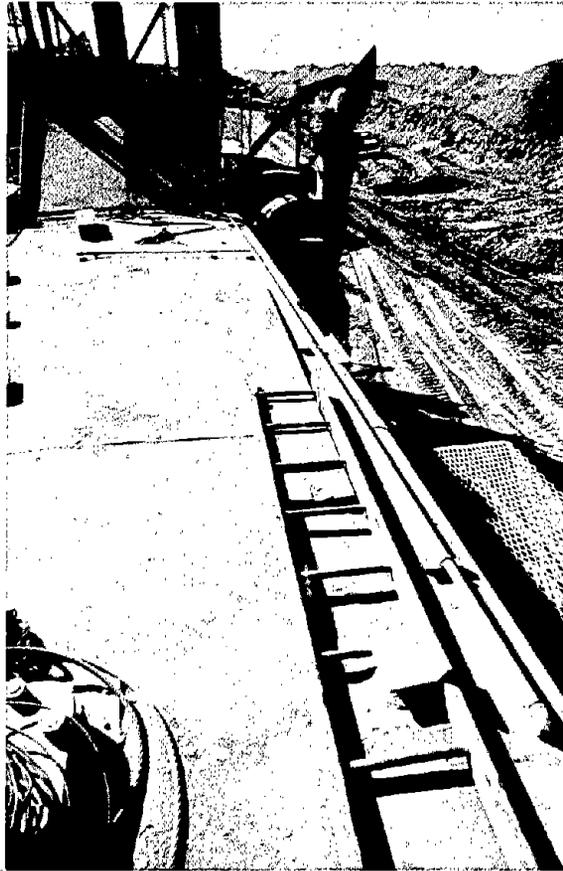


Figure 39 - Externally-Mounted Halon Distribution Piping

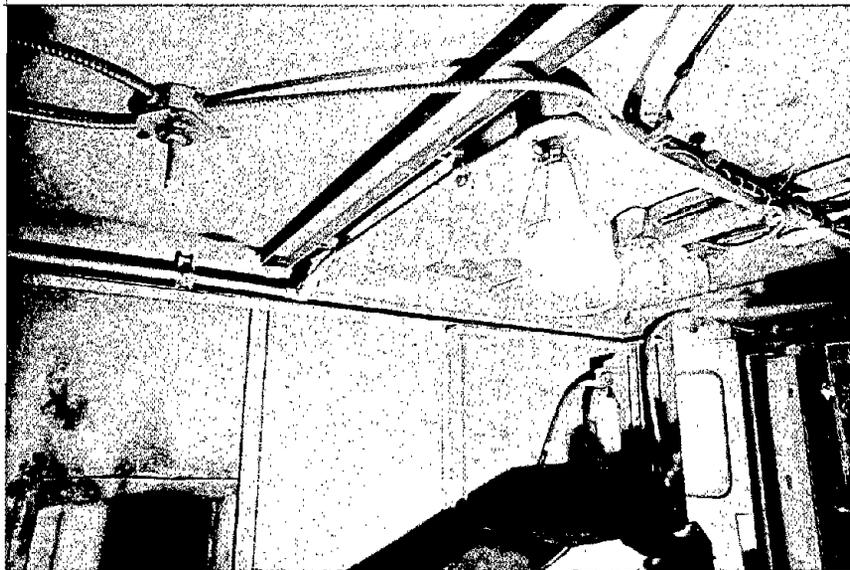


Figure 40 - Thermal Detectors and Brunswick Detector (Right)

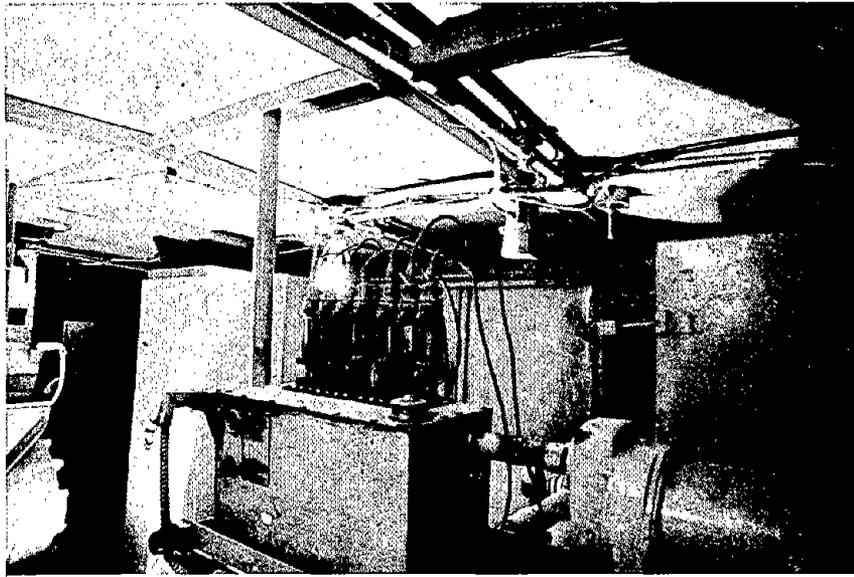


Figure 41 - Brunswick and Thermal Detectors,  
Halon Discharge Nozzle (Left)

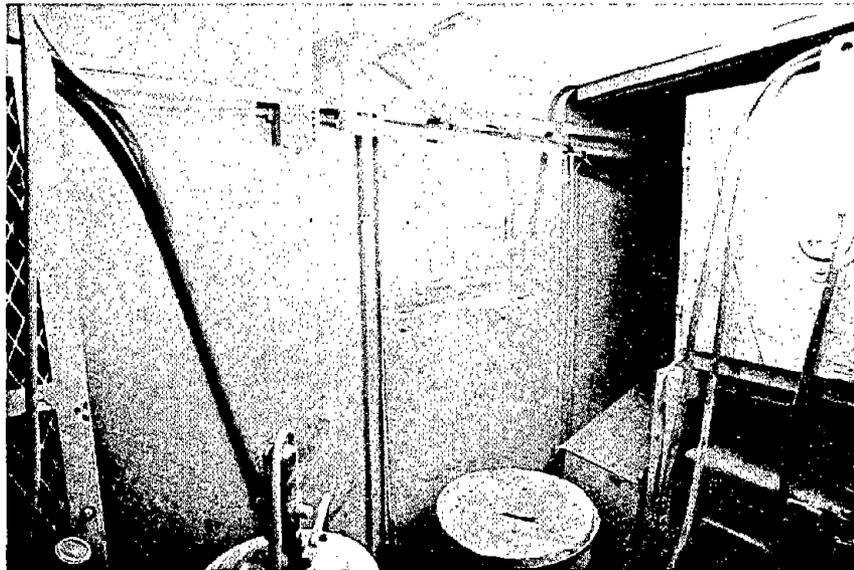


Figure 42 - Main Enclosure Alarm

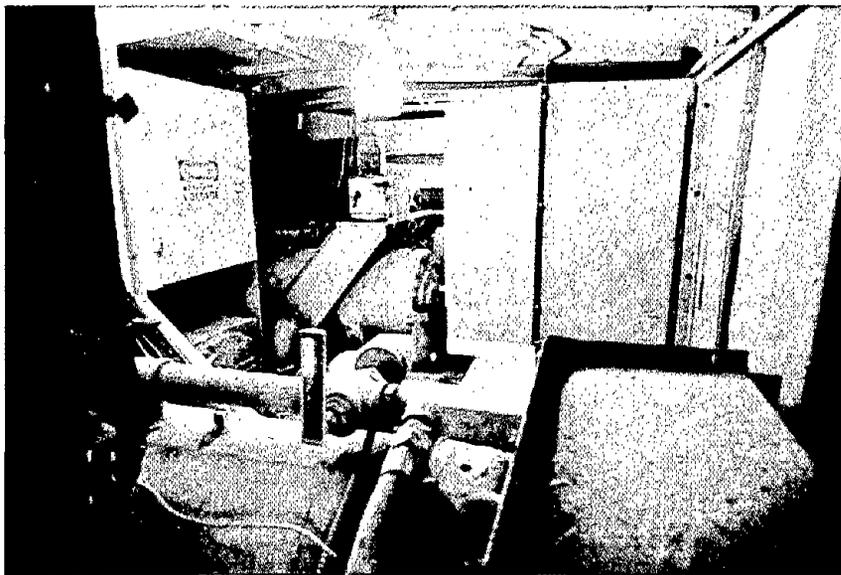


Figure 43 - Fire Canister Location in Main Machinery Enclosure



Figure 44 - Halon Distribution Piping (Along Ceiling)  
Hydraulic Enclosure Fire Canister Location (Bottom)



Figure 45 - Operator's Enclosure Manual Pull Station (Upper)  
Fire Canister (Lower)



Figure 46 - Wiring Insulation Following Extinguishment

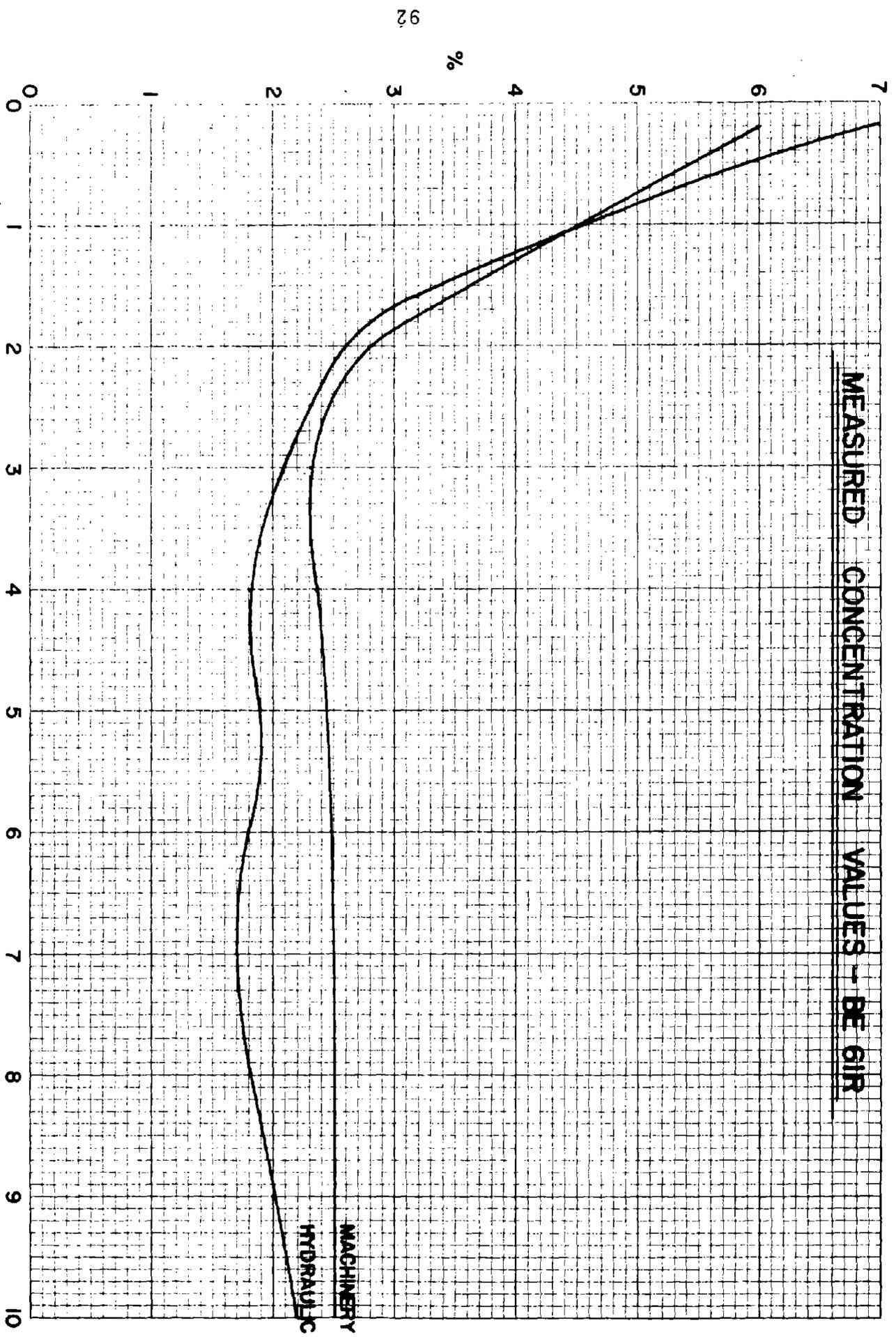
### 8.2.1

#### Blast-Hole Drill Test Description

An actuation and discharge test of the drill suppression system was conducted on October 20, 1977. A description of the testing is as follows:

Two fire canisters, approximately 5" tall x 3" in diameter, containing a cleaning solvent used on the drill, were placed in the operator's cab and hydraulic enclosure. A third container, approximately 8" tall x 5" in diameter, containing cleaning solvent and a bundle of standard plastic insulated electrical wire, was placed in the main machinery enclosure. A Cardox Corporation halon concentration analyzer was used to monitor the concentrations at a point near the ceilings of the hydraulic and machinery enclosures. Following a preburn sufficient to allow the test fires to become well established, the system was discharged by operating the manual pull station in the operator's enclosure.

Immediately upon actuation, the system control sounded alarms in the machinery enclosure and operator's cab and shut down the ventilation system, air compressors and motor-generator sets. Following a 35-second delay, the control unit initiated the halon discharge. All test fires were extinguished in 8-10 seconds from the start of discharge. Photographs 43 through 46 show the locations of the fire canisters within the enclosures and the condition of the wiring insulation following extinguishment. The graph of Figure 47 shows the halon concentrations measured within the machinery and hydraulic enclosures during and following discharge. The concentration within the machinery enclosure registered approximately 7.8% at 15 seconds, then dropped to 5% at one minute. At approximately two minutes 15 seconds into discharge, the concentration leveled at approximately 2.5% and remained at that level until the 10-minute mark following discharge. The concentration within the hydraulic enclosure reached 5.7% immediately after discharge, dropped to 2% at three minutes into discharge, and remained at that level until 10 minutes had elapsed. Continual monitoring of the Brunswick detector output during the test indicated an alarm signal, triggered by the test fire, was



MINUTES  
Figure 47

received approximately one minute before the halon discharge. At no point during the test did the thermal detectors react to the test fires. A detailed report describing the Brunswick detector performance is found in Appendix D.

### 8.2.2

#### Analysis of Test Results

The testing demonstrated the system's ability to correctly perform the alarm and equipment shutdown functions and to produce extinguishing concentrations of Halon 1301 in the various machine compartments. The rapid extinguishment of the test fires correspond to the rapid build-up of the measured concentrations in the machinery and hydraulic enclosures. The peak concentrations reached were slightly above the design values, apparently due to the design procedure of not considering the interior fixtures when calculating the enclosure volume.

The measured concentration decay for the machinery enclosure was more rapid than expected for primarily two reasons. First, the elevated location of the sampling point could be expected to produce a concentration reading lower than the average because of agent settling following the initial discharge. Although the velocity and pattern of the initial discharge produces a near homogeneous agent dispersal, because of a halon density greater than air and lower nozzle velocities during the extended discharge some stratification can be expected to occur. Secondly, the area of the uncloseable opening used in the design calculations apparently failed to account for the small conduit and other miscellaneous openings in the machinery enclosure walls and floor. These openings are not often readily apparent or visible and were overlooked during the design survey.

Accounting for the smaller openings cannot be accomplished by simply estimating and combining their areas. The design procedure of NFPA 12A, A-2530, separately relates leakage to the height and width of a particular opening. Calculating a single opening area with a leakage rate equivalent to that of several smaller openings can be accomplished by calculating and summing the leak rate for each individual opening at

a hypothetical concentration and then, from the chart of A-2530, finding a height and width combination that will produce the calculated total. For small and irregularly shaped openings this procedure can be difficult and require optimizations that would produce questionable results.

The recommended procedure to follow during design and installation is to caulk or otherwise seal all openings not required for ventilating or other operating purposes. This is especially required of floor openings which are apparently not considered by A-2530. The remaining openings would then be measured and accounted for in the system design parameters.

### 8.3

#### Loading Shovel Installation Description

The SCAD/dry chemical system and the Halon 1301 suppression systems were installed on the BE 150-B coal loading shovel at the Peabody Company Lynnville Mine on October 12 through 14. The installation was performed by Ansul and mine personnel for the time and costs indicated in the installation cost estimate. Yet to be provided by mine personnel is a protective enclosure to guard the halon tanks from falling objects and possible overheating by direct exposure to the summer sun. Following is a series of photographs showing the systems as installed:

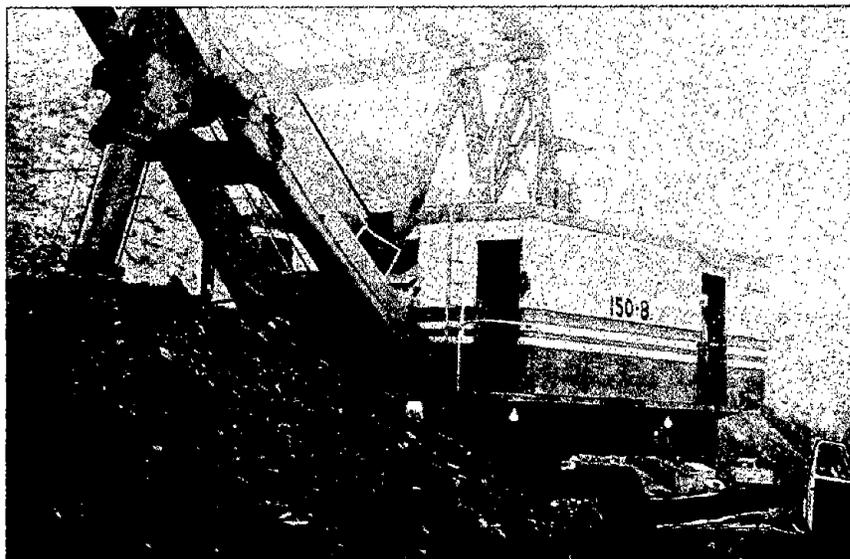


Figure 48 - Bucyrus-Erie 150-B Loading Shovel

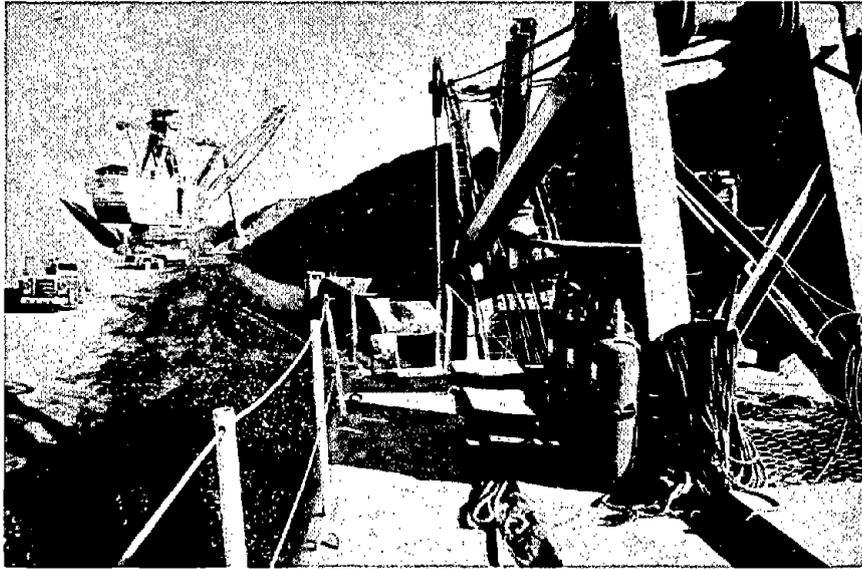


Figure 49 - Halon Tanks Mounting Location

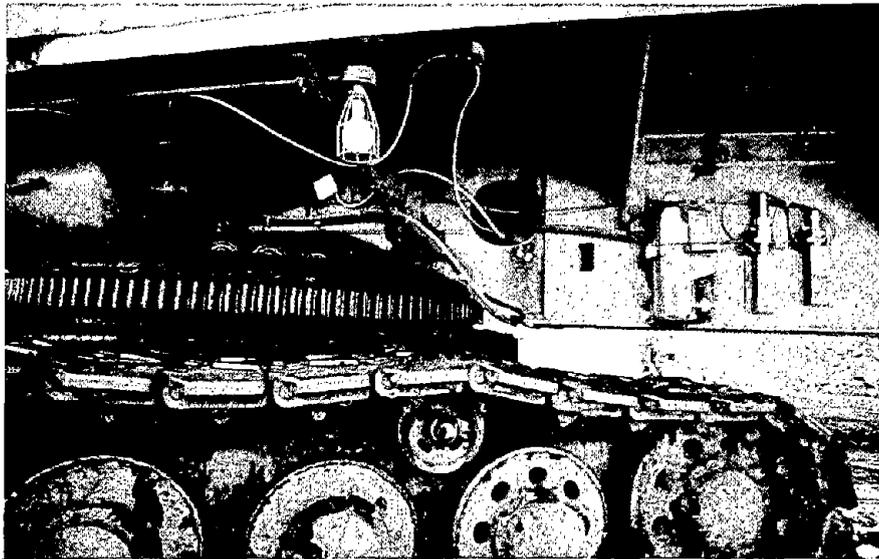


Figure 50 - SCAD/Dry Chemical System Installed on Roller Path



Figure 51 - Halon Nozzle Location

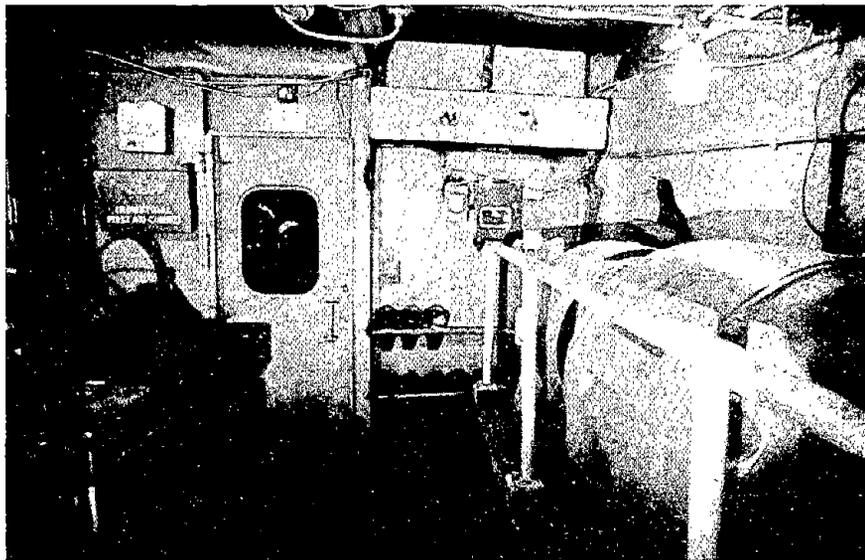


Figure 52 - RCU Control Unit, Manual Pull Station,  
Alarm Horn (Above Door)

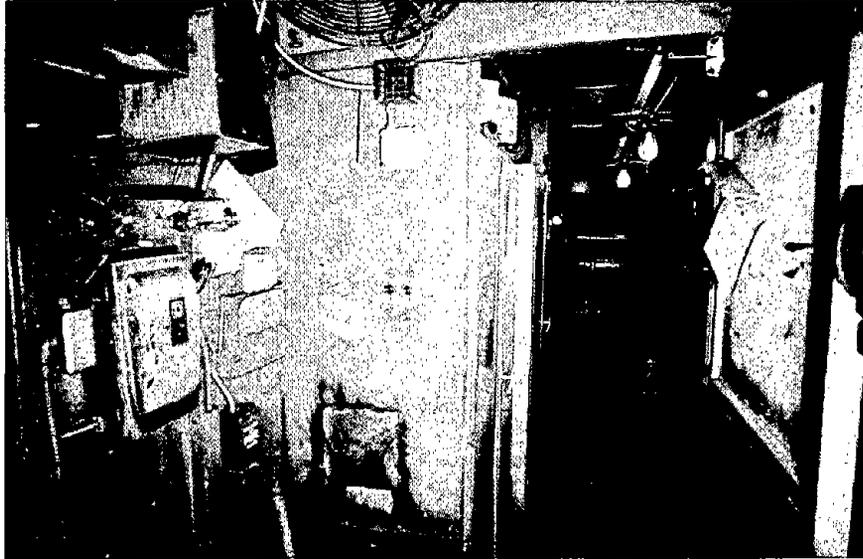


Figure 53 - Operator's Cab Manual Pull Station and Alarm Horn



Figure 54 - Thermal Detectors Above Motor-Generator Sets

### 8.3.1

#### Dry Chemical System Test Description

Testing of the SCAD/dry chemical system on a mock-up of the 150-B collector ring area was conducted at the Ansul Fire Technology Center in Marinette on August 4, 1977. The mock-up was a to-scale steel reconstruction of the volume housing the shovel center pin and collector rings. Represented in the interior of the fixture were a simulated center pin and support gussets. The dry chemical system nozzles were mounted on the exterior and directed to discharge into the volume through a 3" opening along the outer edge.

The test fire was provided by two 18" square pans containing heptane placed within the volume. Rather than placing the detection tubing directly over the fire, a single loop was suspended near the edge of the volume to allow time for the fire to build before the system reacted. Within

seconds following igniting of the heptane the SCAD automatically actuated the dry chemical system. The discharge was immediate and completely extinguished the test fires. Following is a series of photographs showing the test apparatus and the fire testing.

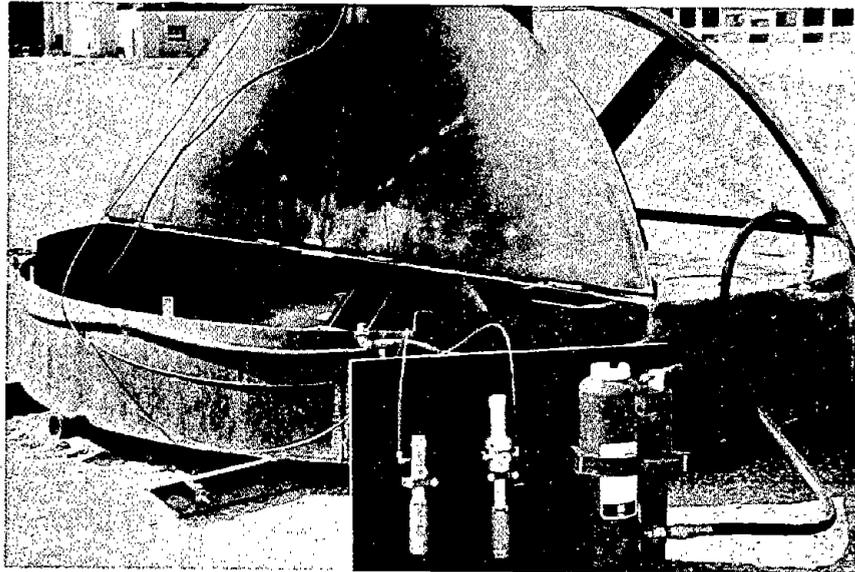


Figure 55 - SCAD/101-20 Dry Chemical System Installed on Roller Path Mock-Up

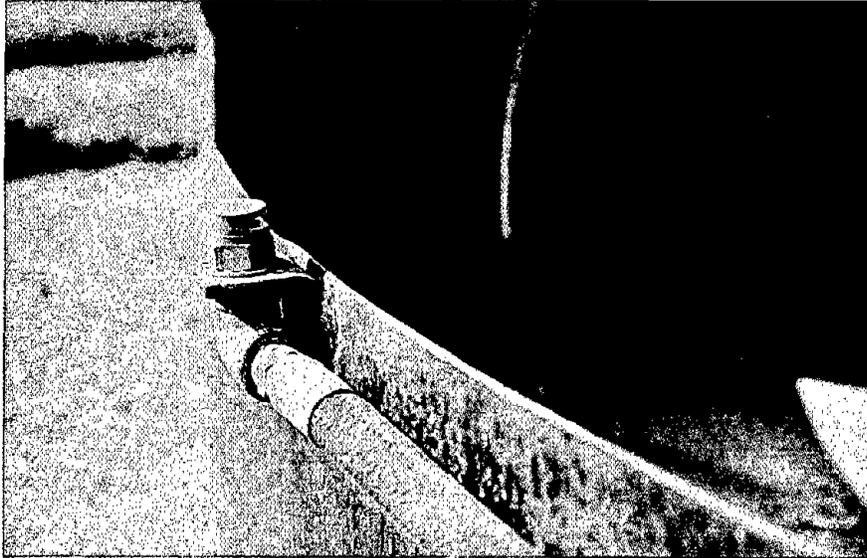


Figure 56 - Nozzle Placement on Mock-Up, SCAD Detection Tubing Shown to Right of Nozzle

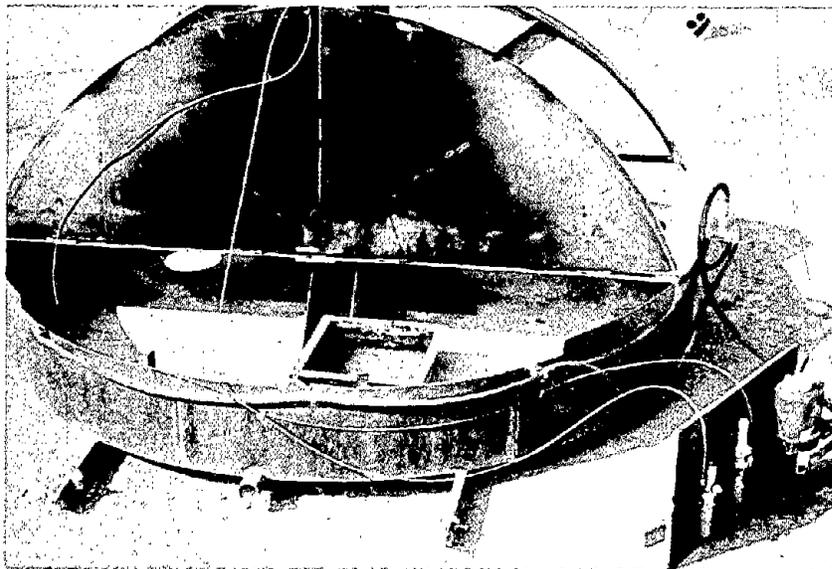


Figure 57 - Fire Test Fuel Pan Containing n-Heptane, Detection Tubing to Left of Pan

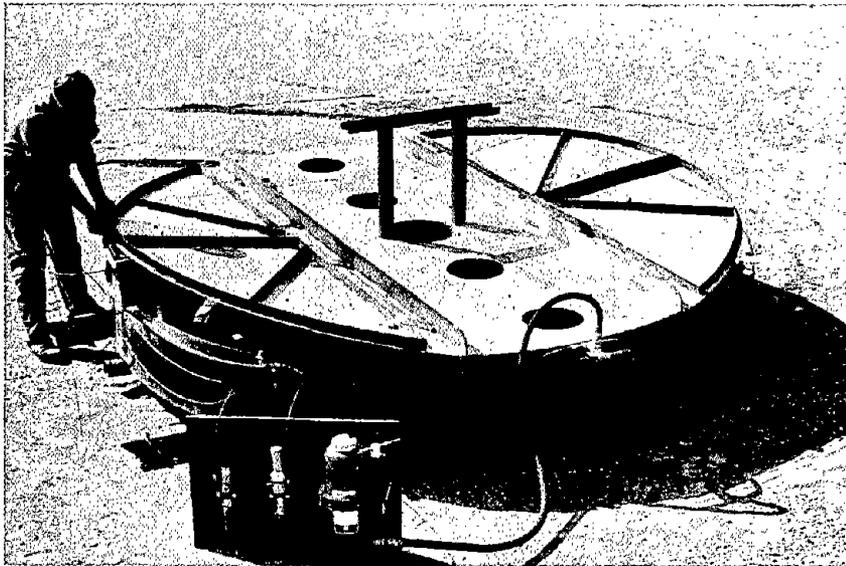


Figure 58 - Covers Lowered in Preparation for Testing

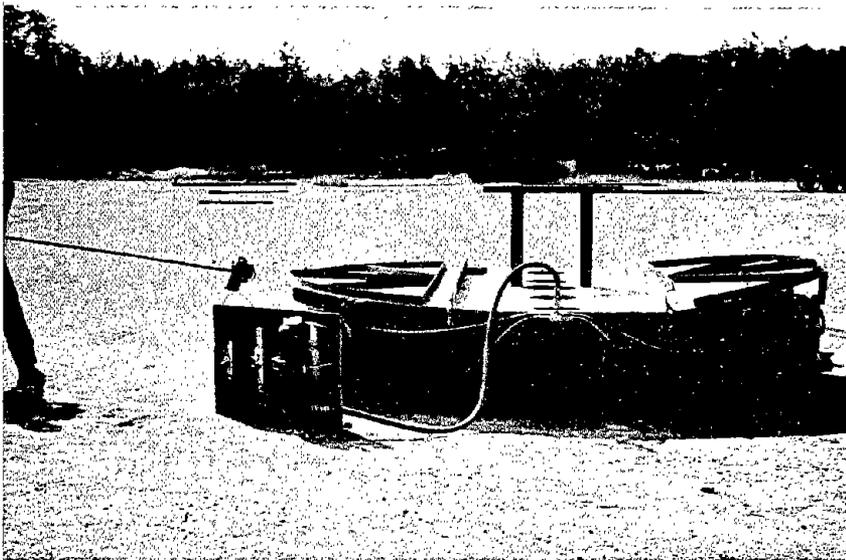


Figure 59 - Covers Closed Completely as Heptane is Ignited

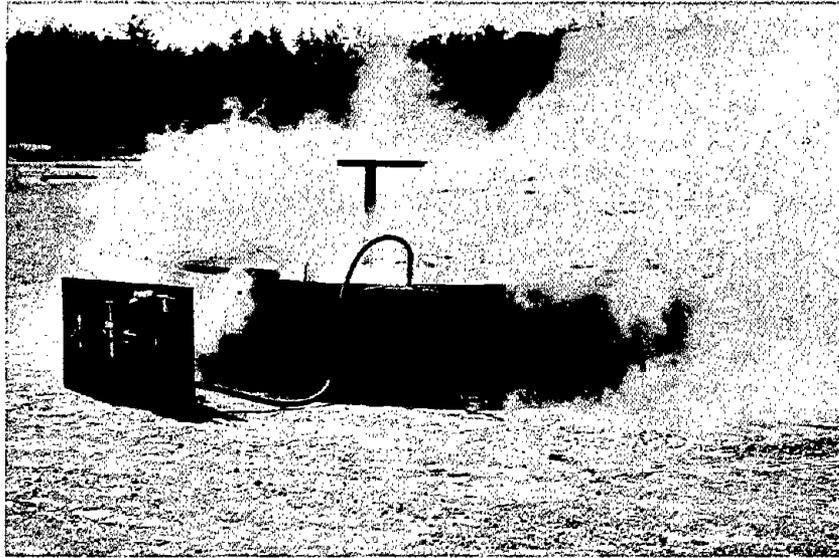


Figure 60 - Automatic Dry Chemical Discharge  
Resulting in Complete Extinguishment of Test Fires

### 8.3.2

#### Halon System Test Description

The installed halon suppression system was tested at the Lynnville Mine on October 20, 1977. During installation a small metal chip lodged in the control unit's power supply creating an electrical short. Because of the limited time assigned to run the test, rather than immediately effect repairs the system was tested using its standby batteries. A description of the testing is as follows:

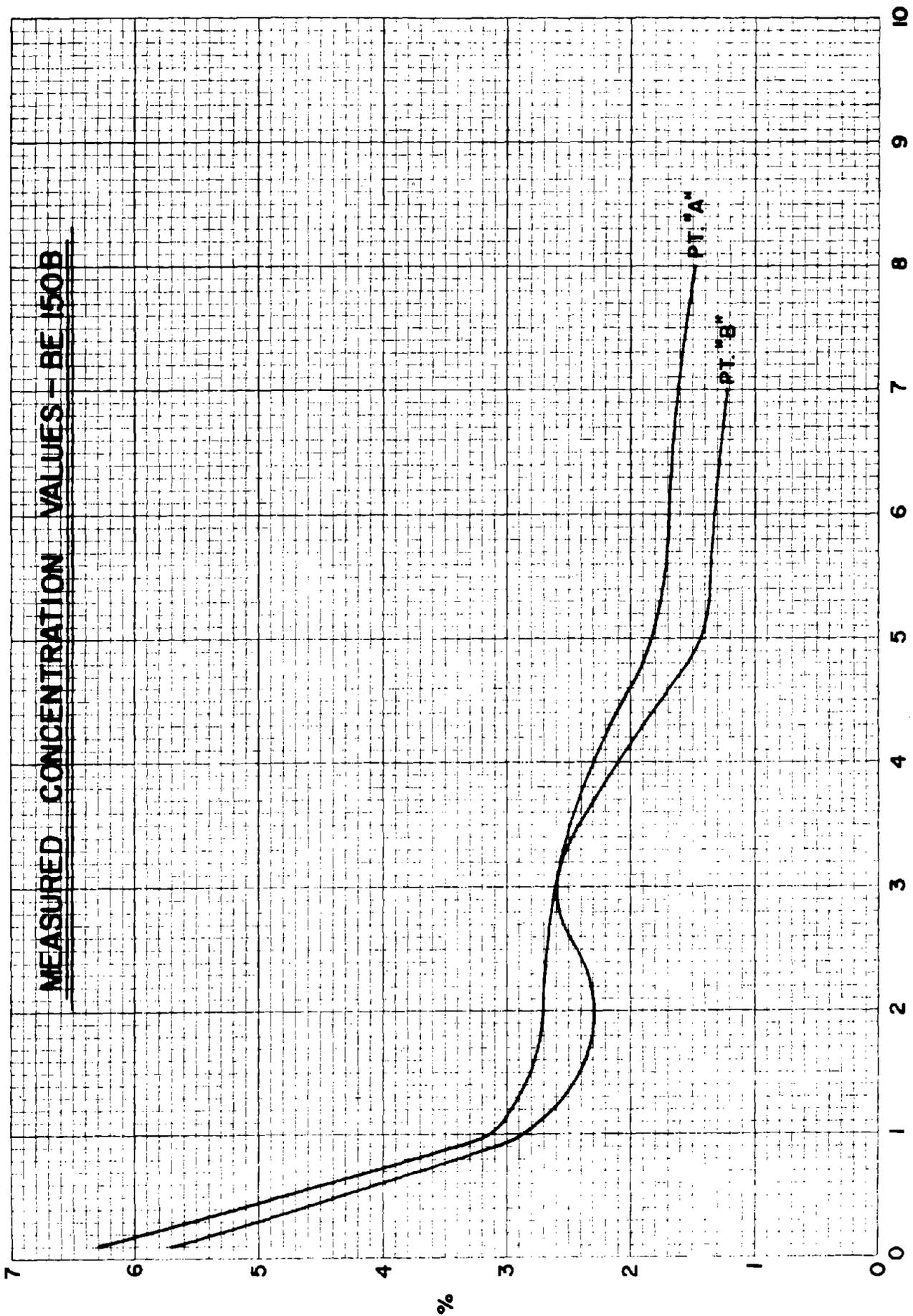
Two fire canisters, identical to those used in the BHD testing, were placed in the machinery enclosure. The solvent and wiring in the canisters was ignited and allowed to burn until established. The system was then actuated using the pull station located near the exit from the machinery enclosure. Immediately upon actuation, the

alarms sounded, doors closed and the ventilating fan was shut down. Following a 30-second delay, the motor-generator sets were shut down and the halon discharge begun. The test fires were completely extinguished in eight and 10 seconds from start of discharge. The concentrations recorded during the initial and extended discharge are shown by the graph of Figure 61. Both sampling points were located near the ceiling of the compartment, Point "A" approximately midway along the side of the enclosure and Point "B" at the rear of the machine near the fan opening.

### 8.3.3

#### Analysis of Halon Test Results

The performance of the loading shovel halon system closely paralleled that of the blast-hole drill system. The alarm and shutdown functions, including closing of the machinery house doors and the halon discharge, all performed as intended. The initial discharge quickly reached the design concentration and rapidly extinguished the test fires. However, as in the drill system testing, during the extended discharge the concentration fell quickly to approximately the 2.5% level. Again, as in the drill system testing, the most probable explanation for the drop in measured concentration is the extreme elevation of the sampling points and the failure to account for the smaller openings in the design procedure.



MINUTES  
Figure 61

APPENDIX A  
PEABODY - ANSUL AGREEMENT



1 reimburse Peabody for all costs directly or indirectly incurred  
2 by Peabody which result from such system installations.

3 The installation of the systems provided herein shall be  
4 accomplished at a time as shall be convenient for Peabody as  
5 determined by Peabody in its sole discretion. It is anticipated  
6 that such installation will be convenient to Peabody when the  
7 shovel and blast-hole drill are non-operational.

8 Section 2. Delivery. Ansul agrees to deliver all component  
9 parts of each system for use on Peabody's shovel and blast-hole  
10 drill at a time as shall be mutually agreed upon. Ansul agrees  
11 to pay all transportation charges and other delivery costs to  
12 Lynnville Mine. At the termination of this Agreement, Peabody  
13 agrees to remove each such system from the shovel and blast-hole  
14 drill so that it may be disposed of by Ansul at Ansul's expense.  
15 Ansul shall reimburse Peabody for all direct or indirect costs  
16 incurred by Peabody in the removal of the systems.

17 Section 3. Risk of Loss. Ansul shall have all risk of loss  
18 or damage to the systems before they are delivered to Peabody.  
19 After delivery and during the performance of this Agreement, Ansul  
20 shall assume all risk of loss or damage to the systems from every  
21 cause whatsoever including damage or loss due to fire, water and  
22 theft except for any loss or damage resulting from the sole  
23 negligence or willful misconduct of Peabody, its agents or  
24 employees. At the termination of this Agreement, possession and  
25 all risk of loss or damage to the systems shall be deemed to pass  
26 to Ansul.

27 Section 4. Demonstration. The demonstration of the systems  
28 shall be conducted by Ansul on a date which shall be mutually

1 agreeable but no later than October 31, 1977. Ansul agrees to  
2 refrain from conducting any demonstration of the systems until  
3 a detailed demonstration plan shall have been first submitted to  
4 Peabody in writing for its review and approval. In the event,  
5 however, that Peabody in its sole discretion subsequently deter-  
6 mines that the demonstration of the systems is in any manner  
7 unsafe or unduly disrupts mining, Peabody shall have the right  
8 to disallow the demonstration.

9 Section 5. Termination. This Agreement shall terminate on  
10 March 9, 1979, unless extended for an eighteen month period in  
11 accordance with Section 11, hereof, in which case the term of  
12 this Agreement shall be so extended. In addition to other legal  
13 and equitable remedies, Peabody reserves the right to terminate  
14 at any time this Agreement as same may be extended, for its own  
15 convenience by giving Ansul ten (10) days written notice.

16 Section 6. Right of Entry. Ansul, its employees and agents  
17 are hereby granted a right to enter on and about Lynnville Mine  
18 for the purpose of performing this Agreement; provided, however,  
19 Ansul shall have first executed a Master Visitor's License Agree-  
20 ment, a copy of which is appended hereto as Exhibit A and in-  
21 corporated by reference herein. In addition, any employees,  
22 agents or representatives of Ansul or others entering Lynnville  
23 Mine at the request of Ansul shall execute a Visitor's License  
24 Agreement in accordance with the terms of the Master Visitor's  
25 License Agreement. Any terms and conditions contained in said  
26 agreements which are inconsistent with this Agreement are hereby  
27 deemed to be non-applicable and null and void.

28

1           The right of entry granted Ansul herein shall be considered  
2 a license, revokable at will without recourse. It is agreed  
3 that Ansul, its agents and employees shall at all times serve  
4 at the direction of Peabody personnel when on Peabody property  
5 and that Peabody may exclude Ansul employees or agents from its  
6 Lynnville Mine at any time for any reason.

7           Section 7. Compliance with Laws. Ansul warrants that all  
8 goods delivered and services performed by it under this Agreement  
9 shall comply with the Fair Labor Standards Act of 1938, as amend-  
10 ed, and the Federal Coal Mine Health and Safety Act of 1969, as  
11 amended, and all other applicable federal, state and local laws  
12 and regulations. Ansul agrees to indemnify and hold harmless  
13 Peabody, its directors, officers and employees from all penalties,  
14 fines and other charges resulting from violations or alleged  
15 violations by Ansul, its agents and employees of such laws, rules,  
16 regulations, orders and ordinances, including but not limited to  
17 the Federal Coal Mine Health and Safety Act of 1969, which relate  
18 to the performance of this Agreement.

19           Ansul agrees to obtain any and all state, federal or local  
20 permits, licenses or authorizations necessary or incidental to  
21 the performance of this Agreement at no cost or obligation to  
22 Peabody.

23           Section 8. Indemnification. Ansul agrees to indemnify and  
24 save harmless Peabody, its officers, agents and employees, from  
25 and against any and all liability, loss, damage, costs, attorney  
26 fees, or other expense of whatsoever nature or character, arising  
27 out of or occasioned by any claim or any suit for damages,  
28 injunction or other relief, on account of injury to or death of

1 any person, damage to any property, or for public charges, or  
2 with respect to any demand, liability or lien, growing out of  
3 or in connection with any act or omission, negligent or other-  
4 wise, of Ansul or any of its servants, agents, or subcontractors,  
5 solely or jointly with others, in the furnishing of articles or  
6 material or in the performance of services hereunder unless  
7 occasioned solely by the negligence or willful misconduct of  
8 Peabody, its agents or employees. In addition, Ansul assumes  
9 all liability for any injuries or damages to its agents, employees  
10 or persons present at its request on Peabody's premises, regard-  
11 less of whether such agent, employee or other person is, at the  
12 time of such injury or damage, acting outside the scope of his  
13 employment or other authority. This indemnity shall survive the  
14 delivery of goods or performance of services hereunder.

15 Anything herein to the contrary notwithstanding, the hold  
16 harmless and indemnification rights granted to Peabody, its  
17 officers, agents and employees, by Ansul pursuant to this  
18 Agreement shall not extend to liability, loss, damage, costs,  
19 attorney fees, or other expenses which arise or are occasioned  
20 by failure of the Fire Suppression Systems to extinguish any  
21 fire which may occur during the Long Term Validation Testing  
22 referenced in Section 11 of this Agreement.

23 Section 9. Insurance. It is agreed that all Ansul  
24 personnel shall remain the employees of Ansul during the  
25 performance of this Agreement. Ansul agrees to carry general  
26 liability, automobile liability and workmen's compensation  
27 insurance in the amounts and in accordance with the provisions  
28

1 of Exhibit B, attached hereto and incorporated by reference  
2 herein. Ansul shall also obtain insurance coverage of those  
3 indemnity provisions above customarily subject to public  
4 liability insurance.

5 Section 10. Patents. Ansul covenants and agrees to save  
6 harmless and indemnify Peabody against all claims, suits, actions  
7 or proceedings by reason of alleged infringement of patents,  
8 trademarks or copyrights or from royalties involved in con-  
9 sequence of the use of the equipment and materials covered by  
10 this Agreement.

11 Section 11. Long Term Validation Testing. Upon completion  
12 of the demonstration specified in Section 5 hereof and provided  
13 it is mutually agreeable, the term of this Agreement shall be  
14 extended and the systems shall remain on the blast-hole drill  
15 and shovel for an additional eighteen month period. It is  
16 agreed that during such period Ansul may periodically inspect  
17 and discharge the systems subject to the terms and conditions  
18 of this Agreement.

19 Section 12. Publication. Neither party to this Agreement  
20 shall make any public statement respecting this agreement or  
21 the performance thereof without the prior written consent of  
22 the other party.

23 Section 13. Notices. All payments, notices, approvals  
24 and other communications required by this Agreement shall be  
25 made in writing to the Parties at the following addresses:

26	Peabody Coal Company	The Ansul Company
27	301 North Memorial Drive	One Stanton Street
28	St. Louis, Missouri 63102	Marinette, Wisconsin 54143
	Attn: W. D. Humphrey	Attn: Gene R. Reid

1            Section 14. Choice of Law. This Agreement is to be  
2 governed in its formation, performance and remedies by the  
3 law of the State of Missouri.

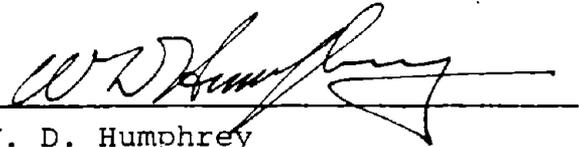
4            IN WITNESS WHEREOF, the Parties have caused this Agreement  
5 to be executed by their duly authorized representatives as of  
6 the date first above written.

7  
8 ATTEST:

PEABODY COAL COMPANY

9  
10 

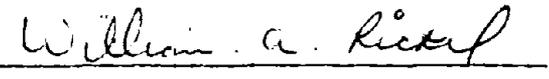
By



11 W. D. Humphrey  
12 Vice President,  
13 Production Development

14 ATTEST:

THE ANSUL COMPANY

15  By 

**PEABODY COAL COMPANY**  
**VISITOR'S LICENSE AGREEMENT (INDIVIDUAL)**

THIS AGREEMENT, made and entered into this \_\_\_\_\_ day of \_\_\_\_\_, 197\_\_\_\_, between PEABODY COAL COMPANY, a Delaware corporation (hereinafter referred to as "Peabody"), and \_\_\_\_\_, (hereinafter referred to as "Licensee");

The parties agree as follows:

1. GRANT OF PERMISSION. In consideration of Licensee's promises herein, Peabody hereby gives permission, revocable and terminable as hereinafter provided, to Licensee to enter on the land owned or controlled by Peabody described below for the purpose of \_\_\_\_\_  
\_\_\_\_\_ all on the terms and conditions herein set forth which Licensee promises to comply and abide with.
2. DESCRIPTION OF PROPERTY. The property owned or controlled by Peabody that Licensee is hereby permitted to enter is described as follows: \_\_\_\_\_  
\_\_\_\_\_ (hereinafter sometimes referred to as "the premises").
3. TERM OF GRANT. The permission granted hereunder shall be effective as of \_\_\_\_\_, 19\_\_\_\_ and shall continue to \_\_\_\_\_, 19\_\_\_\_ unless terminated earlier as provided in paragraph 11 of this Agreement.
4. CONDITION OF THE PREMISES. Licensee knows that the lands involved include active mining areas with rough and unstable surface, loose rock and soil, open pits and shafts, active haulage routes, blasting and subsidence areas, and areas of operations for heavy equipment, or include mined areas with similar conditions, or may include ponds and other waters of irregular shore and bottom, where hazardous objects may have been placed without knowledge of either party. Peabody has not maintained or prepared the land for the purposes of the Licensee, and cannot examine the land or give warning of its conditions, or of the conduct of other persons, to the Licensee. Therefore, Peabody does not warrant or represent that the premises are safe, healthful, or suitable for the purposes for which they are permitted to be used under the terms of this license and makes no representation as to the condition of the premises, or the conduct of others on the land, except that it may be unsafe for the purposes of the Licensee. Licensee by this agreement is informed and understands that Peabody would be exposed to legal liability and cost of an unknown amount in order to extend this use of its land and would not allow this usage without the relief of liability, waiver of claims and compliance with conditions of this Agreement and permits to be issued under this Agreement.
5. ASSUMPTION OF RISK, INDEMNIFICATION AND RELEASE OF LIABILITY. As a material consideration for the privilege of using Peabody's premises, Licensee hereby assumes all risk and responsibility for any injuries or damages sustained by any person, persons or property resulting from, arising out of, or in any way connected with, the occupation or use of the premises by Licensee, or the failure on the part of Licensee to perform all and singular Licensee's promises herein. Licensee does hereby waive and release and agree to indemnify and to hold harmless Peabody, its agents and employees from any and all claims for such injuries and damages and any expenses connected therewith. Peabody shall not be liable to Licensee if for any reason whatever Licensee's use of the premises hereunder shall be hindered or disturbed.
6. DAMAGE TO PEABODY PROPERTY. Licensee agrees to pay for damage to growing crops, pasturage, timber, fences, drain tile, buildings, or any other property of Peabody damaged as a result of Licensee's exercise of the privileges granted under this Agreement.
7. NUISANCE. Licensee shall not perform any disorderly conduct or commit any nuisance on the premises or to use the premises in any way so as to interfere with the exercise by other licensees or permittees of privileges which Peabody may give them in the premises.
8. COMPLIANCE WITH APPLICABLE LAWS. Licensee shall comply with all applicable laws, rules, regulations, orders and ordinances of federal, state and local government offices and authorities and Licensee shall indemnify and hold harmless Peabody, its directors, officers, and employees from all penalties, fines and other charges resulting from violations or alleged violations by Licensee, of such laws, rules, regulations, orders and ordinances, including but not limited to the Federal Coal Mine Health and Safety Act of 1969, as amended.
9. PRIVILEGE NOT ASSIGNABLE. Licensee's privileges hereunder shall not be assignable by Licensee in whole or in part.
10. PERMIT CARD. Licensee has read the Permit Card to be issued under this Agreement and Licensee agrees to observe all conditions stated thereon and to return said Permit Card to Peabody personnel upon termination of the permission granted by this Agreement.

11. **TERMINATION.** Unless terminated earlier as provided in this paragraph, the permission granted by this Agreement shall terminate on the date specified in paragraph 3 of this Agreement. Peabody reserves the right to terminate the permission hereby given at any time by giving Licensee at least three (3) days' written notice of such termination, except that Peabody may, at its election, terminate the permission forthwith at any time if Licensee shall fail to comply with or abide by each and all of the provisions hereof or keep all and singular Licensee's promises herein. Waiver by Peabody of any breach of any term or provision hereof shall not be deemed a waiver of any subsequent breach of the same or any other term or provision hereof.
12. **LICENSE ONLY.** Licensee agrees that it does not and shall not claim at any time any interest or estate of any kind or extent whatsoever in the premises, by virtue of this license or its occupancy or use hereunder. Licensee shall not be deemed in any way to be the servant, agent or representative of Peabody in the exercise of the privileges granted under this Agreement.
13. **AUTHORITY TO SIGN FOR MINOR.** In the event Licensee is a minor, the undersigned states and attests that he has the authority to enter into this Agreement on behalf of Licensee.

IN WITNESS WHEREOF, the parties hereto have caused this Agreement to be executed as of the day and year first above written.

PEABODY COAL COMPANY

By \_\_\_\_\_

\_\_\_\_\_ ("Licensee")

By \_\_\_\_\_

# PEABODY COAL COMPANY

SUBSIDIARY OF KENNECOTT COPPER CORPORATION

301 NORTH MEMORIAL DRIVE · ST LOUIS, MISSOURI 63102

TELEPHONE 314 438-3400

## INSURANCE REQUIREMENTS OF PEABODY FORM 5 (Construction Contract)

READ CAREFULLY!

SUBMIT TO YOUR INSURANCE AGENT, IF NECESSARY! - this summary of Article 7 of Peabody's General Conditions for Construction Contracts relating to Indemnity and Insurance, so that a correct and adequate Certificate of Insurance will be furnished:

### Summary of Requirements

	<u>Type of Coverage</u>		<u>Minimum Limits</u>
(1)	Workmen's Compensation and Employer's Liability	\$	Statutor 100,000
(2)	Auto Liability	Bodily Injury	\$100,000/300,000*
		Property Damage	\$ 50,000
(3)	General Liability, including:		
	(a) Contractors Protective.	Bodily Injury	\$500,000/1,000,000
	(b) Contractual Liability - blanket, or pertaining to this contract.	Property Damage	\$500,000/500,000
	(c) "XCU" coverages, as needed.		
(4)	Certificate must provide for 10 days prior written notice of cancellation, lapse or change - <u>denial of responsibility for failure to notify is not acceptable.</u>		

\*In lieu of these limits, the policy may be for a minimum of \$1,000,000 combined Single Limit, or other equivalent even limits.

APPENDIX B  
FIRE TEST DESCRIPTIONS



**THE ANSUL COMPANY**

MARINETTE, WI 54143, TELEX 26-3433, TELEPHONE (715) 735-7411

September 1, 1977

Mr. W. D. Humphrey  
Vice President, Operations Support  
Peabody Coal Company  
301 North Memorial Drive  
St. Louis, Missouri 63102

Dear Mr. Humphrey:

Subject: Agreement for Installation of Fire Suppression Systems on  
Large Surface Machinery

In accordance with Item 10 of the subject agreement, we are submitting  
Exhibit "B" for your review and approval.

Exhibit "B" describes the test plan to be followed in the planned demon-  
stration.

Sincerely,

THE ANSUL COMPANY

Gene R. Reid, Manager  
Contract Research

GRR:msn  
enclosure

cc: Mr. Alan W. Cook  
Area Safety Supervisor  
Peabody Coal Company  
Box 7, Lynville Mine  
Lynville, Indiana 47619

bcc: ~~A.~~ Kasten  
W. Merholtz

## EXHIBIT "B" OF FIRE DEMONSTRATION AGREEMENT

### Test Description - BE 150 Shovel

Testing of the suppression systems aboard the BE 150 shovel will be conducted in three phases. The first and second phases will test operation of the alarms and auxiliary functions of the halon and SCAD systems. The third phase will be a discharge test of the halon system.

Operation of the halon system alarms and accessories will be tested by removing the solenoid actuator from the cylinder valve and manually actuating the system. Proper operation and sequencing of the alarms, equipment shutdowns and time delay, concluding with energizing of the actuator will be noted.

Operation of the SCAD system alarms will be tested by cutting a section of the pneumatic tubing containing the pressure switch. The actuation cartridge will have been removed to prevent discharge of the dry chemical system.

In preparation for the halon system discharge test, two metal containers approximately 8 inches high and 5 inches in diameter containing one inch of heptane and several coils of insulated electrical wire will be placed in the enclosure. The containers will be mounted on base plates to eliminate the possibility of tipping and will be positioned so as not to endanger the machinery. Gas sampling tubing will be placed within the enclosure and run to a Halon 1301 analyzer located outside the enclosure. The system will then be automatically actuated by placing a small heat source

near one of the detection heads. During and for approximately ten minutes following actuation, the concentration within the enclosure will be monitored. Following the ten minute period, an inspection of the test fire containers will be made. At all times while the test containers are within the machine, they will be under supervision of a trained firefighter.

#### Test Description - BE 6LR BHD

Testing of the halon suppression system aboard the 6LR drill will be conducted in two phases. In the first phase, the solenoid actuator will be removed from the cylinder valve and the system will be manually actuated. Proper operation and sequencing of the alarms, time delay and equipment shut-downs, concluding with energizing of the solenoid actuator, will be noted. In the second test phase, the system will be placed into the fully operational condition. Two small metal containers, approximately 5 inches tall by 3 inches in diameter, containing one inch of heptane will be placed in the operator and hydraulic enclosures. A third container, approximately 8 inches tall by 5 inches in diameter, containing one inch of heptane along with several coils of standard insulated electrical wire will be placed into the main machinery enclosure. All fire test containers will be mounted on a base plate to eliminate tipping and will be placed so as not to endanger the machinery. At all times, while the test containers are within the machine, they will be under the supervision of a

trained firefighter. Concentration sampling tubing will be run from each of the three enclosures to a gas analyzer located outside the machine. The system will then be automatically discharged by applying a small heat source to one of the detection heads. During and for approximately ten minutes following actuation, the Halon 1301 concentration in the operation, hydraulic and machinery enclosures will be monitored. At the end of the ten minute period, an inspection will be made of the test fire containers.

#### Responsibilities

- . Mr Alan Kasten of Ansul will be the test conductor and will be responsible for performing all tasks as described above.
- . Mr. Alan Cook of Peabody will be the safety officer in charge. As the safety officer, Mr. Cook will have the authority to direct that the test be stopped at any time he is concerned for safety. Mr. Kasten will follow the direction of Mr. Cook.

#### Approvals

The described test procedure is approved by the following in accordance with the terms of Item 10 of this agreement.

  
\_\_\_\_\_  
Gene R. Reid  
The Ansul Company

\_\_\_\_\_  
The Peabody Coal Company

APPENDIX C  
DESIGN CALCULATIONS



THE ANSUL COMPANY  
 ONE STANTON STREET  
 MARINETTE, WI 54143 (715/735-7411)

TIME: 15:07CST(21:07GMT)                      DATE: 11/10/77

JOB NUMBER: 05107  
 CUSTOMER NAME: PEABODY COAL  
 LOCATION: LYNVILLE MINE  
 PROTECTED AREA: BE 1508

THIS SYSTEM IS DESIGNED IN ACCORDANCE WITH NFPA-12A, 1977  
 PIPE            1 MAX SIZE = 1.693            FLOW = 9.0 LBS/SEC  
 NEW % IN PIPE = 11.9            OLD % IN PIPE = 8.2  
 NEW % IN PIPE = 11.8            OLD % IN PIPE = 10.1

NOW DESIGN THE NOZZLES

NOZZLE	IDEAL FLOW	ACTUAL FLOW	% ERROR
100	9.00	9.10	1.15

+++ PIPE DATA SECTION +++

NOMINAL TANK SIZE	FILL WT. LBS	FILL DENSITY LB/CU FT	NUMBER OF TANKS	TOTAL AGENT WT. LBS	% IN PIPE
90	90.0	67.6	1	90.0	10.1

FROM	TO	PIPE SIZE	ACT. LGTH	90 DEG	THRU TEE	SIDE TEE UN	SEL VLV	EQUIV LGTH	FLOW LB/SEC	ELEV CHNG
1	100	1 1/2	8.0	2	1	1	0	28.9	9.0	-2.5

DISCHARGE TIME = 10.0 SECONDS  
 VALVE USED IS THE 1977 HIGH-FLOW TYPE  
 PRESSURE AT END OF SIPHON TUBE AND VALVE IS 266.22 psi

AMOUNT OF SCHEDULE 40 ASTM A53 OR A106 PIPE IN SYSTEM  
 8.0 FEET OF 1 1/2 INCH PIPE WEIGHT = 21.8 LBS  
 TOTAL WEIGHT OF PIPE = 21.8 LBS

JOB NUMBER: 05107  
PROTECTED AREA: BE 1508

CUSTOMER: PEABODY COAL  
LOCATION: LYNNVILLE MINE

++++ DESIGN DATA SECTION +++++

AVE. TANK PRESSURE = 266.9 PSIG PIPING VOLUME = 0.11 CUBIC FEET  
PRESSURE AT ENTRANCE TO PIPING SYSTEM IS 266.22 PSIG

	NODE	PRESS PSIG	DENSITY LB/FT <sup>3</sup>	FLOW LB/SEC	ELEV CHNG	PRESS DROP	Y FACT.	Z FACT.
FROM :	1	268.	95.4				465	0.025
TO:	100	266.	94.5	9.0	-2.5	2.0	656	0.035

TYPE 4 NOZZLE W/FLOW = 9.0 LB/SEC & 1-1/2 IN. BODY USE 19/64 ORIFICE(S)

+++ NOZZLE DISCHARGE SUMMARY +++

NOZZLE 100 WILL DISCHARGE A TOTAL OF 90.0 LBS OF AGENT

NOZZLE	IDEAL FLOW	ACTUAL FLOW	% ERROR
100	9.00	9.16	1.83



HALON\$77

Line 0	None		0	0	0								
	Insurance		Connected Reserve		R-12 Tanks								
Line 1	05107	Peabody Coal					Lynnville Mine	325					
	Job No. Customer		Address				Bill of Materials						
Line 2	B.E.150 Mach. Encl.		0	0	0	1	0	0					
	Room Name		Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks				
Line 3	5	5	0	110	0	0	0	24.8	20.5	15.1	3	8.6	0
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
Line 2	999												
	Room Name		Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks				
Line 3	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
Line 2	Room Name		Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks				
Line 3	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
Line 2	Room Name		Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks				
Line 3	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
Line 2	Room Name		Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks				
Line 3	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
Line 2	Room Name		Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks				
Line 3	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1

ANSUL COMPUTERIZED HALON ANALYSIS  
 THE ANSUL COMPANY  
 ONE STANTON STREET  
 MARINETTE, WI 54143 {715/735-7411}

JOB NUMBER 05107 CUSTOMER NAME PEABODY COAL  
 LOCATION: LYNNVILLE MINE  
 DATE OF ANALYSIS 07/05/77 TIME 09:22CDT

ROOM DESCRIPTION	B	E	ISO	MACH.	ENCL.	:CLASS			
	%C	MIN	F	MAX	F	CFM	AREA	HEIGHT	VOL
HALON CRITERIA	5.0	0.		110.		0.	436.0	8.6	3749.
HALON DESIGN BASED ON VENTILATION							SHUTTING DOWN		

-----HALON 1301 RECOMMENDATIONS-----

DISCHARGE ZONE ONE				TYPE OF NOZZLE CENTER			
MINIMUM NO OF NOZZLES	1			MAX SQ/FT PER NOZZLE	448		
NOZZLE COVERAGE	24.8	X	18.1	NOMINAL TANK SIZE	90		
MINIMUM LBS 1301 REQ'D	90			1 EACH	90 LB TANKS	{100.0%}	
LBS 1301 SUPPLIED	90			% C AT MIN TEMP	5.0		
% C AT MAX TEMP				SQUARE INCH FREE VENTING REQUIREMENTS {NFPA 12A 2720}			
RATE LBS/SEC	9.0			LIGHT BUILDING	23.76	NORMAL BUILDING	16.80
				VAULT CONST.			11.88



HALON\$77

Line 0	None		0	0									
	Insurance	Connected Reserve	R-12 Tanks										
Line 1	05107	Peabody Coal	Lynnville Mine				325						
	Job No.	Customer	Address				Bill of Materials						
Line 2	Mach. Encl.		0	0	0	1	0	0					
	Room Name	Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks					
Line 3	5	5	30	130	0	0	0	18.7	18.7	10.4	0	6.25	0
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
Line 2	Hydraulic Encl.		0	0	0	1	0	0					
	Room Name	Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks					
Line 3	5	5	30	100	0	0	0	9.3	9.3	5.25	0	6.9	0
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
Line 2	Operator Encl.		0	0	0	1	0	0					
	Room Name	Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks					
Line 3	5	5	30	100	0	0	0	9.2	9.2	5.25	0	6.9	0
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
Line 2													
	Room Name	Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks					
Line 3								L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
Line 2													
	Room Name	Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks					
Line 3								L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
Line 2													
	Room Name	Ventilation	Nozzle Location	Tank	Discharge Zone		Size Tank	No. of Tanks					
Line 3								L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>	Height	Opt 1

# UNBALANCED ANSUL HALON 1301 HYDRAULIC CALCULATION INPUT FORM

UNBAL\$

Line 1: 05107 , Peabody Coal , Lynnville Mine , 61R BHD  
Job No. Customer Location Protected Area

Line 2: 1 , 54 , 46 , 1 , 0 , 0 , 0 , 0 , 0 , 0  
Tank Location Nominal Tank Size Fill Weight No. of Tanks Valve Type  
 0 = New 1 = Old  
 Manifold Exit 0 = Center 1 = End  
 Manifold Size  
 Long or Short Print Out 0 = Long 1 = Short  
 Discharge Time 0 = 10 Seconds  
 Connected Reserve 0 = No 1 = Yes

PIPE DATA:

From	To	Diameter	Length Ft.	Elevation Change Ft.	90° EL	Thru Tee	Side Tee	Union	Selector Valve	Nozzle Output Total Lbs. Output	Nozzle Type 1, 2, or 4	Pipe Schedule* /0 = Sch 40
1	2	0	13	3.75	4	1	0	1	0	0	0	0
2	100	0	5.2	0	0	0	2	0	0	29	4	0
2	3	0	30.25	.67	3	1	2	0	0	0	0	0
3	200	8.25	2.5	0	1	0	1	0	0	8	4	0
3	300	8.25	11.75	0	1	1	1	0	0	8	4	0

\*Schedule 80 Available 12/31/77

ANSUL COMPUTERIZED HALON ANALYSIS

THE ANSUL COMPANY  
 ONE STANTON STREET  
 MARINETTE, WI 54143 (715/735-7411)

JOB NUMBER 05107 CUSTOMER NAME PEABODY COAL  
 LOCATION: LYNNVILLE MINE  
 DATE OF ANALYSIS 07/22/77 TIME 11:15CDT

ROOM DESCRIPTION	MACH. ENCL.	:CLASS			
	%C MIN F.	MAX F	CFM	AREA HEIGHT	VOL
HALON CRITERIA	5.0 30.	130.	0.	194.5 6.2	1216.
HALON DESIGN BASED ON VENTILATION				SHUTTING DOWN	

-----HALON 1301 RECOMMENDATIONS-----

DISCHARGE ZONE ONE

MINIMUM NO OF NOZZLES	1	TYPE OF NOZZLE CENTER	
NOZZLE COVERAGE	18.7 X 10.4	MAX SQ/FT PER NOZZLE	194
MINIMUM LBS 1301 REQ'D	28	NOMINAL TANK SIZE	54
LBS 1301 SUPPLIED	29	1 EACH	46 LB TANKS {63.0%}
% C AT MIN TEMP	5.3	% C AT MAXTEMP	6.4
SQUARE INCH FREE VENTING REQUIREMENTS {NFPA 12A 2720}			
RATE LBS/SEC	LIGHT BUILDING	NORMAL BUILDING	VAULT CONST.
2.9	7.66	5.41	3.83

ROOM DESCRIPTION	HYDRAULIC ENCL.	:CLASS			
	%C MIN F.	MAX F	CFM	AREA HEIGHT	VOL
HALON CRITERIA	5.0 30.	100.	0.	48.8 6.9	337.
HALON DESIGN BASED ON VENTILATION				SHUTTING DOWN	

-----HALON 1301 RECOMMENDATIONS-----

DISCHARGE ZONE ONE

MINIMUM NO OF NOZZLES	1	TYPE OF NOZZLE CENTER	
NOZZLE COVERAGE	9.3 X 5.2	MAX SQ/FT PER NOZZLE	48
MINIMUM LBS 1301 REQ'D	8	NOMINAL TANK SIZE	54
LBS 1301 SUPPLIED	8	1 EACH	46 LB TANKS {17.4%}
% C AT MIN TEMP	5.3	% C AT MAXTEMP	6.0
SQUARE INCH FREE VENTING REQUIREMENTS {NFPA 12A 2720}			
RATE LBS/SEC	LIGHT BUILDING	NORMAL BUILDING	VAULT CONST.
0.8	2.11	1.49	1.06

ROOM DESCRIPTION	OPERATOR ENC.	:CLASS
	% C MIN F. MAX F.	CFM AREA HEIGHT VOL
HALON CRITERIA	5.0 30. 100.	0. 48.3 6.9 333.
HALON DESIGN BASED ON VENTILATION		SHUTTING DOWN

-----HALON 1301 RECOMMENDATIONS-----

DISCHARGE ZONE ONE			
MINIMUM NO OF NOZZLES	1	TYPE OF NOZZLE	CENTER
NOZZLE COVERAGE	9.2 X 5.2	MAX SQ/FT PER NOZZLE	48
MINIMUM LBS 1301 REQ'D	8	NOMINAL TANK SIZE	54
LBS 1301 SUPPLIED	8	1 EACH	46 LB TANKS {17.4%}
% C AT MIN TEMP	5.4	% C AT MAXTEMP	6.1
SQUARE INCH FREE VENTING REQUIREMENTS {NFPA 12A 2720}			
RATE LBS/SEC	LIGHT BUILDING	NORMAL BUILDING	VAULT CONST.
0.8	2.11	1.49	1.06

THE ANSUL COMPANY  
 ONE STANTON STREET  
 MARINETTE, WI 54143 (715/735-7411)

TIME: 14:28CDT( 19:28GMT)

DATE: 09/20/77

JOB NUMBER: 05107  
 CUSTOMER NAME: PEABODY COAL  
 LOCATION: LYNNVILLE MINE  
 PROTECTED AREA: 61R BHD

THIS SYSTEM IS DESIGNED IN ACCORDANCE WITH NFPA 12A, 1977

PIPE	1	MAX SIZE = 1.221	FLOW = 4.5	LBS/SEC
PIPE	2	MAX SIZE = 0.993	FLOW = 2.9	LBS/SEC
PIPE	3	MAX SIZE = 0.750	FLOW = 1.6	LBS/SEC
PIPE	4	MAX SIZE = 0.541	FLOW = 0.8	LBS/SEC
PIPE	5	MAX SIZE = 0.541	FLOW = 0.8	LBS/SEC

NOW DESIGN THE NOZZLES

NOZZLE	IDEAL FLOW	ACTUAL FLOW	% ERROR
100	2.90	3.01	3.96
200	0.80	0.82	2.87
300	0.80	1.03	28.92

NOZZLE	IDEAL FLOW	ACTUAL FLOW	% ERROR
100	2.90	3.01	3.89
200	0.80	0.81	1.47
300	0.92	0.96	4.83

+++PIPE DATA SECTION+++

NOMINAL TANK SIZE	FILL WT. LBS.	FILL DENSITY LB/CU FT	NUMBER OF TANKS	TOTAL AGENT WT. LBS	% IN PIPE
54	46.0	57.6	1	46.0	31.6

FROM	TO	PIPE SIZE	ACT. LGTH	90 DEG	THRU TEE	SIDE TEE	SEL UN	EQUIV LGTH	FLOW LB/SEC	ELEV CHNG
1	2	1	13.0	4	1	0	1	26.6	4.6	3.7
2	100	3/4	5.2	0	0	2	0	14.2	2.9	0.
2	3	1/2	30.2	3	1	2	0	43.2	1.7	0.7
3	200	1/4	2.5	1	0	1	0	5.2	0.8	0.
3	300	1/4	11.7	1	1	1	0	15.0	0.9	0.

DISCHARGE TIME = 10.0 SECONDS

VALVE USED IS THE 1977 HIGH-FLOW TYPE

PRESSURE AT END OF SIPHON TUBE AND VALVE IS 267.10 PSI

AMOUNT OF SCHEDULE 40 ASTM A53 OR A106 PIPE IN SYSTEM	
130	14.2 FEET OF 1/4 INCH PIPE WEIGHT = 5.7 LBS
	30.2 FEET OF 1/2 INCH PIPE WEIGHT = 25.7 LBS
	5.2 FEET OF 3/4 INCH PIPE WEIGHT = 5.9 LBS
	13.0 FEET OF 1 INCH PIPE WEIGHT = 21.8 LBS
	TOTAL WEIGHT OF PIPE = 59.1 LBS



HALON\$77

Line 0	None		0		0															
	Insurance		Connected Reserve		R-12 Tanks															
Line 1	05107	Peabody Coal																	325	
	Job No.	Customer																	Bill of Materials	
Line 2	Controls Room 1		0		0		0		1		0								0	
	Room Name		Ventilation		Nozzle Location		Tank		Discharge Zone		Size Tank								No. of Tanks	
Line 3	1	6	40	80	0	0	0	14	14	10	0								9.5	1
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>								Height	Opt 1
Line 2	Controls Room 2		0		0		0		1		0								0	
	Room Name		Ventilation		Nozzle Location		Tank		Discharge Zone		Size Tank								No. of Tanks	
Line 3	1	6	40	80	0	0	0	18	18	10	0								9.5	1
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>								Height	Opt 1
Line 2	999	//////																		
	Room Name		Ventilation		Nozzle Location		Tank		Discharge Zone		Size Tank								No. of Tanks	
Line 3																				
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>								Height	Opt 1
Line 2																				
	Room Name		Ventilation		Nozzle Location		Tank		Discharge Zone		Size Tank								No. of Tanks	
Line 3																				
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>								Height	Opt 1
Line 2																				
	Room Name		Ventilation		Nozzle Location		Tank		Discharge Zone		Size Tank								No. of Tanks	
Line 3																				
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>								Height	Opt 1
Line 2																				
	Room Name		Ventilation		Nozzle Location		Tank		Discharge Zone		Size Tank								No. of Tanks	
Line 3																				
	Room Class	%C	Min. Temp.	Max. Temp.	Decay CFM	Detection CFM	Volume	L <sub>1</sub>	L <sub>2</sub>	W <sub>1</sub>	W <sub>2</sub>								Height	Opt 1

JOB NUMBER: 05107      CUSTOMER: PEABODY COAL  
 PROTECTED AREA: 61R BHD      LOCATION: LYNNVILLE MINE

+++ DESIGN DATA SECTION +++

AVE. TANK PRESSURE = 268.6 PSIG      PIPING VOLUME = 0.17 CUBIC FEET  
 PRESSURE AT ENTRANCE TO PIPING SYSTEM IS 267.10 PSIG

	NODE	PRESS PSIG	DENSITY LB/FT <sup>3</sup>	FLOW LB/SEC	ELEV CHNG	PRESS DROP	Y FACT.	Z FACT.
FROM:	1	265.	89.4				1754	0.090
TO:	2	260.	87.1	4.6	3.7	4.9	2193	0.115
FROM:	2	260.	87.1				2193	0.115
TO:	100	256.	85.3	2.9	0.	3.9	2522	0.137
TYPE 4 NOZZLE W/FLOW = 2.9 LB/SEC & 3/4 IN. BODY USE 11/64 ORIFICE(S)								
FROM:	2	259.	87.0				2224	0.117
TO:	3	241.	78.0	1.7	0.7	18.4	3758	0.227
FROM:	3	241.	78.0				3758	0.227
TO:	200	232.	73.5	0.8	0.	8.8	4436	0.285
TYPE 4 NOZZLE W/FLOW = 0.8 LB/SEC & 1/4 IN. BODY USE 6/64 ORIFICE(S)								
FROM:	3	241.	78.0				3758	0.227
TO:	300	203.	58.6	0.9	0.	37.8	6371	0.511
TYPE 4 NOZZLE W/FLOW + 0.9 LB/SEC & 1/4 IN. BODY USE 7/64 ORIFICE(S)								

+++ NOZZLE DISCHARGE SUMMARY +++

NOZZLE 100 WILL DISCHARGE A TOTAL OF 28.9 LBS OF AGENT  
 NOZZLE 200 WILL DISCHARGE A TOTAL OF 8.0 LBS OF AGENT  
 NOZZLE 300 WILL DISCHARGE A TOTAL OF 9.1 LBS OF AGENT

NOZZLE	IDEAL FLOW	ACTUAL FLOW	% ERROR
100	2.90	3.08	6.11
200	0.80	0.84	4.42
300	0.92	1.00	9.38

# UNBALANCED ANSUL HALON 1301 HYDRAULIC CALCULATION INPUT FORM

UNBAL\$

Line 1: 05107 / Peabody Coal / Lynnville Mine / Controls Rooms  
Job No. Customer Location Protected Area

Line 2: 1 / 90 / 85 / 1 / ∅ / ∅ / ∅ / ∅ / ∅ / ∅  
Tank Location Nominal Tank Size Fill Weight No. of Tanks Valve Type Manifold Exit Manifold Size Long or Short Print Out Discharge Time Connected Reserve  
0 = New 0 = Center 0 = Long 0 = 10 Seconds 0 = No  
1 = Old 1 = End 1 = Short 1 = Yes

PIPE DATA:

From	To	Diameter	Length Ft.	Elevation Change Ft.	90° EL	Thru Tee	Side Tee	Union	Selector Valve	Nozzle Output Total Lbs. Output	Nozzle Type 1, 2, or 4	Pipe Schedule* / 0 = Sch 40
1	2	.75	6	6	2	1	0	0	0	0	0	0
2	100	.5	5	0	1	0	0	0	0	48	4	0
2	200	.5	15	10	3	0	0	0	0	37	4	0
999												

\*Schedule 80 Available 12/31/77

ANSUL COMPUTERIZED HALON ANALYSIS

THE ANSUL COMPANY  
 ONE STANTON STREET  
 MARINETTE, WI 54143 (715/735-7411)

JOB NUMBER 05107 CUSTOMER NAME PEABODY COAL  
 LOCATION: LYNNVILLE MINE  
 DATE OF ANALYSIS 06/30/77 TIME: 09:03CDT

ROOM DESCRIPTION CONTROLS ROOM 1 :CLASS COMPUTER ROOM  
 %C MIN F. MAX F. CFM AREA HEIGHT VOL  
 HALON CRITERIA 6.0 40. 80. 0. 140.0 9.5 1330.  
 DETECTION BASIS 0.  
 HALON DESIGN BASED ON VENTILATION SHUTTING DOWN

-----HALON 1301 RECOMMENDATIONS-----

DISCHARGE ZONE ONE  
 MINIMUM NO OF NOZZLES 1 TYPE OF NOZZLE CENTER  
 NOZZLE COVERAGE 14.0 X 10.0 MAX SQ/FT PER NOZZLE 140  
 MINIMUM LBS 1301 REQ'D 36 NOMINAL TANK SIZE 90  
 LBS 1301 SUPPLIED 37 1 EACH 85 LB TANKS {43.5%}  
 % C AT MIN TEMP. 6.3 % C AT MAXTEMP 6.8  
 SQUARE INCH FREE VENTING REQUIREMENTS {NFPA 12A 2720}  
 RATE LBS/SEC LIGHT BUILDING NORMAL BUILDING VAULT CONST.  
 3.7 9.77 6.91 4.88

-----DETECTION ANALYSIS-----

NO. SMOKE DETECTORS 2 NO. AUDIBLES 1  
 SQ. FT. PER DETECTOR 70  
 NO. REMOTE LAMPS 0 NO. MANUAL STATIONS 1

ROOM DESCRIPTION CONTROLS ROOM 2 :CLASS COMPUTER ROOM  
 %C MIN F. MAX F. CFM AREA HEIGHT VOL  
 HALON CRITERIA 6.0 40. 80. 0. 180.0 9.5 1710.  
 DETECTION BASIS 0.  
 HALON DESIGN BASED ON VENTILATION SHUTTING DOWN

-----HALON 1301 RECOMMENDATIONS-----

DISCHARGE ZONE ONE  
 MINIMUM NO OF NOZZLES 1 TYPE OF NOZZLE CENTER  
 NOZZLE COVERAGE 18.0 X 10.0 MAX SQ/FT PER NOZZLE 180  
 MINIMUM LBS 1301 REQ'D 46 NOMINAL TANK SIZE 90  
 LBS 1301 SUPPLIED 48 1 EACH 85 LB TANKS {56.5%}  
 % C AT MIN TEMP 6.3 % C AT MAXTEMP 6.8  
 SQUARE INCH FREE VENTING REQUIREMENTS {NFPA 12A 2720}  
 RATE LBS/SEC LIGHT BUILDING NORMAL BUILDING VAULT CONST.  
 4.8 12.67 8.96 6.34

-----DETECTION ANALYSIS-----

NO. SMOKE DETECTORS 2 NO. AUDIBLES 1  
 SQ. FT. PER DETECTOR 90  
 NO. REMOTE LAMPS 0 NO. MANUAL STATIONS 1

THE ANSUL COMPANY  
 ONE STANTON STREET  
 MARINETTE, WI 54143 (715/735-7411)

TIME: 10:38CDT (15:38GMT)      DATE: 06/30/77

JOB NUMBER: 05107  
 CUSTOMER NAME: PEABODY COAL  
 LOCATION: LYNNVILLE MINE  
 PROTECTED AREA: CONTROLS ROOMS

THIS SYSTEM IS DESIGNED IN ACCORDANCE WITH NFPA 12A, 1977

+++ PIPE DATA SECTION +++

NOMINAL TANK SIZE		FILL WT. LBS	FILL DENSITY LB/CU FT	NUMBER OF TANKS	TOTAL AGENT WT. LBS	% IN PIPE
90		85.0	63.9	1	85.0	5.0

FROM	TO	PIPE SIZE	ACT. LGTH	90 DEG	THRU TEE	SIDE TEE	UN	SEL VLV	EQUIV LGTH	FLOW LB/SEC	ELEV CHNG
1	2	3/4	6.0	2	1	0	0	0	11.8	8.5	6.0
2	100	1/2	5.0	1	0	0	0	0	6.7	4.8	0.
2	200	1/2	15.0	3	0	0	0	0	20.1	3.7	10.0

DISCHARGE TIME = 9.6 SECONDS  
 VALVE TYPE IS NEW  
 PRESSURE AT END OF SIPHON TUBE AND VALVE IS 272.72 PSI

AMOUNT OF SCHEDULE 40 ASTM A53 OR A106 PIPE IN SYSTEM  
 20.0 FEET OF 1/2 INCH PIPE WEIGHT = 17.0 LBS  
 6.0 FEET OF 3/4 INCH PIPE WEIGHT = 6.8 LBS  
 TOTAL WEIGHT OF PIPE = 23.8 LBS

+++ DESIGN DATA SECTION +++

AVE. TANK PRESSURE = 273.4 PSIG    PIPING VOLUME = 0.06 CUBIC FEET  
 PRESSURE AT ENTRANCE TO PIPING SYSTEM IS 272.72 PSIG

	NODE	PRESS PSIG	DENSITY LB/FT <sup>3</sup>	FLOW LB/SEC	ELEV CHNG	PRESS DROP	Y FACT.	Z FACT.
FROM:	1	268.7	94.1				758	0.039
TO:	2	240.4	80.2	8.5	6.0	28.3	3265	0.199
FROM:	2	240.4	80.2				3265	0.199
TO:	100	212.3	65.3	4.8	0.	28.1	5326	0.403
TYPE 4 NOZZLE W/FLOW = 4.8 LB/SEC & 1/2 IN. BODY USE 13/64 ORIFICE								
FROM:	2	234.8	77.3				3706	0.235
TO:	200	177.5	47.2	3.7	10.0	57.4	7303	0.729
TYPE 4 NOZZLE W/FLOW = 3.7 LB/SEC & 1/2 IN. BODY USE 13/64 ORIFICE								



**I. GENERAL INFORMATION**

Ansul Job No. 05107 Calculated By AEK Date 7/20/77  
Customer Name Peabody Coal Location Lynnville Mine

**II. DESCRIPTION OF HAZARD**

Name Transformer Enclosure Fuel or Material Dielectric fluid  
Volume 3638 (net) cu. ft. Area 240 sq. ft.

**III. DESIGN CRITERIA**

Application Method Total Flood Minimum Pounds Agent Required 140 lbs.  
Minimum pounds/second agent required 4.5 lbs./sec.  
Minimum number nozzles required 4 Nozzle Type Required 1

**IV. SYSTEM SELECTION**

System Size PS-150B Agent Type Plus Fifty C Number of Nozzles 4  
Nozzle Type d-1 Nozzle Height Above Hazard \_\_\_\_\_

**V. PRESSURE LOSS**

Pipe Branch	A	B	C	D	E	F	G
a. Pipe size	<u>1/2"</u>	<u>3/4"</u>	<u>1"</u>	_____	_____	_____	_____
b. Minimum allowable rate	<u>1.0</u>	<u>1.9</u>	<u>3.1</u>	_____	_____	_____	_____
c. Design/assumed flow rate	<u>1.125</u>	<u>2.25</u>	<u>4.5</u>	_____	_____	_____	_____
d. Pressure loss per foot	<u>0.13</u>	<u>0.20</u>	<u>0.21</u>	_____	_____	_____	_____
e. Equivalent length – elbows	<u>(1) 24</u>	<u>-</u>	<u>(2) 18</u>	_____	_____	_____	_____
f. Equivalent length – tees	<u>--</u>	<u>(1) 43</u>	<u>(1) 38</u>	_____	_____	_____	_____
g. Equivalent length – other	<u>--</u>	<u>--</u>	<u>--</u>	_____	_____	_____	_____
h. Length – straight pipe	<u>2.5</u>	<u>3.75</u>	<u>20.3</u>	_____	_____	_____	_____
i. Total equivalent length	<u>26.5</u>	<u>46.8</u>	<u>94.3</u>	_____	_____	_____	_____
j. Pressure loss/pipe size	<u>3.4</u>	<u>9.4</u>	<u>19.8</u>	_____	_____	_____	_____
k. Elevation loss – 1/3 height	<u>-</u>	<u>-</u>	<u>4.6</u>	_____	_____	_____	_____
l. Total pressure loss	<u>3.4</u>	<u>9.4</u>	<u>24.4</u>	_____	_____	_____	_____
			Total pressure loss	<u>37.2</u>	<u>(2)</u>	_____	_____

**VI. BALANCING**

Outlet pressure = Total pressure loss + Nozzle pressure  
165 psi = 37.2 psi + 60 psi ± 5 psi  
 (1) (2) (3)

**VII. SYSTEM DESIGN PERFORMANCE**

Design Flow Rate 4.5 lbs./sec. Nozzle Flow Rate 1.125 lbs./sec.  
 Outlet Pressure 165 Total Pressure Loss 37.2 Nozzle Pressure 60  
 Nozzle Range -- Nozzle Stream Width --  
 Nozzle Stream Thickness - Discharge Time 33.3 sec



**I. GENERAL INFORMATION**

Ansul Job No. 05107 Calculated By A. Kasten Date 7/15/77  
Customer Name Peabody Coal Location Lynnville Mine

**II. DESCRIPTION OF HAZARD**

Name 2570W Roller Path Fuel or Material Lubricants  
Volume --- cu. ft. Area 860 sq. ft.

**III. DESIGN CRITERIA**

Application Method Local (Special) Minimum Pounds Agent Required \_\_\_\_\_ lbs.  
Minimum pounds/second agent required \_\_\_\_\_ lbs./sec.  
Minimum number nozzles required \_\_\_\_\_ Nozzle Type Required \_\_\_\_\_

**IV. SYSTEM SELECTION**

System Size PS-500B Agent Type Plus Fifty B Number of Nozzles 16  
Nozzle Type F-1 Nozzle Height Above Hazard --

**V. PRESSURE LOSS**

Pipe Branch	A	B	C	D	E	F	G	
a. Pipe size	<u>2</u>	<u>1½</u>	<u>1</u>	<u>¾</u>	<u>½</u>			
b. Minimum allowable rate	<u>12.1</u>	<u>7.3</u>	<u>3.1</u>	<u>1.9</u>	<u>1.0</u>			
c. Design/assumed flow rate	<u>20.0</u>	<u>10.0</u>	<u>5.0</u>	<u>2.5</u>	<u>1.25</u>			
d. Pressure loss per foot	<u>.21</u>	<u>.15</u>	<u>.265</u>	<u>.2</u>	<u>.165</u>			
e. Equivalent length – elbows	(2) <u>12</u>	<u>--</u>	(1) <u>18</u>	(1) <u>21</u>	(1) <u>24</u>			
f. Equivalent length – tees	(1) <u>26</u>	(1) <u>30</u>	(1) <u>38</u>	(1) <u>43</u>	<u>--</u>			
g. Equivalent length – other	<u>--</u>	<u>--</u>	<u>--</u>	<u>--</u>	<u>--</u>			
h. Length – straight pipe	<u>30</u>	<u>7.8</u>	<u>27.8</u>	<u>10</u>	<u>7</u>			
i. Total equivalent length	<u>64.0</u>	<u>37.8</u>	<u>84.0</u>	<u>74.0</u>	<u>31.0</u>			
j. Pressure loss/pipe size	<u>13.4</u>	<u>5.7</u>	<u>22.3</u>	<u>14.8</u>	<u>5.1</u>			
k. Elevation loss – 1/3 height	<u>--</u>	<u>--</u>	<u>--</u>	<u>--</u>	<u>--</u>			
l. Total pressure loss	<u>13.4</u>	<u>5.7</u>	<u>22.3</u>	<u>14.8</u>	<u>5.1</u>			
	Total pressure loss <u>61.3</u> (2)							

**VI. BALANCING**

Outlet pressure = Total pressure loss + Nozzle pressure  
94.0 psi = 61.3 psi + 33.0 psi ± 5 psi  
(1) (2) (3)

**VII. SYSTEM DESIGN PERFORMANCE**

Design Flow Rate 20.0 lbs./sec. Nozzle Flow Rate 1.25 lbs./sec.  
Outlet Pressure 94.0 Total Pressure Loss 61.3 Nozzle Pressure 33.0  
Nozzle Range 5 foot radius Nozzle Stream Width --  
Nozzle Stream Thickness -- Discharge Time 25 seconds

APPENDIX D

BRUNSWICK REPORT ON EARLY WARNING SYSTEM

PEABODY COAL COMPANY  
SMOKE DETECTOR INSTALLATION  
AND  
DEMONSTRATION REPORT

CONTRACT P/O X7165 141F

OCTOBER 1977

PREPARED FOR:  
THE ANSUL COMPANY

PREPARED BY:

 DEFENSE DIVISION  
3333 Harbor Boulevard  
BRUNSWICK Costa Mesa, CA 92626

PEABODY COAL COMPANY  
SMOKE DETECTOR INSTALLATION  
AND  
DEMONSTRATION REPORT

PREPARED BY: *E. C. Thomas*  
E. C. Thomas  
Program Manager

APPROVED BY: *E. Morris*  
E. Morris, Manager  
Hazard Protection Systems

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## SECTION 1.0

## SCOPE

This report describes the Brunswick Smoke Detection System installed in a Bucyrus-Erie vertical blast hole drill at the Peabody Coal Company, Evansville, Indiana. The performance of the system during the Ansul conducted simulated fire demonstration is also included.

The purpose of this installation is to demonstrate the feasibility of the Brunswick Corporation Smoke Detector to operate in the environment of fire hazard areas of surface mining equipment.

## SECTION 2.0

## DESIGN DESCRIPTION

Brunswick Corporation Early Warning Hazard Detector is not a new concept but a unique application of current early warning detection that not only increases the sensitivity of the original sensor but also increases its operational environmental applications to encompass wide extremes in ambient conditions.

In two examples of this capability, the Brunswick Corporation Detector provides an alarm at the initial phase of an abnormal condition, before visual smoke:

- In dust conditions over 600 times more severe than normal room ambient with the air velocity at 3,000 ft/min (1 m/sec.)
- At an air temperature of -65°F (-54°C) and an altitude of 50,000 ft (1524 meters).

In addition, the Brunswick Corporation Detector has successfully demonstrated its capability to provide the same early warning capabilities in the hostile environment of a U.S. Navy shipboard gas turbine engine room.

The Brunswick Corporation Detector design has been dictated by the exacting requirements of the NASA Space Shuttle Orbiter and European Spacelab programs which requires:

- A design goal operational life in excess of 20,000 hours.
- Operation in extreme environment free of false alarms including severe dust/dirt conditions and air velocities up to 15 m/sec (3,000 ft/min).

## 2.0 Cont'd

- Low maintenance and calibration requirements (none are required).
- An alarm in the initial phase (before visual smoke) of a hazardous condition.

The first production units of this detector were delivered and installed in the Space Shuttle in January 1976. With the proven success of this design, a program has been initiated for a productionized design version with applications in many areas within DOD and the commercial/industrial market.

### 2.1 Principle of Operation

Industry has long searched for means to detect pending hazardous conditions so that corrective measures can be taken before lives, equipment, or production loss occurs. Although various new concepts are now being investigated, the designs that have had the widest acceptance are the early warning ionization and photoelectric smoke detectors, and the thermal, ultraviolet, and infrared fire detectors.

These early warning ionization/photoelectric detectors respond to the changes in suspended airborne particles that occur as a fuel is heated beyond its operational limits, dispersing large amounts of particles into the surrounding area due to destructive distillation of the material. The detector alarm thresholds must be set sufficiently above normal variations in suspended airborne particles to control false alarms.

Fire detectors respond to the large amounts of energy that are dispersed into the surrounding environment after fuel ignition and combustion is sustained.

Although the state-of-the-art photoelectric and ionization detectors do an excellent job when properly applied, they quickly reach a low level of operational

## 2.1 Cont'd

efficiency when environmental conditions (wind, dust, etc.) become unstable. When this occurs, industry can no longer use the early warning hazard detector because of false alarms and must resort to fire detectors which provide warning after the hazard has occurred.

The Brunswick Corporation Detector uses one of the latest commercial ionization sensors manufactured by Pyrotronics, Cedar Knolls, New Jersey. The sensor application and operational response is entirely different in the Brunswick Corporation Detector than in its commercial detector application. In both applications, detectors respond to the abnormal presence of particles (aerosols) of pre-combustion/combustion. However, the Brunswick Corporation Detector responds to only a selective particulate environment while its counterpart and other off-the-shelf ionization detectors do not.

The basic reason for this particle selectivity can be seen by the following comparison of suspended ambient particle concentrations and the induced effect caused by pre-combustion/combustion conditions:

### Ambient Phase

- (1) Particles less than 2 microns in size, approximately 17% of an overall normal room ambient, are kept in constant suspension and are not affected by gravity due to Brownian motion.
- (2) Particles greater than 2 microns in size are affected by gravity and settle in an environment as dust, dirt, etc.
- (3) Variations in an ambient environment such as air currents, maintenance activities, etc. create large fluctuations in the suspended concentration of the gravity sensitive particles greater than 2 microns in size but have relatively no effect on the less than 2 micron size particles.

Pre-Combustion/Combustion Phases

- (1) First Phase - Large concentrations of small invisible size particles (mainly submicron) are released as the fuel is heated beyond its normal operating condition.
- (2) Second Phase - Large concentration of both invisible and visible (smoke) particles are released as abnormal heating is continued.
- (3) Third Phase - Large concentration of invisible, visible particles and energy (heat, fire) are released and combustion is sustained.

The basic principle of operation involves two features that control the detector's unique operation features. One is the separation, from the ambient environment being sampled, of all false alarm gravity sensitive particles leaving for sensing a stable background condition. The second feature is the direction of this separated flow through the sensing chamber. This is in direct contrast to other detectors which sample the environment by convection which entails not only a slow processes of getting particles into the chamber, but also in getting them out after the ambient environment condition has been corrected. The flow through feature not only increases the sensitivity of the sensing chamber but allows for the remote monitoring of the hazard condition and the ability to operate with no effect to sensitivity or calibration:

- (1) In extreme dust/dirt conditions without false alarms
- (2) In zero to high air velocities without false alarms
- (3) From sea level to 50,000 feet without false alarms

## 2.2 Design

The Brunswick Corporation Detector design consists of four functional components, the separator, sensor, pump/motor and the electronics. The complete integrated detector weighs 1.5 pounds and dissipates 6 watts.

### Separation

The separator design is based entirely on aerodynamic principles through the application of proven criterion. Separation is accomplished by placing into the entering airstream the sensor inlet with its opening in the downstream side. The inlet creates families of streamlines depending on its shape. The larger particles are entrained in the streamlines furthest from the inlet with the smaller particles entrained in the streamlines closest to the inlet. By providing for a slight pressure differential at the sensor inlet, the rate and maximum particle size that will be drawn into the sensor will depend on the airstream velocity and geometry of the inlet.

### Sensor

The sensor is a modified version of a standard off-the-shelf low voltage twin ionization chamber using Americium 241 as the radiation source. Each chamber functions identically by ionizing the air molecules present in the radiation field. The ionized molecules travel to the outer cover which acts as an electrode creating a current flow. Particles present in the air flow will attach themselves to the molecules, reducing their mobility and causing a drop in the current flow. Both chambers are equally affected by the normal changes in ambient temperature, humidity and pressure. With only the sensing chamber subjected to the particulate flow, a measure

## 2.2 Cont'd

### Sensor(Cont'd)

of the current difference between the two chambers results in the elimination of normal ambient temperature, humidity, and pressure changes.

In most, if not all commercial ionization detectors, the sensor must be protected from direct exposure to ambient with a protective cover. Changes in ambient particulate distribution, the basis for alarm, must find their way into (and out of) the sensing chamber by diffusion through specially designed openings in the protective cap.

In the Brunswick Detector only particles less than 2 microns in size are directed through the sensing chamber at a predetermined flow that does not vary regardless of changes in the outside environment. This use of an off-the-shelf sensor as a flow through rather than a static ionization device has not only made it insensitive to variations in ambient conditions, but also has increased its sensitivity up to 27 times.

### Pump/Motor

The pump is a miniaturization of a standard 3 vane positive displacement pump. The solid state, commutated motor is an off-the-shelf design and is the life-limiting component with an MTBF in excess of 20,000 hours. The flow requirement for the pump is approximately 6 liters/min.

### Electronics

The three piece microelectronic assembly consists of a hybrid voltage to frequency converter, a hybrid motor controller, and a large scale integrated circuit. This assembly provides the following:

## 2.2 Cont'd

Electronics (Cont'd)

- (1) Sensor output voltage to continually monitor the status of the abnormal condition.
- (2) A discrete alarm signal indicating that an abnormal level of particles in the less than 2 micron size exists.
- (3) A discrete alarm signal indicating that an abnormal rate of increase in concentration of suspended particles is present. (A differentiation of the sensor output voltage over a 20 second period).
- (4) A reset capability to instantly recycle the alarm signal to reassess the hazard condition.
- (5) A built-in test circuit to continually monitor the on-line status of the detector.

## SECTION 3.0

## INSTALLATION DESCRIPTION

The principle system installed for long term demonstration consisted of one smoke detector unit, detector control box and a strip chart recorder for data gathering. A second detector was installed temporarily to be used as a reference during the simulated fire demonstration.

Both detectors were mounted to the roof of the machinery compartment over each of the motor compressor units about six feet apart. The control box and recorder were installed in the transformer room.

The control box and recorder are driven from the 115V supply. The control box supplies 28VDC to the detector for operation. The alarm and alarm reset circuits are also 28VDC and are contained in the control box.

The original intent of coupling the detector alarm signal into the Ansul control box was delayed to a future time because of an operational characteristic of this particular installed detector. This prototype detector does not contain an alarm suppression during startup. The alarm is normally triggered by a reduction in sensor output voltage and during startup, the alarm level is exceeded before the normal voltage is reached. This means that every time there is a loss of 115V power that after the power is returned, the alarm signal would require resetting. Until the suppression feature is added to the system it would become a nuisance to reset the signal in the Ansul control box. This condition does not affect the sensor output data being recorded, but does prevent the detector from signalling the crew of a potential hazard.

## SECTION 4.0

## OPERATIONAL RESULTS

System operating time during drill operation was restricted to only 20 hours prior to the simulated fire demonstration because of time required to get power available to the controller. The data gathered during this time showed a steady normal detector signal. It was noted that at the end of this period there was a fine coating of dust over the entire surface of the detector that did not affect the sensor signal.

Detector responses during the fire simulation were as follows:

1. Small response from both detectors as soon as the fire container was placed in the machinery compartment.
2. A rate alarm was received 146 seconds later and alarm reset.
3. A level alarm was received at 186 seconds, reset and alarm returned.
4. At 204 seconds, the Halon system was discharged and a slight increase of detector signal noted, which is normal.
5. The signal began decreasing and 94 seconds after the Halon discharge the signal returned to below the alarm level.

Figure 1 shows the recorder traces during the test. It should be noted that both detector signals track one another fairly closely even though they are 6 feet apart.

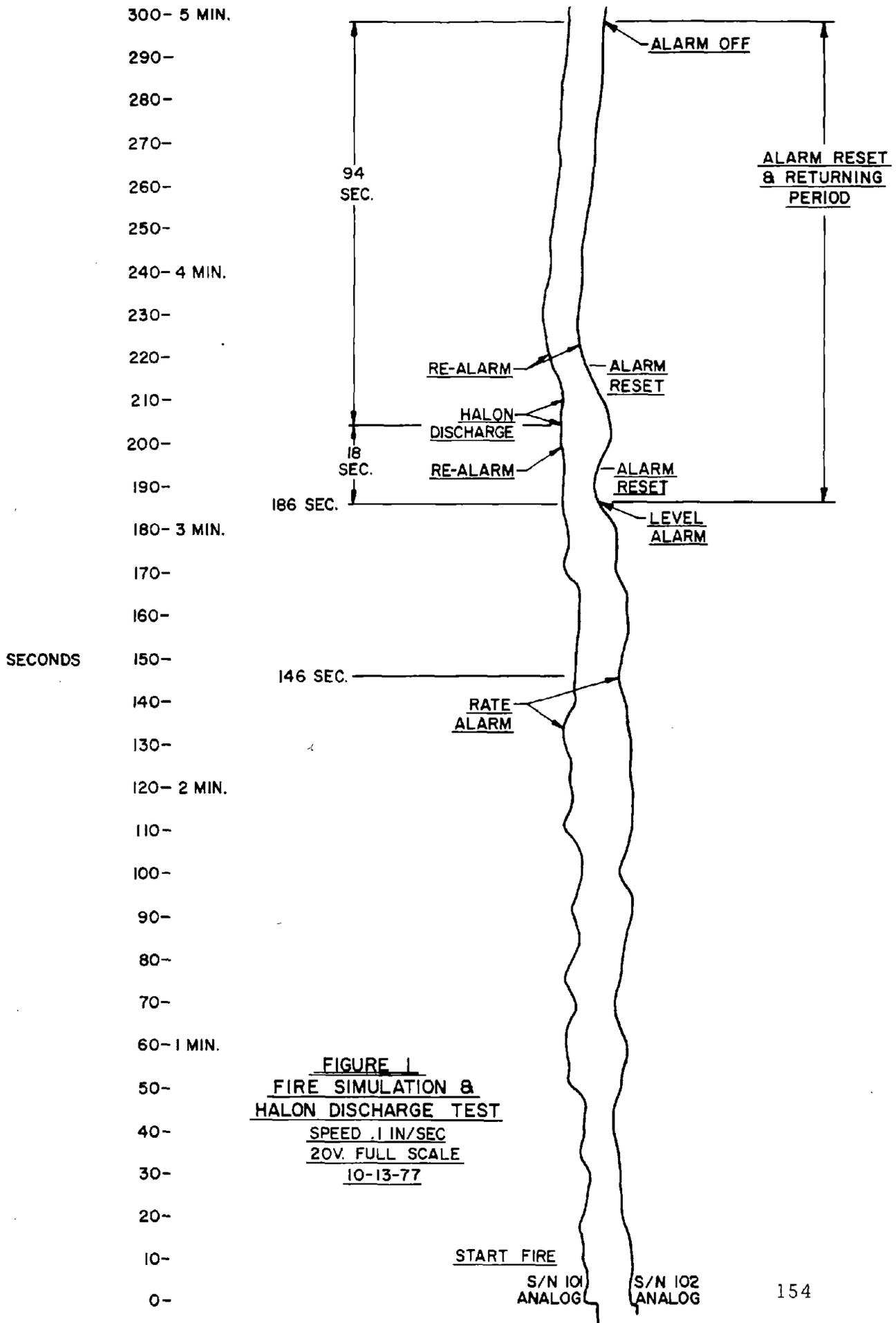
## SECTION 5.0

## CONCLUSIONS AND RECOMMENDATIONS

The following conclusions may be made of the Brunswick Corporation Smoke Detection installation:

- Detector system operated during 20 hours of drill operation without false alarms.
- Detector system responded and alarmed properly during simulated fire test.

It is recommended that after reviewing the first recorder roll of data (approximately 2 months) that an appropriate time be established to modify the system to incorporate the detector startup alarm suppression and to couple our alarm into the "trouble light" circuit of the Ansul control box. Until this is accomplished, the performance of the Brunswick Corporation detector is not being properly demonstrated to the parties concerned.



APPENDIX E  
ELECTRICAL WIRING DIAGRAMS  
FOR

- RUGGEDIZED CONTROL UNIT
- BLAST HOLE DRILL
- LOADING SHOVEL

