BuMines OFR 48-79

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DESIGN AND FABRICATION OF INSTRUMENTATION FOR REMOTE SEALING OF UNDERGROUND COAL MINE PASSAGEWAYS

Prepared for

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF MINES

by

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Volume I
Final Technical Report

on

Contract No. H0144004
Remote Sealing of Underground Coal Mine Passageways

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16. Abstract (Limit: 200 words)

This report describes instrumentation that is part of a system for extinguishing mine fires by pumping material through surface boreholes to seal off all underground passageways leading to the fire area. Major instrumentation systems include a closed-circuit television (CCTV) probing system and an acoustic seal checking system. The latter consists of a speaker probe, a receiver probe, and related signal processing equipment. All probes can be winch-deployed down a 6-inch diameter borehole. The CCTV unit can be rotated 360^0 in the horizontal plane, and contains sufficient lighting to reliably assay conditions for sealing or rescue within a 200-foot radius. The acoustic seal checker monitors the completion of a seal as it progresses by use of probes lowered through boreholes on either side of the seal.

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Extinguishing mine fires
TV borehole probe
Sealing mine passageways
Remote sealing

b. Identifiers/Open-Ended Terms

c. COSATI Field/Group 08I, 13L

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FOREWORD

This report was prepared by Foster-Miller Associates, Inc. (FMA) of Waltham, Massachusetts under USBM Contract Number HO144004. The contract was initiated under the Coal Mine Health and Safety Program. It was administtered under the technical direction of PSMRC. The original Technical Project Officer was Mr. Don Mitchell, replaced first by Mr. Merle Bowser, and finally by Mr. Roger King. Mr. A. G. Young was the Contracting Officer for the Bureau of Mines. Mr. Frank M. Naughton was the Contract Specialist.

This report is the summary of the work recently completed as part of this contract during the period September 1973 through July 1977.

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1. INTRODUCTION

This document represents Volume I of the final report on the "Design and Fabrication of Instrumentation for Remote Sealing of Underground Coal Mine Passageways." It is a technical report which summarizes the results of a system development program. Volume II of this final report is an Operator's Manual for the application of the Remote Sealing System to a coal mine fire.

Another document prepared under this contract, "The Joanne Mine Remote Sealing Operation," presents the details of the application of the Remote Sealing System to an actual mine fire in the Spring of 1974.

1.1 Background

In July of 1972, Foster-Miller Associates, Inc. was awarded a contract by the U.S. Bureau of Mines to develop a system for isolating an active fire zone by remotely sealing coal mine passages from the surface. Under this contract FMA developed the technique and hardware required to emplace fly ash seals in mine passageways through boreholes from the surface. In addition, instrumentation was developed to inspect the condition of the passageways through the boreholes prior to sealing and to determine the effectiveness of the seals during and after emplacement.

This equipment and instrumentation was of a prototype nature - built to establish feasibility and assist in collecting the information required prior to construction of a field worthy system. The field test program established the feasibility of the proposed remote sealing concept and the proposed techniques for sonar probing of the passage prior to sealing and acoustic evaluation of seal quality.

The field tests also established the need for several major additions and improvements to the system - both in the material emplacement system and the instrumentation. Two contracts were let: one to develop a fieldworthy fly ash emplacement system using oxygen depleted gas as the transport medium; the second to develop a fieldworthy instrumentation system for preliminary probing of the passageways and seal evaluation, both using bore-hole probes.

The second contract is the subject of this report. The prototype instrumentation system developed under the original contract is described in detail in a previous FMA report. A brief description of the components and the improvements desired under this contract are presented in the following two sections.

The balance of the report presents and describes in detail the various subsystems which make up the remote sealing instrumentation system. The operation of the instrumentation is described in detail in Volume II of this report - the Operations Manual. The field testing of the major parts of this system is described in the Final Technical Report, "Joanne Mine Remote Sealing Operation," also written under this contract.

1.2 Description of Original Prototype System

The objective of the original program was to develop a system to extinguish coal mine fires by remote sealing of the underground passageways. The system required sufficient versatility to function under a wide range of operating conditions, including large variations in passageway geometry, depth of mine, water conditions, both in the mine and at the surface, and rubble in the mine passage. The system developed had to include instrumentation for the remote probing of the passageway prior to sealing, a system for sealing the mine passages, and instrumentation for remote monitoring of the quality of the seal during and after construction.

These objectives were successfully achieved during the program. The remote mine sealing capability of the system was satisfactorily demonstrated in a field test conducted at the Eastern Associated Coal Corp., Federal No. 1 Mine in Grant Town, West Virginia.

The original prototype remote sealing system consisted of:

- A pole lowered sonar initial probing system which operates satisfactorily even in the presence of dense smoke. The system is capable of determining both the local passageway geometry, identifying the presence of cribs and other obstructions, and the position of the borehole in the mine passage.

- A mine sealing material system which utilizes fly ash for making the complete seal or as a bulk filler in conjunction with a urethane, froth foam, seal topping system. The choice of using fly ash alone or fly ash with foam topping depends on a number of factors, such as quality of seal desired, time available per seal, depth of borehole, passageway geometry, and water holding requirement.

The fly ash-foam seal is a better seal, capable of sealing against a higher water head than fly ash alone. The fly ash sealing system uses a high velocity technique for injecting fly ash into the mine. This method results in the development of a large crater in the fly ash pile and causes the seal to form first at the ribs and, subsequently, to move in towards the borehole. The presence of the crater eliminates the chance of premature plugging of the borehole and provides a receptacle for the froth foam used to top off the seal.

The froth foam system uses a downhole static mixing head designed to provide uniform mixing of the foam components.

- A pole lowered acoustic seal checking system which is capable of monitoring the continuous development of the seal during seal construction and providing a sensitive indication of the quality of the completed seal. The system senses the decay in strength of an acoustic signal passing through the sealed passage as a measure of the quality of the seal.

Figure 1 illustrates the operation of the prototype remote mine sealing system developed in the original program. The system is shown in various phases of operation at three different sealing locations. A total of three boreholes per seal are required, one for sealing and one on either side of the seal for seal checking. The boreholes must be cased and grouted to prevent borehole water flow into the mine passage being sealed.

At the first location in Figure 1, the primary borehole has been drilled, and the sonar probe has been lowered into the mine passage. The sonar probe is used to scan the passageway, in order to determine local passageway geometry, position of the borehole, cribs, rubble piles, or other obstructions. The display on the surface indicates the distance of a target in any desired direction, as determined by the compass markings on the rotary table at the surface. The probing information is used to establish the operating conditions of the fly ash delivery system. The system has a range of 20 feet.

The second sealing location shows the acoustic seal checking system deployed through the two seal checking boreholes. The system consists of a line array of speakers on one side of the seal and a microphone on the other. As the seal develops, the strength of the signal received at the microphone decays. This reduction in sound level is a direct measure of the percentage

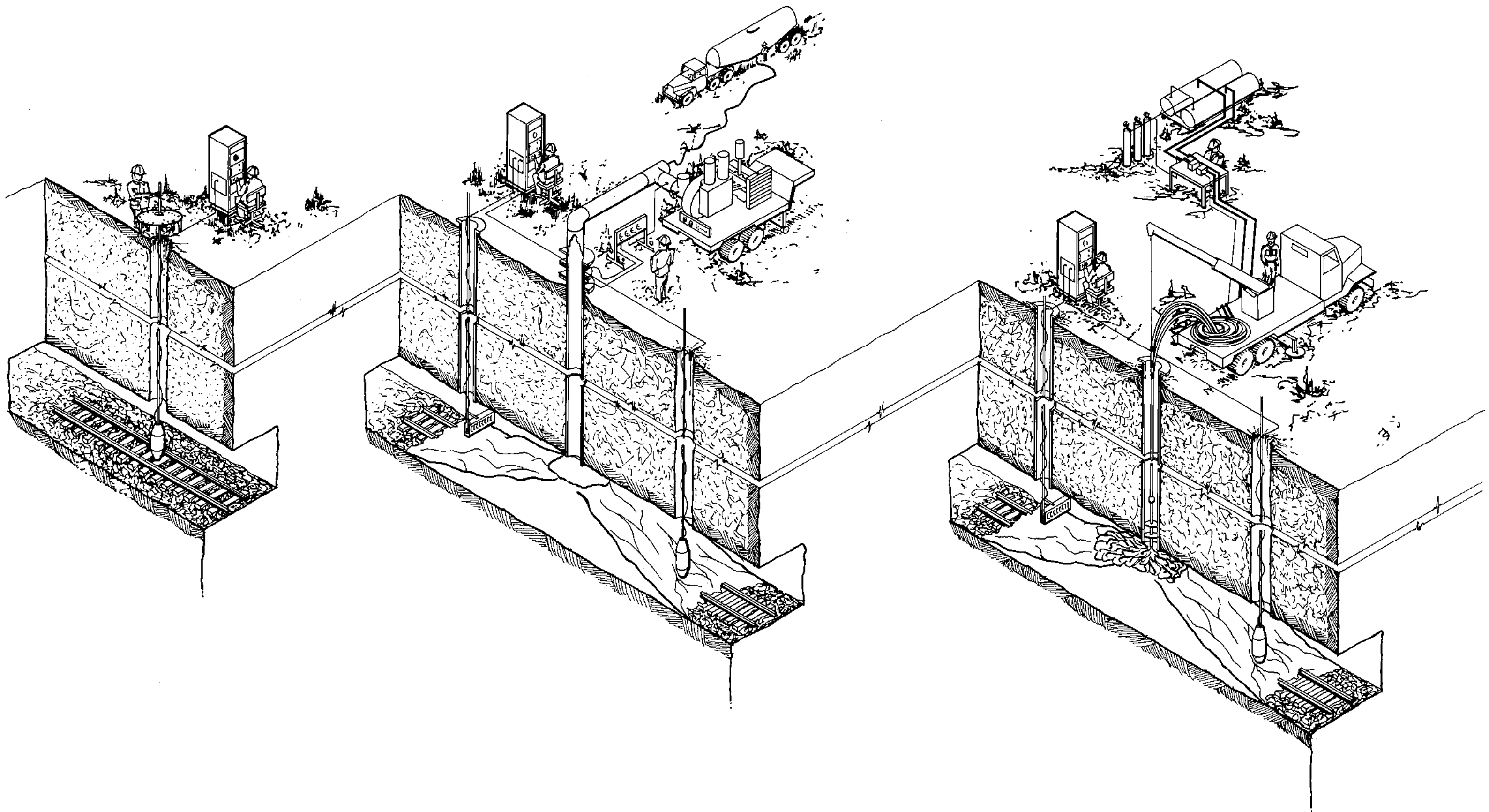


Figure 1. Remote Mine Sealing System

of the mine passage area blocked by the seal. The electronic signal processing system includes a pulse-gating technique to eliminate the effect of sound traveling through parallel passageways to reach the microphone.

The fly ash pumping system utilized the blower contained on the fly ash truck plus an auxiliary, diesel-driven blower, which provides ten times the air flow available from the truck. The truck pumps fly ash through a standard 4 inch hose to a special mixing nozzle, which injects the fly ash into the high-flow air stream from the auxiliary blower and, thence, through an 8 inch pipe to the borehole. Instruments monitor the air flow rate, fly ash flow rate, the pressure at critical points in the system. The system has an air flow capacity of 5000 scfm. Typical air flow rates utilized for remote sealings were in the range of 1500 to 2500 scfm, depending on passage geometry.

The froth foam topping system is shown in use at the third sealing location, with the seal-checking system being used to verify that a 100 percent seal has been formed. The components of the foam are stored and pumped separately to the remote mixing head, which is lowered by a truck-mounted crane. Instruments monitor the system pressures and flow rates.

1.3 Modifications for Fieldworthy System

The modifications to the remote sealing instrumentation system under the subject contract fall into the following major classifications:

(a) Development of a Cable Lowered Deployment System for the Dowhole Probes. The prototype instrumentation systems had employed rigid poles connected end to end to lower the probes into the mine passageways. This technique was slow and cumbersome, requiring auxiliary equipment such as scaffolding and winches for deployment and separate electrical and mechanical cables through the borehole. Rotation of those probes with directional characteristics (the preliminary probe and the speaker probe) was accomplished by rotation of the torsionally rigid pipe stack from the top.

A cable lowered deployment system was implemented to increase the speed and reliability of deployment and to eliminate the need for cumbersome auxiliary support equipment. The replacement of the rigid pipe stack with the cable demanded a rotator downhole to turn the probe and a remote reading compass to indicate the probe's orientation.

(b) Expand the Capabilities of the Preliminary Probing System. The prototype preliminary probing system utilized an air-coupled sonar ranging device to determine the distance to the nearest large object in its line of sight. By manually rotating the device with the torsionally rigid pipe stack the entry could be mapped and critical dimensions established. The prototype sonar provided this level of information even in dense smoke. The focusing of the acoustic beam was not sufficient to provide good resolution, however, and readings were erratic under conditions of low roof or a cluttered passageway.

To improve the quality of the information obtainable through the preliminary probing operation, a low light level closed circuit television (CCTV) camera was added to the preliminary probe. In addition, performance of the sonar probe was upgraded to provide interpretable information under a broader range of passage conditions. Cable deployment required the addition of a downhole rotator and remote reading compass to the downhole probe. Finally, the several components; rotator, CCTV, sonar and compass, were modularized to permit the use of any or all of the components depending on the situation.

(c) Development of an Improved Acoustic Seal Checker System. The prototype seal checking system employed an array of eight speakers to achieve the desired acoustic intensity. The array was lowered with rigid poles as is the sonar probe. These poles permitted rotation to the desired orientation from the surface.

The microphone was deployed using a small winch and separate mechanical and electrical cables. A headframe and pulley assembly was required and tangling of the cables was a problem during retrieval.

The original signal processing electronics made no provision for suppression of background acoustic noise. The signal was occasionally garbled by electrical signal feedback directly from the power amplifier to the sound level circuit.

Modification of the acoustic seal checker system included redesign of the speaker assembly to a more manageable size with minimum sacrifice in available acoustic power. A rotator for the speaker was added to permit optimum orientation although no compass was required. No rotator was required for the microphone because of its omni-directional characteristics.

The signal processing circuitry was refined to suppress background acoustic noise and the conductors shielded sufficiently to eliminate troublesome "cross talk" between the signal to the speakers and the sound level meter.

(d) Outfitting an Instrumentation Van. To ensure a field-worthy system, in readiness for emergencies, an instrument van was added to the system. It houses the several instrument consoles and downhole probes as well as the auxiliary equipment required for field applications.

(e) Development of Backup Systems and Field Inventory. To avoid lost time during emergency situations, a complete backup instrumentation system was assembled. This includes additional instrumentation consoles, spare parts for the deployment winches, and extra interchangeable probes.

2. REMOTE SEALING SYSTEM DESCRIPTION AND APPLICATION

The remote sealing system consists of four major parts:

- Preliminary Probing System
- Mine-Sealing System
- Inert Gas Generation System
- Acoustic Seal-Checking System.

The instrumentation and downhole deployment equipment associated with the preliminary probing system and the acoustic seal checking system are of primary interest in this report. For completeness, each of the major subsystems is described in the following paragraphs along with a summary of the overall system operation.

2.1 Preliminary Probing System

The preliminary probing system consists of a low light level CCTV for visual observation of downhole conditions and a sonar ranging device for accurately determining passage dimensions or assisting the probing when dense smoke prohibits visual observation. The downhole portion of the preliminary probing system also includes a rotator for downhole scanning and a remote reading compass for correlating downhole information with the mine map and engineering survey at the surface. The information obtained during preliminary probing is useful for establishing suitability of borehole locations, sealing material requirements, location of potential obstructions for the sealing material, and correlation between engineering surveys and the mine maps.

The preliminary probe is lowered from a hydraulic powered winch using an electromechanical (e/m) cable. A boom and head-sheave assembly mounted as part of the winch package permits easy location of the probe over the borehole. The CCTV signal and the sonar and compass signals are fed back to a control console located on the surface. From this console the operator controls the downhole package and interprets the information being returned.

2.2 Mine Sealing System

The mine sealing system utilizes fly ash either for making a complete seal or as a bulk filler in conjunction with a urethane froth foam seal topping system. The choice between seals of fly ash alone or fly ash and froth foam depends on a number of factors including desired seal quality, available time and equipment, borehole depth, passage geometry and water holding requirements. The froth foam topped seal is more desirable, particularly in passages with irregular roof or excessive water flows. An improved froth foam deployment system is currently under development to increase the speed and reliability of froth foam emplacement through long boreholes.

For cases where the decision is made to flood the fire zone with water, a modification to the basic fly ash sealing system has been developed to contain the associated waterhead. This modification involves using a 50-50 mixture of fly ash and bentonite for the main sealing operation. This seal is then topped with a 50-50 mixture of fly ash and Reg-set cement, and then finally with frothed foam as already described. The bentonite/fly ash mix swells upon wetting and the bulk of the seal then becomes impervious to water. The Reg-set/fly ash topping hardens to a "crust" and prevents erosion at the foam/fly ash interface.

2.3 Inert Gas Generation System

The inert gas generation system combines nitrogen supplied by an independent organization with air compressed in a positive displacement blower. This yields gas with oxygen content sufficiently low to eliminate the explosion hazard common to oxygen methane gas mixtures. The gas so produced is used for pneumatic emplacement of the fly ash sealant material and subsequently for inerting of the sealed fire zone.

2.4 Acoustic Seal Checking System

The acoustic seal checking system is capable of monitoring the development of the seal during emplacement and providing a sensitive indication of the quality and completeness of the seal. Decay in strength of a repeated acoustic signal passing through the area to be sealed is used as a measure of the quality of the seal. A high intensity speaker is lowered by cable through a borehole on one side of the intended seal location, and a sensitive microphone is lowered on the opposite side of the same seal. Winch packages similar to that used for the preliminary probe are employed. Prior to seal formation the speaker is activated with pulsed energy and the intensity of the sound monitored at the microphone. This is repeated at intervals as the seal is emplaced. The decay in strength of the acoustic signal passing through the seal is a measure of the seal quality.

A console on the surface controls the speaker input and receives the signal from the microphone. The signals are processed electronically and a meter reading provides an indication of seal completeness.

2.5 Remote Sealing System Operation

Figure 2 illustrates the operation of the complete remote mine sealing system with improvements added in recent programs. The system is shown in various phases of operation at three different sealing locations. Three boreholes per seal are required, one for sealing and one on either side of the seal for seal checking. The boreholes must be cased and grouted to prevent borehole water flow into the mine passage being sealed.

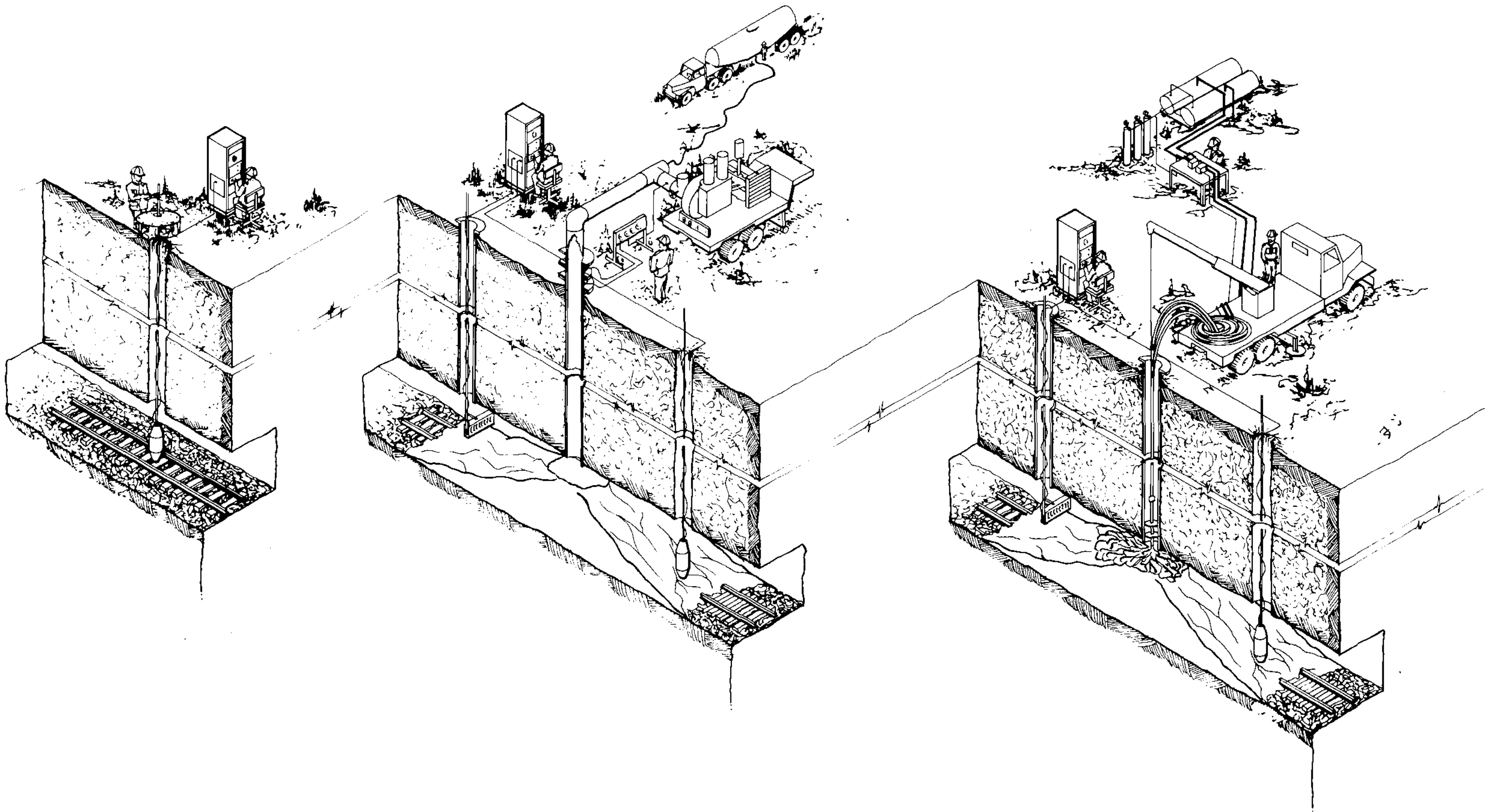


Figure 2. Improved Remote Mine Sealing System

The sequence of operation of the remote sealing system is:

a. Determine borehole locations through engineering survey.

b. Drill, case and grout boreholes.

c. Probe passageway through main sealing borehole and seal checking boreholes if necessary. Retrieve system after completion of probing.

d. Deploy acoustic seal checking system through outer boreholes.

e. Deliver fly ash through main borehole using nitrogen-enriched air delivery system.

f. Monitor seal development and terminate fly ash pour either after completion of bulk filling or complete fly ash seal.

These additional steps are necessary if the fly ash is to be topped with foam:

g. Deploy downhole froth foam system to top bulk-filled fly ash pile.

h. Complete foam topping while monitoring seal completion with the acoustic seal checker.

i. Retrieve froth foam system and acoustic seal checker.

At the first location, shown in Figure 2, the primary borehole has been drilled and the preliminary probing system has been cable-lowered into the mine passage. The combined CCTV and sonar probe is used to scan the passageway to determine local passageway geometry, position of the borehole, cribs, rubble piles, or other obstructions. The display on the surface permits visual observation of downhole conditions and indicates the distance of a target in any desired direction, as indicated by the remote reading compass located on the probe. The probing information is used to establish the operating conditions for the fly ash delivery system. The probe has a range of approximately 40 feet when the light source is diffused and approximately 200 feet when the light source is focused. This focussing capability provides either a general illumination over the entire TV screen area or a more intense lighting which does not illuminate the full screen area, but can reveal greater detail on "set" for greater distances then the general illumination.

The second sealing location shows the fly ash filling operation with the acoustic seal checking system deployed through the two seal checking boreholes. The seal checker consists of a single high intensity speaker on one side of the seal and a microphone on the other, both units being cable lowered by independent winches. As the seal develops, the strength of the signal received at the microphone decreases. This reduction in sound level is a direct measure of the percentage of the mine passage area blocked by the seal. The electronic signal processing system utilizes a pulse-gating technique to eliminate the effect of sound traveling through parallel passageways to reach the microphone.

The fly ash pumping system utilizes the blower contained on the fly ash truck, an auxiliary, diesel-driven blower, and a source of nitrogen to be mixed with the blower air. This combination provides ten times the air flow normally available from the truck. Fly ash is pumped from one or more fly ash trucks through a standard 4 inch hose to a special mixing nozzle, which injects the fly ash into the high-flow stream from the nitrogen source and the auxiliary blower and thence through an 8 inch pipe to the borehole. Instruments monitor the gas flow rate, fly ash flow rate, temperature and pressure at critical points in the system. Typical gas flow rates lie in the range of 1500 to 2500 scfm, depending on passage geometry.

The present froth foam topping system is shown in use at the third sealing location with the seal-checking system being used to verify that a 100 percent seal has been formed. The two components of the foam are stored and pumped separately to the remote mixing head, which is lowered by a truck-mounted crane. The two liquid components are combined in the remote mixing head, mixed with a catalyst, and released from pressure, causing the liquid to froth as it passes through the vanes of a static mixer. In this manner, the foam materials are thoroughly mixed with no moving parts in the remotely deployed mixing head. A more reliable, more easily deployable froth foam system is currently under development.

3. PRELIMINARY PROBING SYSTEM

Conditions in the entry to be sealed, particularly in the vicinity of the borehole, may influence the sealing technique or even affect confidence in the entire sealing operation. In order to accurately determine these conditions the preliminary probing system was developed. It provides information regarding entry geometry, borehole location, water pools, roof irregularities, obstructions and cavities.

The preliminary probe includes a CCTV system for visual feedback and a sonar device for measuring distance to critical objects or blind probing of passage dimensions when visibility is limited. The probe is equipped with a 360 degree rotator to aid in scanning and a remote reading compass for establishing absolute references. The complete probe is shown in Figure 3.

The following sections describe the major components and their operation.

3.1 Downhole Components

The preliminary probe system consists of three major subsystems; a downhole probe, a deployment system and control console as shown schematically in Figure 4.

The probe is lowered through a drilled and cased borehole into the passage to be probed. The probe is suspended from an electromechanical cable having 18 conductors and a coax cable, enclosed in an armored shield to provide mechanical strength. The cable enters the rotator housing through a packing gland required to keep the rotator module explosion proof. The rotator bolts directly to the CCTV module with four bolts. Electrical connections are made with two standard connectors, one coaxial and one multipin. The sonar/compass module in turn bolts directly

Figure 3. Complete Preliminary Probe Assembly

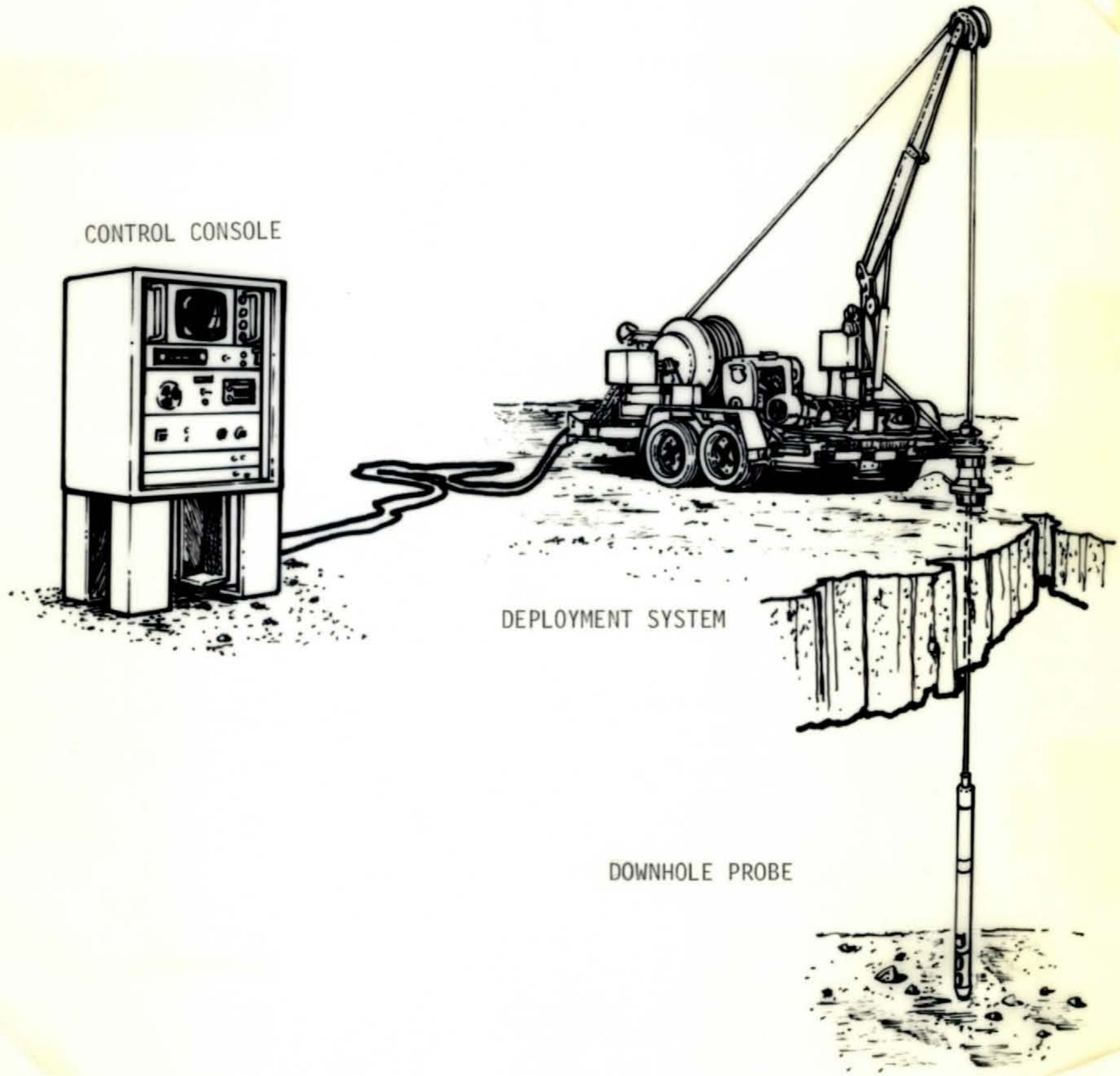


Figure 4. Preliminary Probing System

to the lower end of the CCTV module and connects electrically using a single multipin connector. In this configuration both CCTV and sonar can be operated simultaneously. If one capability or the other is not desired or not required, the unnecessary module can be removed without affecting overall operation. The modules are mechanically and electrically compatible with the rotator and thus are interchangeable and the sonor and compass are intrinsically safe. The complete preliminary probe assembly is photographed in Figure 3.

The rotator module has been certified explosion proof (MESA Certification No. XP-2097) by Approval and Testing. A photograph of the rotator housing is shown in Figure 5a. Figure 5b shows the rotator assembly with the housing removed.

(a) CCTV Rotator in Housing

(b) CCTV Rotator Assembly with Housing Removed

Figure 5. Rotator Assembly for Preliminary Probe

The CCTV probe has also been certified explosion proof (MESA Certification No. XP-2085). Figure 6a shows the complete CCTV housing while Figure 6b shows a close up of the window for the lens and light source. The camera lens is oriented vertically downward while the lamp is directed horizontally. A mirrored surface is used to permit the lens to view horizontally. A view of the internals of the CCTV probe with the housing removed is presented in Figure 7. The CCTV camera is a Concord Model CTC-30 IR.* It is a commercially available unit, repackaged by FMA to fit in the desired envelope. Use of a mirror in this fashion

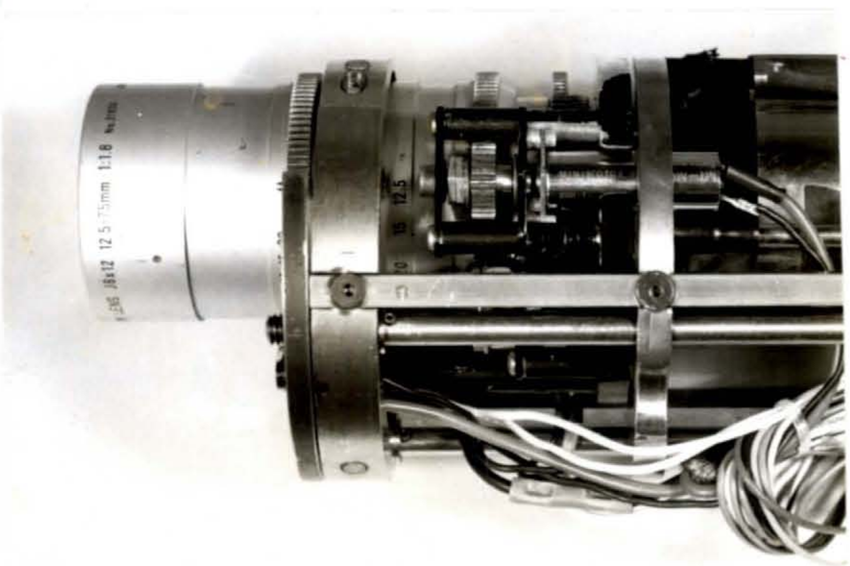
(a) CCTV Probe (b) CCTV Window

Figure 6. Details of CCTV Housing

*Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

(a) Complete Housing Assembly

(b) CCTV Internals



(c) Lens Drive

Figure 7. Disassembled CCTV Probe

presents the lens with a "mirror image," that is, with a right-left reversal. To prevent confusion from this, the normal scan pattern of the camera has been reversed. By simply switching leads, the monitor shows a reversal of the mirror image; the scene appears as it would to the unaided eye.

The sonar and compass modules are both intrinsically safe and are contained within a single housing shown in Figure 8a. Figure 8b shows the sonar and compass module with the housing removed. The compass module is mounted below the sonar "lenses" at the bottom of the assembly. Figure 9a provides another view of internals of the sonar/compass module. Figure 9b shows a module which houses only the compass for applications where sonar is not required, while Figure 9c shows a closeup view of the remote reading compass module removed from the housing.

(a) Sonar/Compass Probe (b) Probe with Housing Removed

Figure 8. Intrinsically Safe Sonar/Compass Probe

(a) Sonar/Compass Internals

(b) Compass Probe

(c) Compass Module

Figure 9. Detail Views of Compass Assembly

The compass is a commercially available unit modified by the manufacturers for this application. It includes a Digicourse Model 121 sender, Model 102 readout and a Model 103 junction box.* The sonar was developed completely by FMA personnel. It does use a Heathkit display panel, however. A schematic of the sonar circuitry is presented in Figure 10. A complete electrical diagram of the entire preliminary probing system is presented in Figure 11.

3.2 Deployment System

The preliminary probe is suspended from 1650 feet of electromechanical cable (Vector Cable Company Model No. A42005 R-13).* This cable has a wire rope exterior (tensile strength greater than 30,000 pounds) with an outside diameter of 0.880 inch. Inside the armored layer is a neoprene jacket, within which are an R.G. 59 coax conductor, 13 No. 16 AWG conductors and 5 No. 18 AWG conductors.

The cable is deployed from a hydraulically actuated winch. A manually operated boom is used to support the headsheave over the borehole. The winch is powered by either a 18 horsepower Wisconsin gasoline engine or explosion proof Reliance electric motor rated at 15 horsepower.* These alternate power sources provide the ultimate in flexibility; an explosion proof package if methane is a problem and electric power is available or a completely self-contained gas-powered system for remote applications when conditions permit.

The preliminary probe deployment system is mounted on a small, truck towable, flatbed trailer. This trailer provides over-the-road mobility as well as easy movement at the site.

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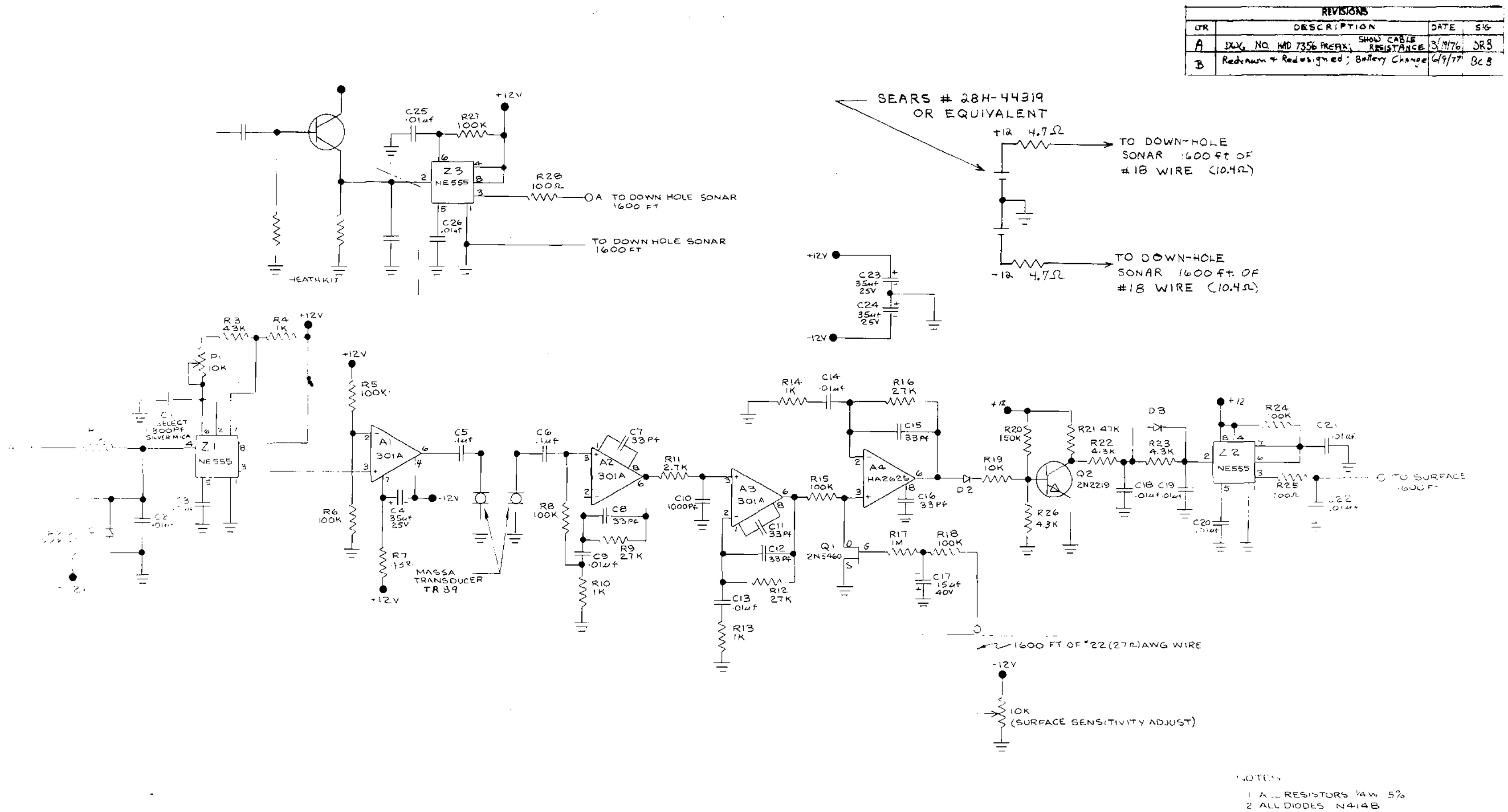
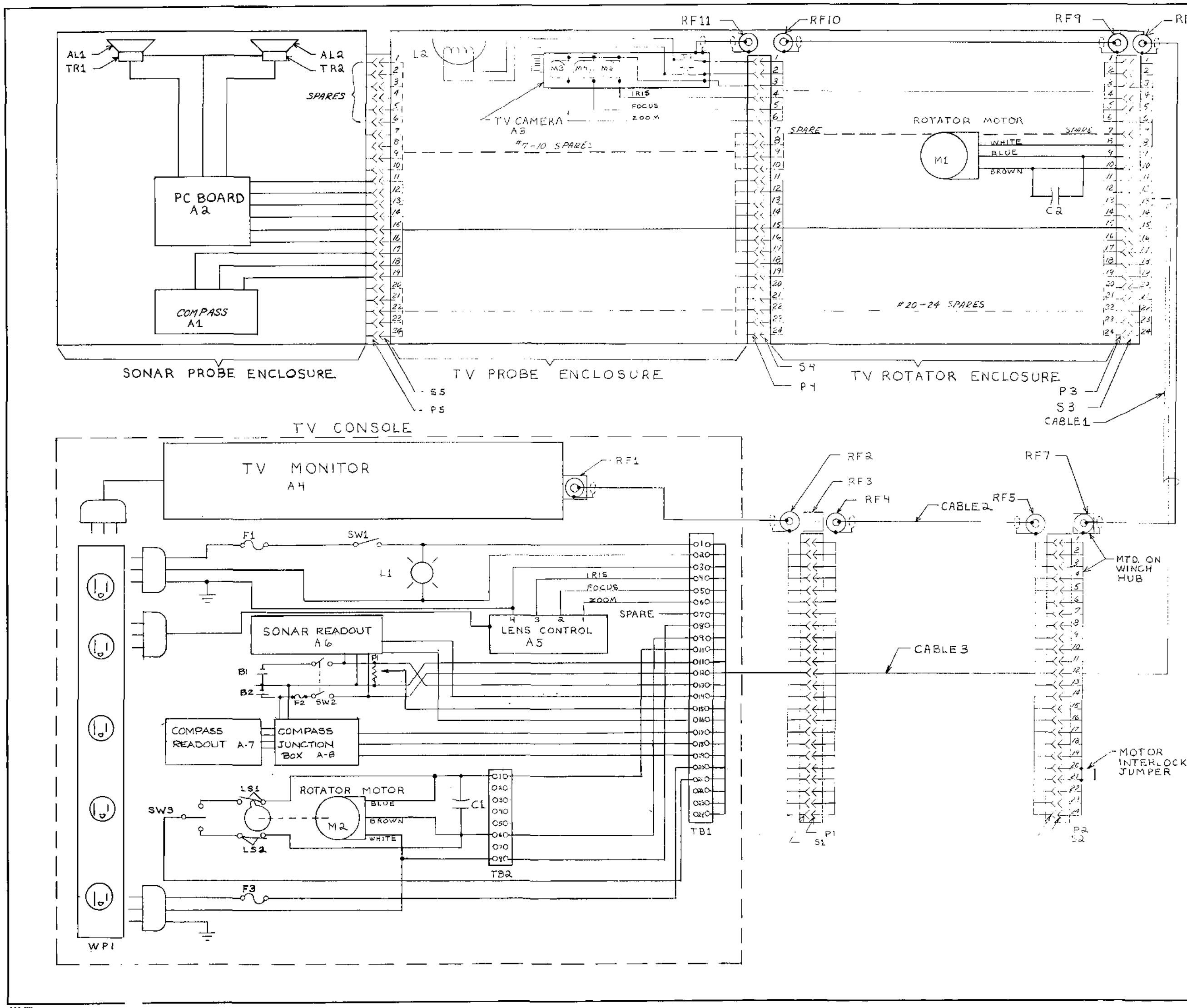


Figure 10. Circuit Diagram for Sonar Probe



REVISIONS

LTR	DESCRIPTION	DATE	SIG

ITEM NO.	PART NO	DESCRIPTION
T1	273 - 1511	TRANSFORMER 12.6VCT 3 AMP
WP1	602	EXTENSION CORD, 115VAC-WABER
LS1,2	BZ2RW822-A2	LIMIT SWITCH - MICRO
F3	AGC	FUSE, 5AMP
F2	3AG-1	FUSE, SB, 1AMP
F1	MDL-1	FUSE, S.B., 1AMP
C1,2	MFP 4W1	CAPACITOR, 1MFD 400VDC-CDE
S3	JBT 58271	SWITCH, SPDT
S2	MS-054-055	SWITCH, DPDT, - MIYTAMA
S1	32-2A	SWITCH, SPST, 250VAC @ 6A-MIYTAMA
P1		POTENTIOMETER, 10K OHMS
B1,2		BATTERY 12VDC
TB2	8-142	TERMINAL STRIP-CINCH
TB1	2EA. - 12-142	TERMINAL STRIP - CINCH
CABLE 3	SO	CABLE 30#18 CONDUCTORS (50 FT.)
CABLE 2	RG 59U	COAX CABLE - 75 OHM (50 FT.)
CABLE 1	1650 FT.	EM CABLE, 1 COAX, 7#18 WIRES, 20#22 WIRES
TR1,2	TR 89 B	ACOUSTIC TRANSDUCER - MESSA
AL1,2	DWG NO.	ACOUSTIC LENS
L2	ERC	LAMP 25W, 14V, 200 HR.-
L1	1050 A1	INDICATOR LAMP - IND. DEVICES
M3,4,5	12 UDC	MOTORS - VICON IND. INC
M1,2	33A638-4126	MOTOR - GLOBE INDUSTRIES
RF9,11	31-002 (MIL. NO. UG88)	BNC STIGHT JACK - AMPHENOL
RF8,10	31-005 (MIL. NO. UG89)	BNC STRIGHT JACK - AMPHENOL
RF3	83-1J (MIL. NO. PL258)	UHF STRIGHT ADAPTERS - AMP.
RF2,4,5	83-822 (MIL. NO. PL259)	UHF STRIGHT PLUGS - AMPHENOL
RF1,7	83-1R (MIL. NO. 50239)	UHF PANEL RECEPTACLE - AMP.
S1,2,3,4,5	48-16R16-24S	BAYONET SOCKET - AMPHENOL
P2	48-13R16-24P	BAYONET PLUG, SINGLE MTD. HOLE
P1,3,4,5	48-16R16-24P	BAYONET PLUG - AMPHENOL
A8	103	COMPASS JUNCTION BOX - DIGICOURSE
A7	102	COMPASS READOUT - DIGICOURSE
A6	M1030	SONAR READOUT - HEATHKIT
A5	V100C	LENS CONTROL - VICON
A4	EVM-11R	CCTV MONITOR - ELECTROHOME
A3	CTC 36	CCTV CAMERA - CONCORD
A2		REMOTE PROBE CIRCUIT (SONAR)
A1	100A	ELECTRONIC COMPASS - DIGICOURSE

ITEM NO. QTY | PART NO | DESCRIPTION | SPECIFICATION

PARTS LIST

FOSTER-MILLER ASSOCIATES
INCORPORATED
135 SECOND AVENUE WALTHAM MA 02154

APPLICATION

TV PROBE
ELECTRICAL SYSTEM

ORIGINAL PROJECT: 7356 | SIZE: D | 11598 | REV: N/C

ACTIVE PROJECT NO: BM 7473

Figure 11. Complete Wiring Diagram for Preliminary Probe System

Figure 12 shows the deployment system suspending the preliminary probing assembly. Figure 13 shows the deployment system collapsed and ready for over-the-road transportation. A more detailed description of the deployment system is presented in Section 5 along with the design and operation of the seal checker deployment systems.

3.3 Control Console

The control console for the preliminary probing system is pictured in Figure 14. Figure 14a shows an overview of the weather-proof enclosure while Figure 14b provides a closeup of the controls.

The console contains an 11 inch rack mounted Electrohome monitor* with the controls required for adjustment. Directly below the monitor is the remote control panel for the camera lens. This panel contains controls for the lens focus, iris, and zoom. There is a separate control which regulates the rate at which the lens controls operate.

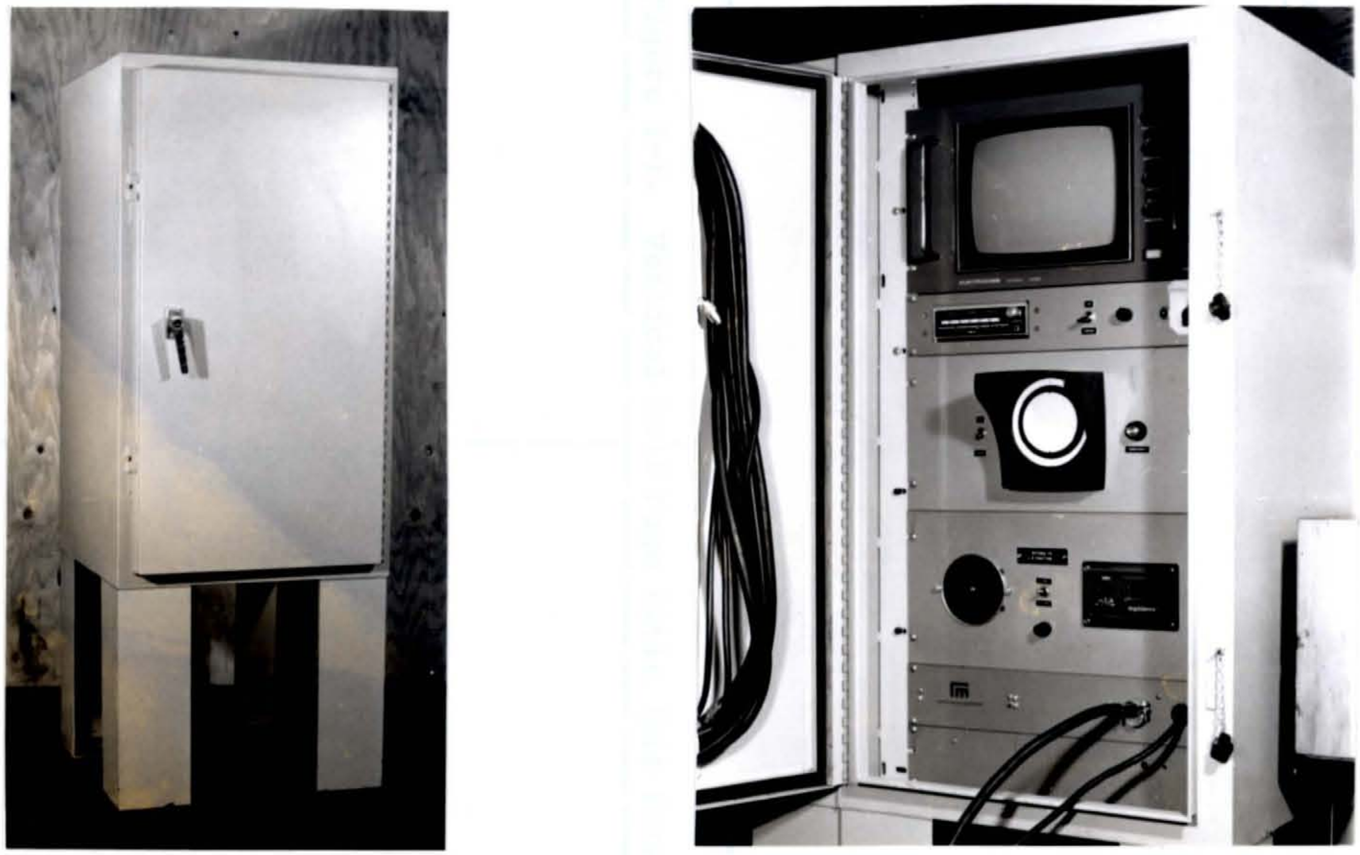
Below the lens control panel is the sonar readout panel which indicates the distance in feet to the object toward which the probe is pointed. This object will be centered in the TV picture if both systems are operated simultaneously. A rotator control and readout panel are mounted below the lens controller along with a digital readout from the remote reading compass.

The console operates partially on 110 Vac power and partially on small lead-acid batteries. A 15 foot cable is permanently attached to the console for the purpose of connecting to the

*Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

Figure 12. Preliminary Probe Deployment System

Figure 13. Preliminary Probe Deployment System - Ready for Transport



(a) Weatherproof Enclosure (b) Controls and Instrumentation

Figure 14. Preliminary Probing Control Console

electro-mechanical cable through the winch hub. An additional cable 200 feet in length is provided as an extension to minimize relocation of the console close to the boreholes.

Two consoles are available as described above. An additional console is available without the TV monitor for use with the sonar probe only.

3.4 System Operation

Operation of the deployment system is discussed in general in Section 5. Details of the operation of the deployment system and the probing system are presented in Volume II of this report.

3.5 System Maintenance, Inspection and Repair

Maintenance of the preliminary probing system is limited to ensure that batteries are kept fully charged for operation of the sonar and compass units.

Field repair of the system should be limited to repair of cables and cable terminators. To aid in this effort, Figure 11 shows the complete wiring diagram for this system.

If part of the system malfunctions or is damaged, a spare unit should be used and the defective unit sent to the USBM designated contractor for repair or replacement.

4. ACOUSTIC SEAL CHECKING SYSTEM

A technique for assuring that a remotely emplaced seal has effectively blocked an underground mine passage is vital to the success of a mine recovery operation. The system for remotely checking the effectiveness of the seals utilizes acoustic devices; a high intensity speaker and a sensitive microphone which are cable lowered into the mine on opposite sides of the region to be sealed. The major components; the microphone and speaker probes, the deployment winches and the control console are shown schematically in Figure 15.

4.1 Acoustic Seal Checking System Description

A block diagram of the entire seal checking system is shown in Figure 16.

A special control circuit triggers the random noise generator, which emits a burst of "noise." This signal is amplified and transmitted to the downhole speaker. The microphone picks up the noise (which has been diminished by an amount proportional to the percent of seal completion), which is amplified and transmitted up-hole to the sound level meter. The sound level meter provides further amplification, displays the instantaneous sound level, and transmits this signal back to the control circuit. The control circuit is designed to "listen" only for the pulse of sound going across the seal, ignoring the sound which may reach the microphone by taking a longer route (such as bypassing the seal by going around a coal pillar). This unit also subtracts out background noise. After this process, the signal is transmitted to the output display.

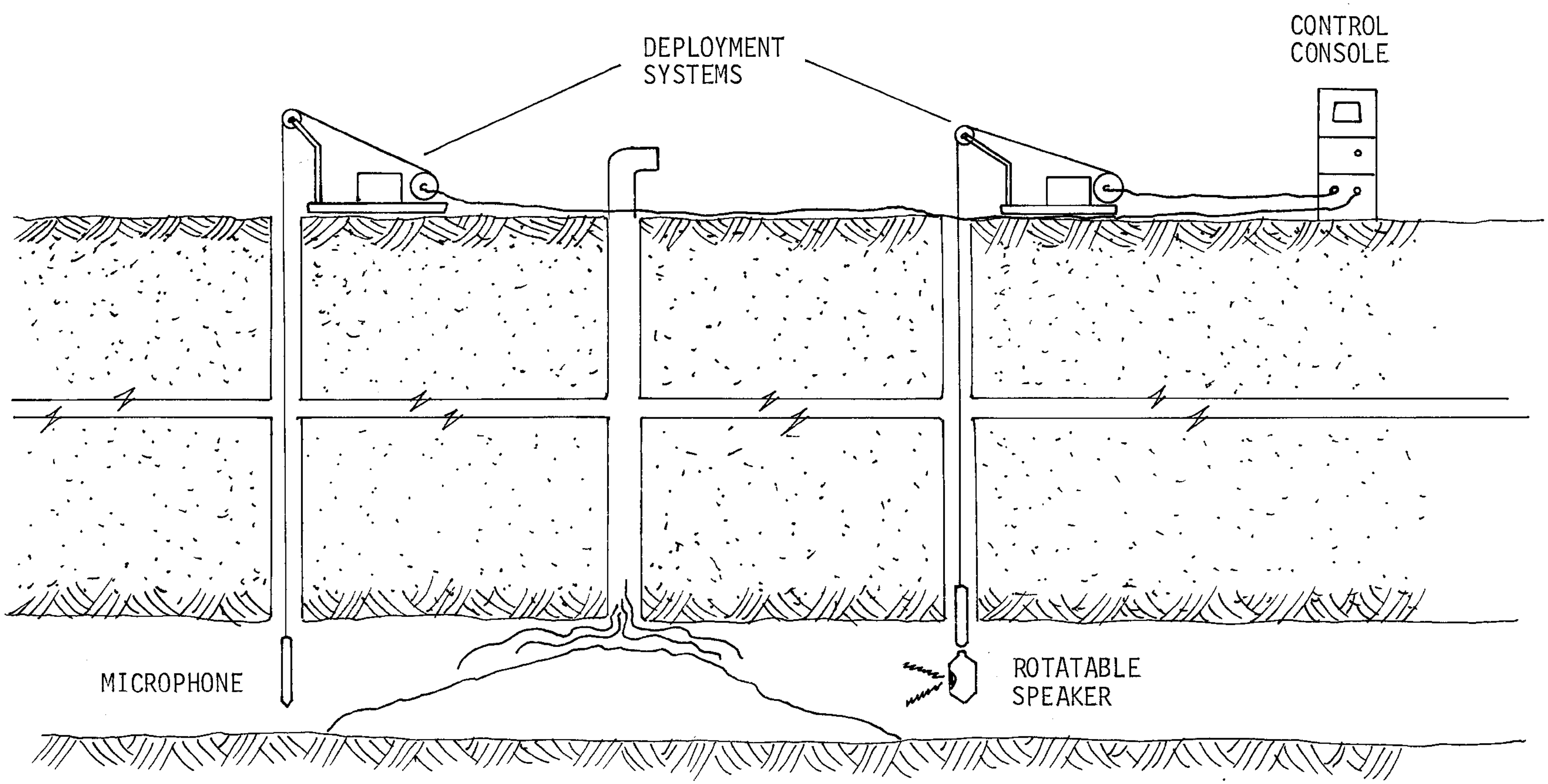


Figure 15. Acoustic Seal Checker System in Operation

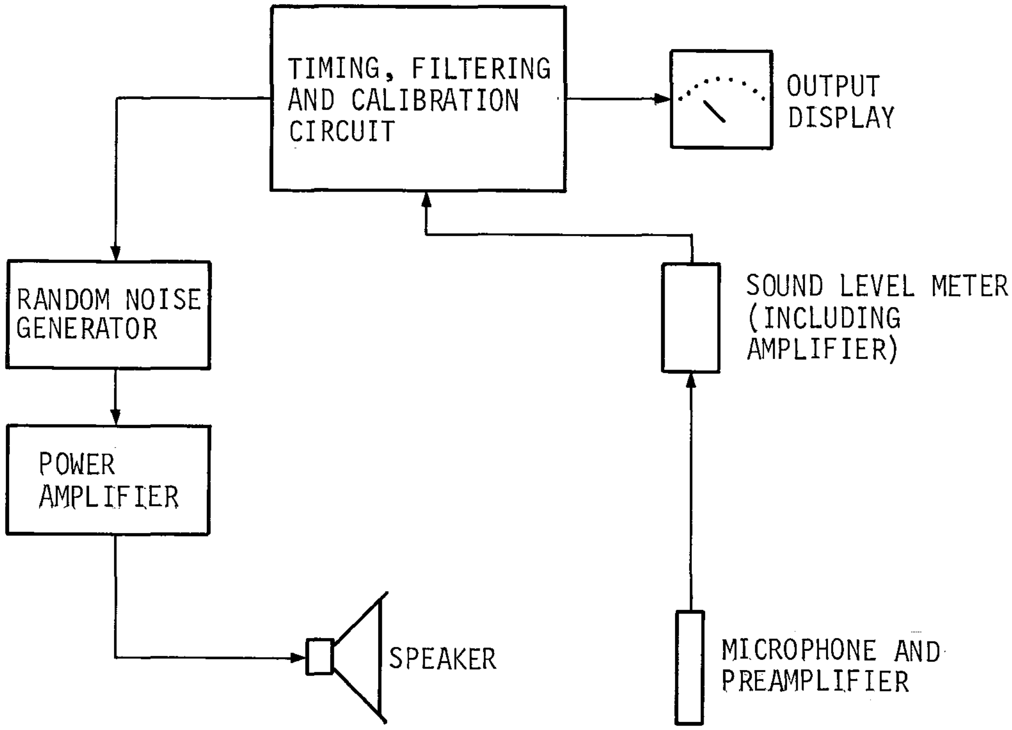


Figure 16. Block Diagram of Seal Checking System

4.1.1 Downhole Probes

The downhole speaker probe and its rotator are pictured in Figure 17. A closeup of the speaker probe and a view of the rotator, partially disassembled, are shown in Figure 18. The speaker is a University Sound Model MIS-4* and is approved by MESA as intrinsically safe for operation below 12 volts. The speaker rotator is custom-designed by FMA and enclosed in an explosion proof housing, MESA Certification No. XP-2054.

A complete wiring diagram for the speaker system is presented in Figure 19.

*Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines

Figure 17. Speaker Probe and Rotator

A microphone probe is shown in Figure 20a. It houses a General Radio Model 1560-9570 microphone and a General Radio Model 1560-P40 preamplifier* both shown in Figure 20b. A ceramic microphone was selected because it is a self-generating device, requiring no polarizing voltage. In addition it is reliable, stable and rugged. The preamplifier couples the microphone to coaxial cable without voltage loss or with a gain of 10 to 1 as desired. The preamplifier is desirable to minimize the effect of the 1600 feet of cable from the microphone to the amplifier, boosting the signal before the cable improves the signal to noise ratio at the amplifier.

Since the microphone and preamplifier are intrinsically safe, connections are made through a three pin microphone

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(a) Speaker Probe (b) Speaker Rotator - Partially Disassembled

Figure 18. Downhole Speaker Probe Components

connector at the output end of the preamplifier. The power required by the preamplifier is 1 to 2 milliamperes at 15 to 25 volts. This power is supplied by two 9 volt "transistor-type" batteries. The microphone and preamplifier are both MESA approved. A complete wiring diagram for the microphone system is presented in Figure 21.

The microphone and preamplifier are both rigidly mounted in the steel housing to provide mechanical protection during lowering. Protection from mositure and fly ash is provided without decreased sensitivity by covering the opening in the housing with a single sheet of 1 mil polyethylene plastic.

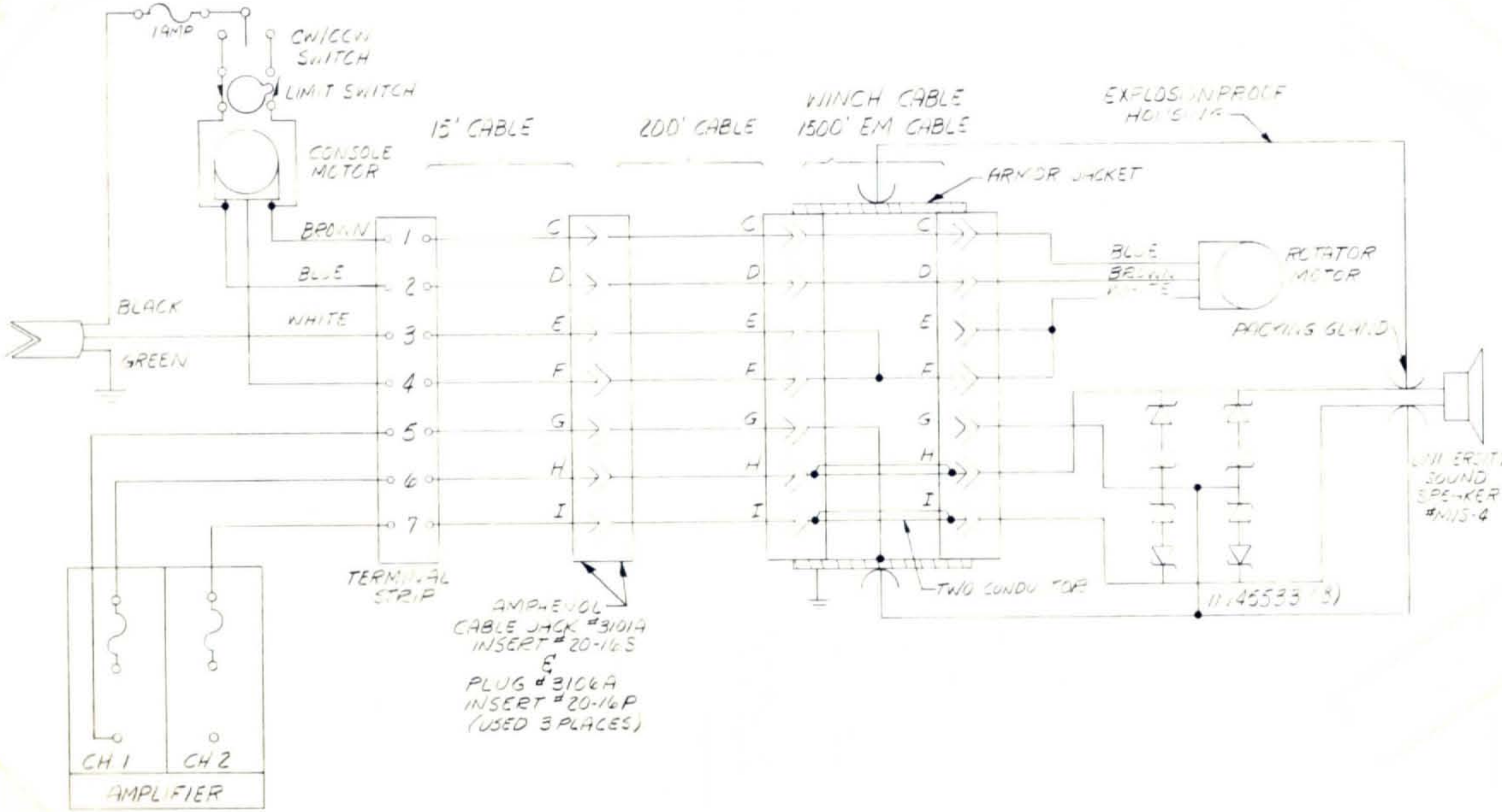

Figure 19. Wiring Diagram for Speaker, Acoustic Seal Checker

(a) Microphone Housing

(b) Microphone and Preamplifier

Figure 20. Downhole Microphone Probe Components

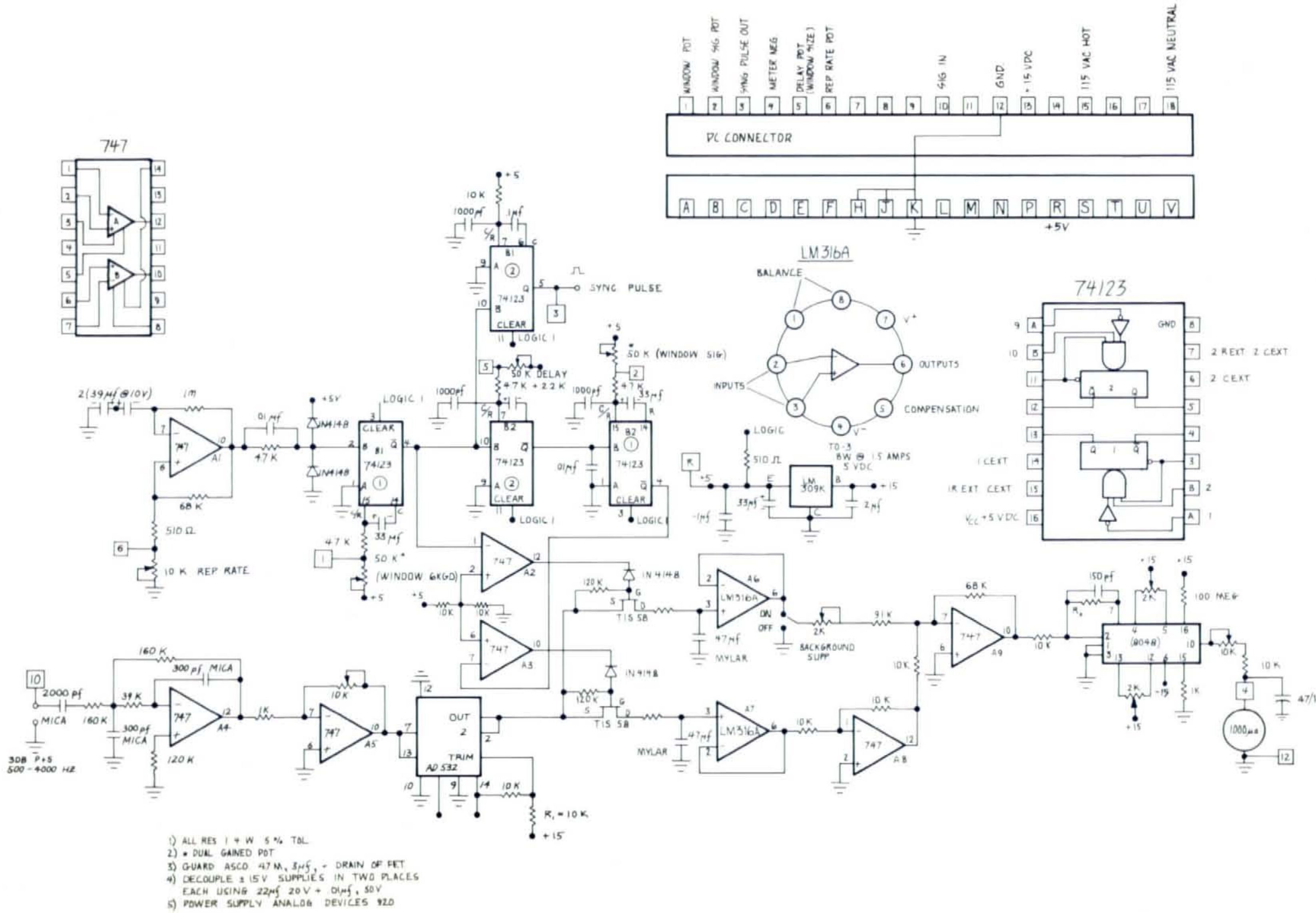

Figure 21. Wiring Diagram for Microphone, Acoustic Seal Checker

Both the microphone probe and speaker/rotator probe are suspended from Amergraph No. 7H37SB electro-mechanical cables.* These cables are identical having a total of seven No. 20 conductors wrapped in a mylar shield. A double armor covering provides protection and a 12,000 pound tensile strength. The cables measure 3/8 inch in diameter and weigh 0.241 pounds per foot.

4.1.2 Deployment System

The microphone and speaker probes are deployed using a pair of identical hydraulically powered winches. As with the preliminary probing system both a gasoline engine and an electric motor are available to power the system hydraulics. For these winches the gasoline engines are 9.2 horsepower Wisconsin units while the 440 volt 3 phase explosion proof Reliance electric motors are rated at 7.5 horsepower.*

The winch packages are skid mounted and include manually operated hydraulic booms to support the probes over the borehole. Photographs of the speaker and microphone winches are presented in Figure 22.

The winches are mounted on a single, lightweight, flatbed trailer for over the road transport. On site, they are drawn from the trailer and dragged into position at the boreholes. Figure 23 shows the pair of winches mounted on the trailer, while the sequence of Figure 24 shows the maneuvering of the winches in the field.

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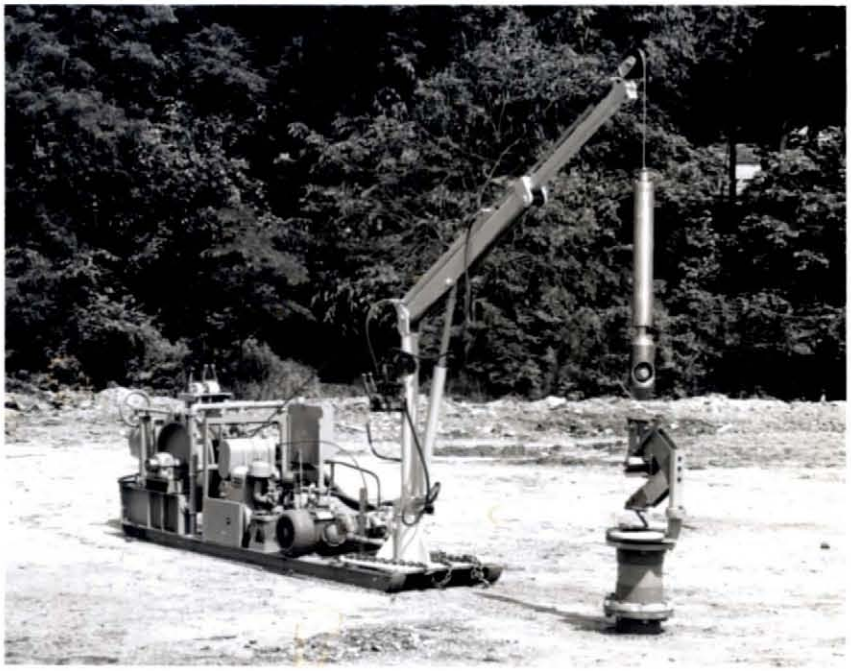

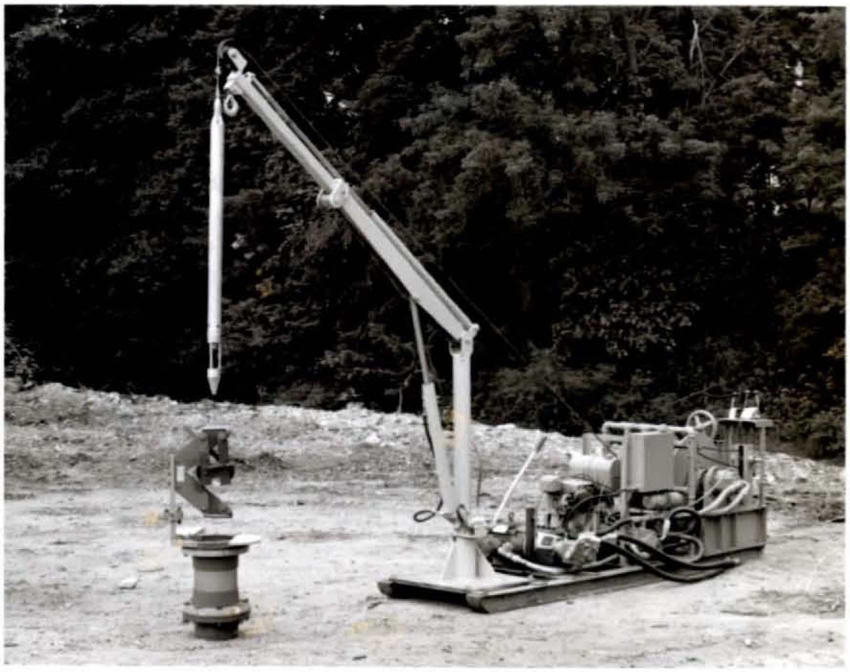

Figure 22. Speaker and Microphone Winches

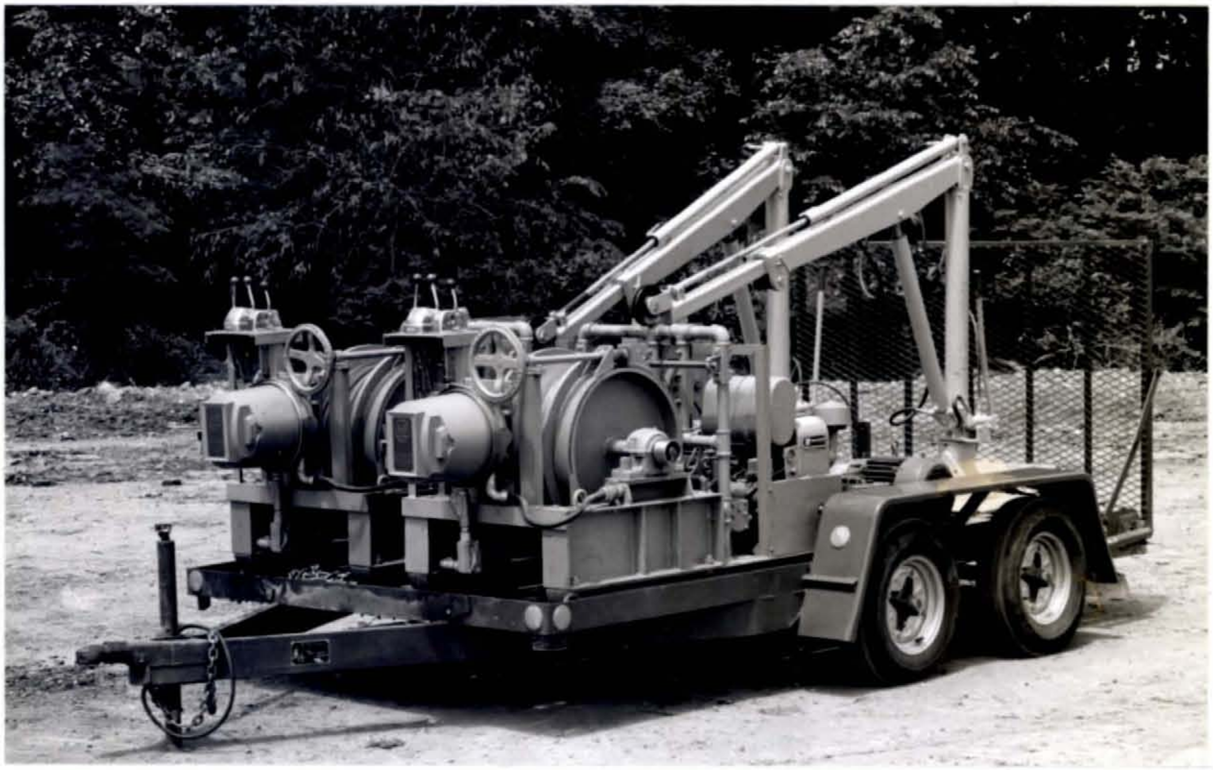

Figure 23. Seal Checker Winches on Trailer

4.1.3 Control Console

A photograph of the control console for the seal checking system is presented in Figure 25. The console includes a Testronics Pseudo-Random Noise Generator* which produces identical bursts of random noise in the 500 to 4000 Hertz range. The duration of these bursts and the time delay between bursts are adjustable. The signal from the random noise generator is fed into an 800 watt Bose Model 1801 Amplifier* which provides the signal levels required to drive the speaker through 1600 feet of cable. The output amplitude of the amplifier has been factory set to comply with MESA permissibility standards. UNDER NO CONDITIONS SHOULD THIS SETTING BE ADJUSTED.

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Figure 24. Seal Checker Movement at Site

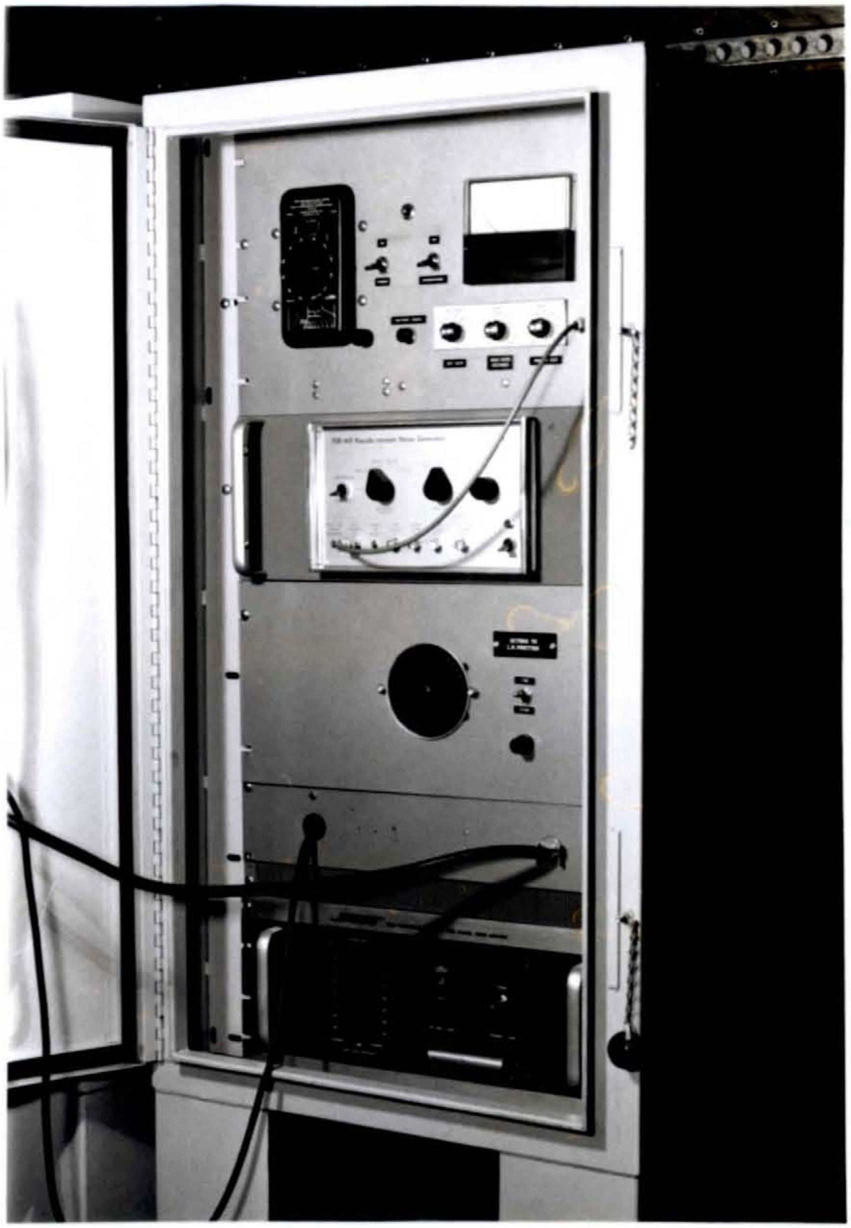


Figure 25. Acoustic Seal Checker Console

The acoustic signal from the speaker is received by the microphone and reconverted to an electrical signal. This is fed into a Scott Instrument Labs Type 452 Sound Level Meter* mounted in the control console which indicates the instantaneous level of the received signal. This signal is also processed electronically to provide an average value of the received signal intensity rather than an instantaneous level. This average value is indicated on a meter on the console.

The signal processing electronics in the console include a pulse gating network which "listens" only during the period when the signal from the speaker arrives at the microphone directly across the area to be sealed. The signal arriving along parallel but longer paths is "ignored" electronically. In addition, a background noise suppression system permits operation of the system in the presence of high but continuous ambient noise. The output meter display provides a continuous reading of the pulsed signal strength reaching the microphone, whereas the display on the sound level meter gives only an instantaneous reading of the noise level, uncorrected for background noise.

The console also includes the rotator drive and rotation indicator for speaker orientation. No compass is required since absolute orientation is of no interest. The signal received by the microphone is sufficiently sensitive to provide the feedback required for speaker orientation. The speaker position indicator does indicate that the speaker is rotating on command, however.

4.2 Seal Checker Operation

Details of seal checker operation are presented in Volume II of this report. The probes are lowered through boreholes into the mine passageway on opposite sides of the area to be sealed. The system is activated with pulse rate and duration selected based on the passage geometry. The speaker is rotated to the point of maximum sensitivity and a baseline decibel level is established.

To determine the percentage of seal completion at any time during the operation, observe the signal level on the output display and subtract this number from the original signal level. Reference to Figure 26 will yield the seal completion percentage. Knowing the original cross-section of the passage from the probing operation, it is possible to estimate the area remaining clear at any time.

4.3 System Maintenance, Inspection and Repair

Maintenance of the acoustic seal checking system is limited to ensuring that fresh batteries are installed in the console for operation of the sound level meter and microphone preamplifier. Use 9 volt "transistor" batteries.

Field repair of the system should be limited to repair of cables and cable terminations. To aid in this effort, Figures 19 and 21 show the complete wiring diagram for the speaker and microphone systems respectively.

If part of the system malfunctions or is damaged, a spare unit should be used and the defective unit sent to the USBM designated contractor for repair or replacement.

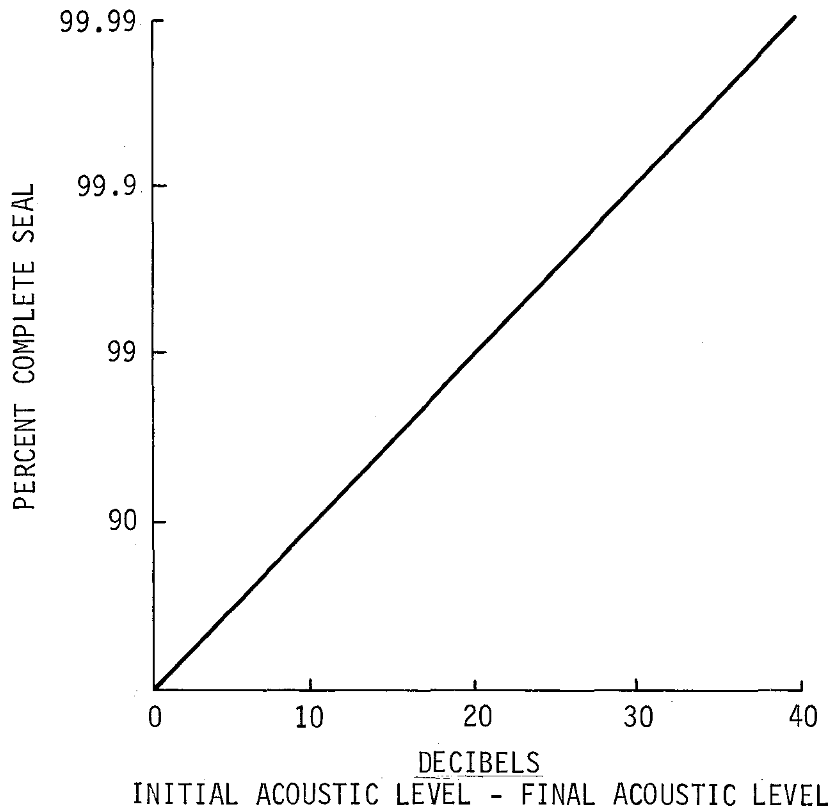


Figure 26. Calibration Curve for Acoustic Seal Checker

5. INSTRUMENT PROBE DEPLOYMENT SYSTEMS

Deployment of the preliminary probing system and the acoustic seal checking system through the boreholes is accomplished with powered winches and electro-mechanical cables. Deployment systems for the speaker probe and microphone probe are identical; the system for the preliminary probe is similar in design and operation but larger in size. The following sections describe the deployment systems and their operation in detail. Except as noted all systems are similar in design and operation.

5.1 Deployment System Description

There are three different probing systems:

- Preliminary probing system (sonar and CCTV)
- Acoustic seal checker loudspeaker
- Acoustic seal checker microphone.

The deployment equipment for each of these units are similar, consisting of the following hardware:

- Hydraulically-driven winch
- Gasoline engine and explosion proof electric motor for powering the hydraulic drive
- 1650 feet of electro-mechanical cable
- Manually-controlled telescopic boom with headsheave
- Borehole airlocks (mounted to borehole)
- Footage counter (mounted to borehole airlock)
- Trailer.

The deployment hardware is skid-mounted as an integral package (Figure 27).

The hydraulic winch packages were custom built to FMA specifications by Hathaway Machinery Co., Inc., of Fairhaven, MA. They include Sundstrand hydraulic pumps and motors, Wisconsin four-cycle gasoline engines and Reliance, 213 TC, explosion proof, 440 volt, 3 phase electric motors.*

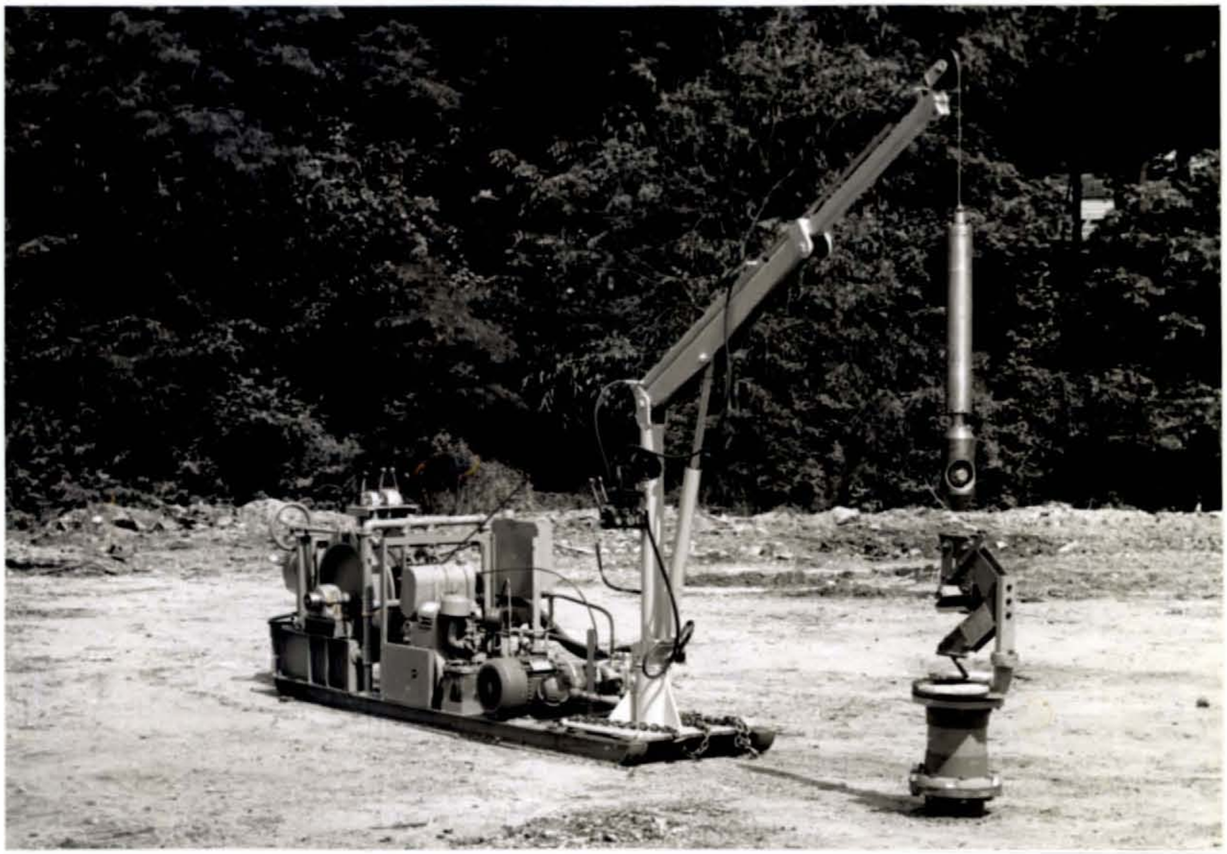


Figure 27. Small Support System, Deployed

*Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

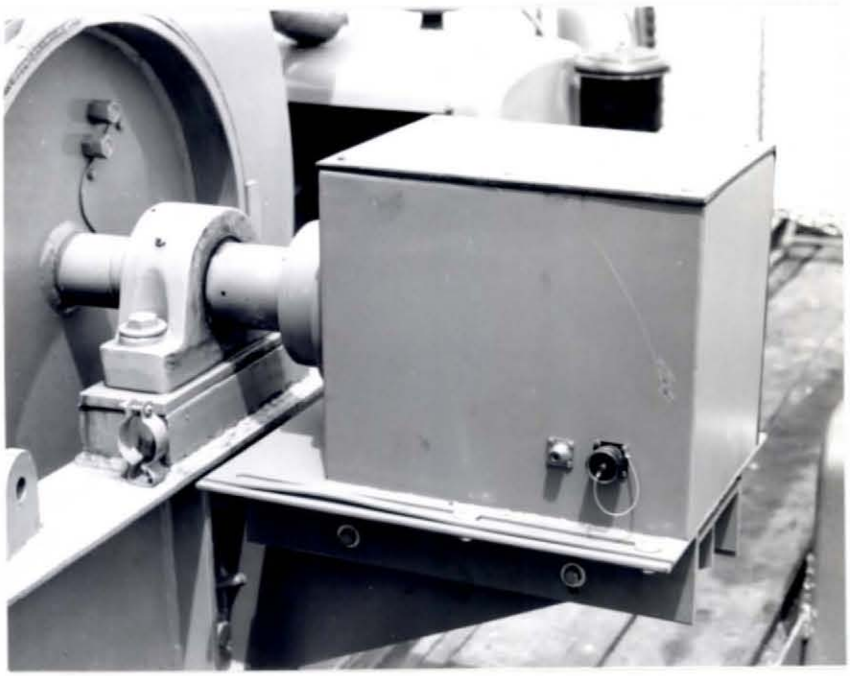
The hydraulic winch drive provides single-lever control over both the speed and direction (up or down) of the cable-lowered probe. Where a potential explosion hazard exists, the explosion-proof electric motors may be used to power the hydraulic drive. If electric power is unavailable and/or there is no explosion hazard, the gas engine would be used. The telescoping boom has a manual hydraulic pump and associated plumbing to permit positioning the headsheave at the desired position above the borehole. There is no need for an auxiliary headframe or other support equipment over the borehole for deployment to depths of 1000 feet. For deployment depths in excess of 1000 feet, the tripod assembly must be used (Figure 28a).

Slip rings illustrated in Figure 28b make it possible to operate the CCTV system while lowering the camera into a borehole. Therefore the lowering of the probe into an underground opening can be observed on the monitor.

The manual level winds, shown in Figure 29, are a subsystem of the acoustic seal checker winches. They provide means for a single operator to safely rewind the cable. Removable lights have been provided on the winches for night operation.

Air locks have been developed to prevent communication between the mine atmosphere and ambient air during probing and thus reduce the probability of an explosive methane-oxygen mixture in the borehole or immediate vicinity. They have been designed to fit 6, 8, 10, and 12 inch borehole casings. They are shown in detail in Figure 30. They bolt directly to a standard pipe flange which attaches to the top of the borehole casing. A pair of split diaphragm seals made from compliant materials isolate the borehole atmosphere from the surface under normal conditions. During instrument lowering, they open under the weight of the probe. After the probe has passed the airlock, the split diaphragms close around the electromechanical cable.

(a) CCTV Winch Tripod



(b) Slip Ring Enclosure

Figure 28. Preliminary Probing Deployment Subsystems

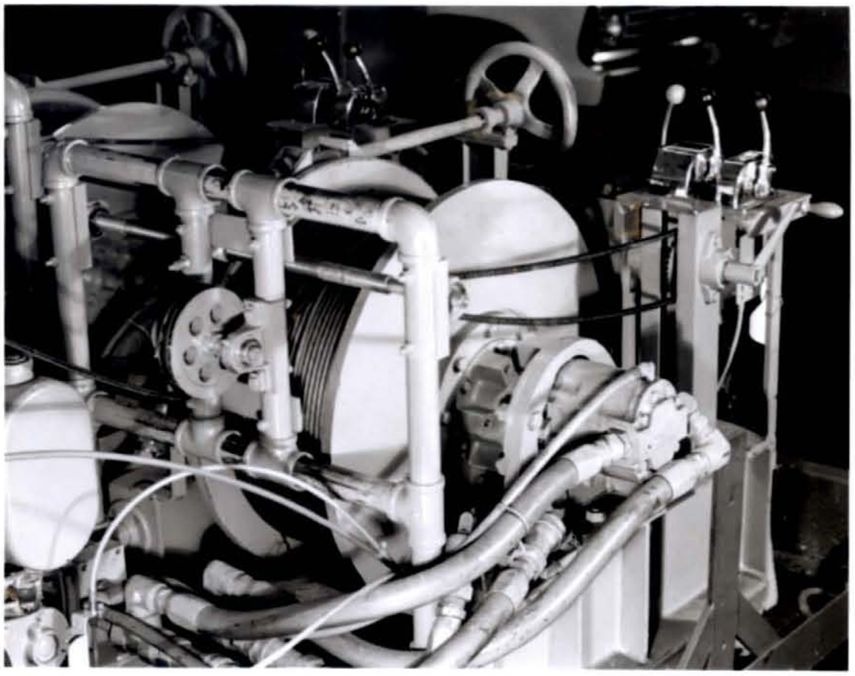


Figure 29. Manual Level Winds

(a) Airlock and Footage Counter

(b) Airlock in Use

Figure 30. Airlocks for Microphone, Speaker, and CCTV Probe

These airlocks have provision for nitrogen pressurization between the seals to provide additional isolation under extreme conditions.

A footage counter, shown in Figure 31 is provided with each winch system. They have been built by modifying a commercially available unit, Reel-O-Matic Model 1001.* The counters bolt to the top of the airlock assembly or to the borehole casing flange and monitor the vertical travel of the probe in the borehole.

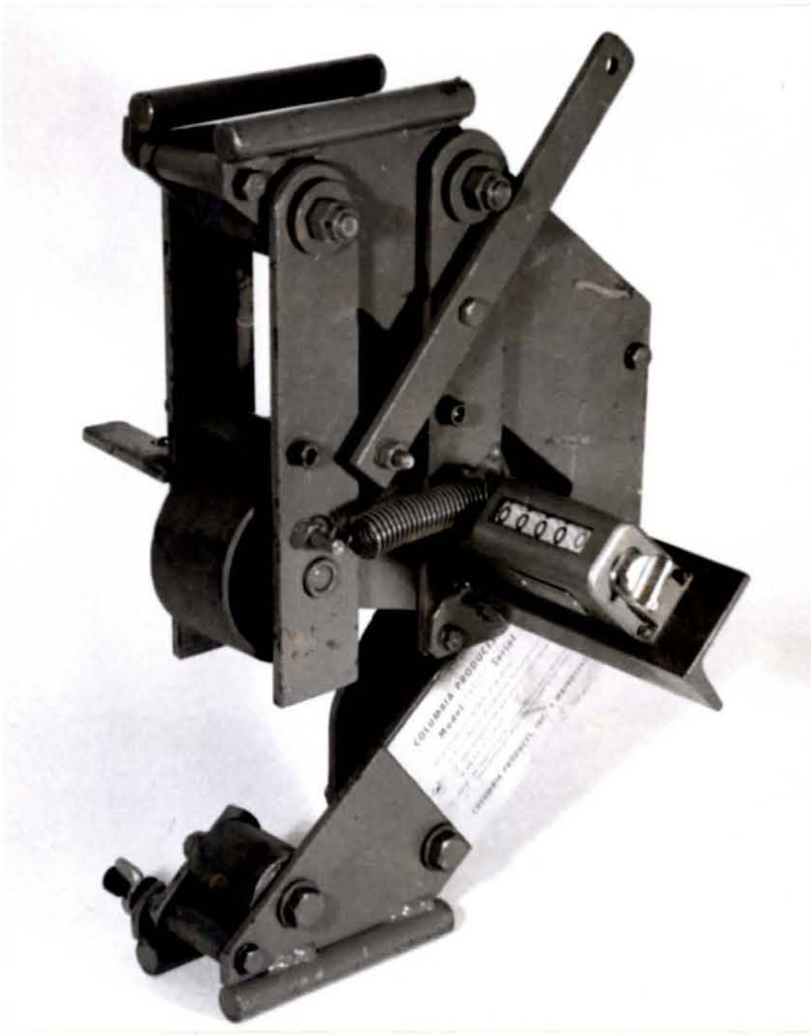


Figure 31. Footage Counter

*Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

Four identical tandem axle flatbed trailers equipped with 2 inch ball hitches have been provided for transportation of the deployment winch systems. Two trailers carry the larger winch systems used with the preliminary probe. The other trailers carry the two smaller seal checker winches side by side. The trailers carrying the winches are shown in Figure 32.

5.2 Deployment System Operation

Operation of the deployment systems is straightforward. At site, the microphone winch and speaker are removed from their trailer and dragged to their desired borehole locations with available equipment. At the boreholes, crib blocks and wedges are used to locate and level the skid as required. Several stages of this field movement are shown in Figure 24. Because of its greater size and weight the preliminary probing winch remains on the trailer at site if possible and is drawn to locations by the instrument truck.

Selection of gasoline engine or electric motor depends on conditions at the borehole and the availability of electric power. This decision must be made by mine and MESA personnel.

Details of the operation of the motors and winches are presented in considerable detail in the Operations Manual which comprises Volume II of this report.

5.3 Maintenance, Inspection and Repair

Field maintenance of the deployment systems is minimal; the required items are presented in Volume II of this report.

More extensive maintenance is required after every field exercise; this work would be performed by competent personnel under contract to the USBM.

(a) Preliminary Probe Winch

(b) Seal Checker Winches

Figure 32. Trailer Mounting of Winch Systems

Field repair will usually consist of nothing more complicated than repairing broken leads at cable terminations. For more serious problems, spare equipment should be utilized while the defective hardware is returned to the USBM - designated contractor for factory repair.

6. INSTRUMENT VAN

A custom built instrument van was prepared during this program to provide storage, transportation and a field operation center for the remote sealing instrumentation systems. The vehicle is highly mobile and self sufficient, suited for long range driving and some off road operation.

It provides towing capability for either the preliminary probe deployment system or the acoustic seal checker systems as desired. At the site it can provide the power required for the instrumentation as well as temperature control required for comfort and reliable instrument operation.

The van is described in the following section followed by a detailed description of the components and accessories normally included in the van.

6.1 Truck Description

The van is constructed around a 1975 Ford Model F-350 chassis with an enclosed cab.* A wheelbase of 161 inches and a cab to axle dimension of 84 inches was specified to accommodate the custom truck body. The truck is rated at a gross vehicle weight of 10,000 pounds.

It is powered by a 390 cubic inch V-8 engine through a manual four speed forward transmission with a limited slip differential rear axle carrying dual wheels with 7:50 by 16 inch, 8 ply tires. A 61 ampere alternator charges a 70 ampere-hour battery to provide the electrical power required for accessories and reliable cold weather starting.

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The suspension system has been stiffened in anticipation of heavy loads with heavy duty shock absorbers front and rear and 900 pound auxiliary springs. A heavy duty towing package and a custom built adjustable height hitch will assist in towing the instrumentation deployment systems. A Warner Electric Trailer Brake Unit* has been added for this purpose as well. Frame mounted tow hooks are available for field operation of the truck.

A 22.5 gallon auxiliary fuel tank with gages increases the effective range of the van. A high output heater in the cab, an AM radio and large, side mounted mirrors provides increased safety and comfort, particularly on long trips.

6.2 Van Body Description

The F-350 chassis has been fitted with a box body by Jannell in Woonsocket, Rhode Island. The inside dimensions are 12 feet long, 96 inches wide and 79 inches high at the floor of the box. Additional volume for storage is available in an extension 4 feet in length and 3 feet high over the cab. The floor is hardwood and the body finish is smooth, white enamel.

The body has been fitted with a roll up full width rear door and a curbside door with a step and louvered window with screen. An additional louvered window with screen is located opposite the door and a translucent panel is located in the roof to improve daytime illumination. The van is shown in Figure 33.

Two flutter drain valves are provided for cable access. Two fluorescent light fixtures with wall switch, three duplex receptacles, one breaker box and one outlet strip have been included.

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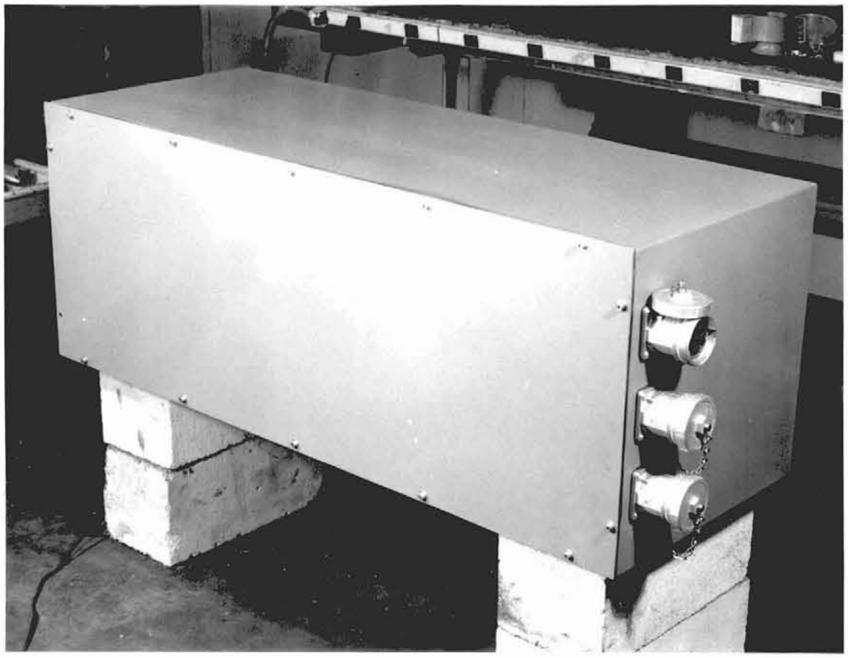
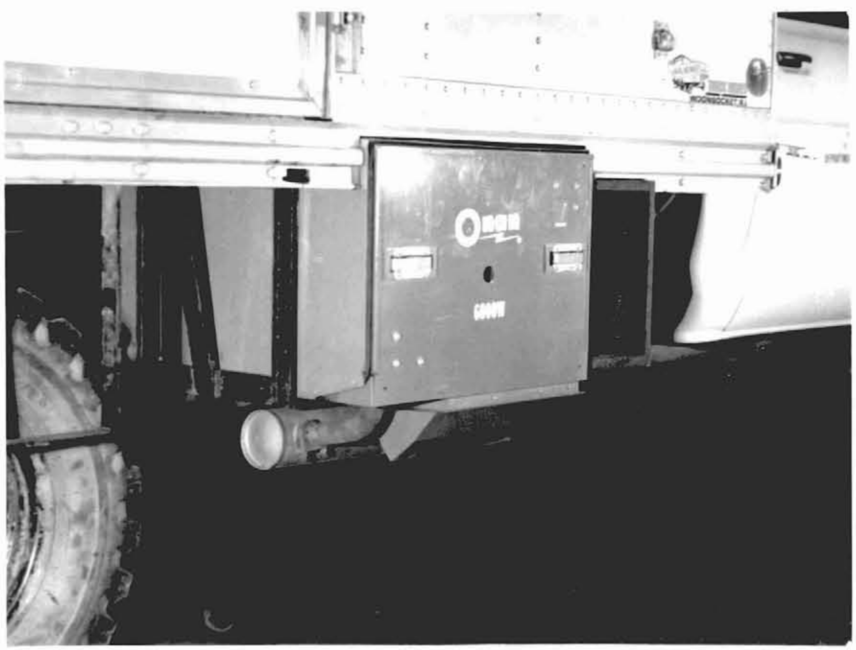
*Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

Figure 33. Instrument Van

Primary electrical power requirements for the entire instrumentation system is 3 phase 440/480 volts. This power is routed through a special distribution box, shown in Figure 34a which includes electrical phase and fault detection devices. A complete schematic diagram of the distribution box is shown in Figure 35. These devices combine state-of-the-art electrical safety components in an effort to provide a warning system when electrical problems exist. THESE DEVICES DO NOT PREVENT SHOCK HAZARDS. The distribution box also provides 30 ampere 440 Vac outlets for operation of the electric motors on the winches and 110 outlets for supply of the portable lighting equipment plus a 110 outlet for the instrument van operation. The instrument van may also be powered directly from an external 120 volt supply, or from the truck-mounted generator shown in Figure 34b.

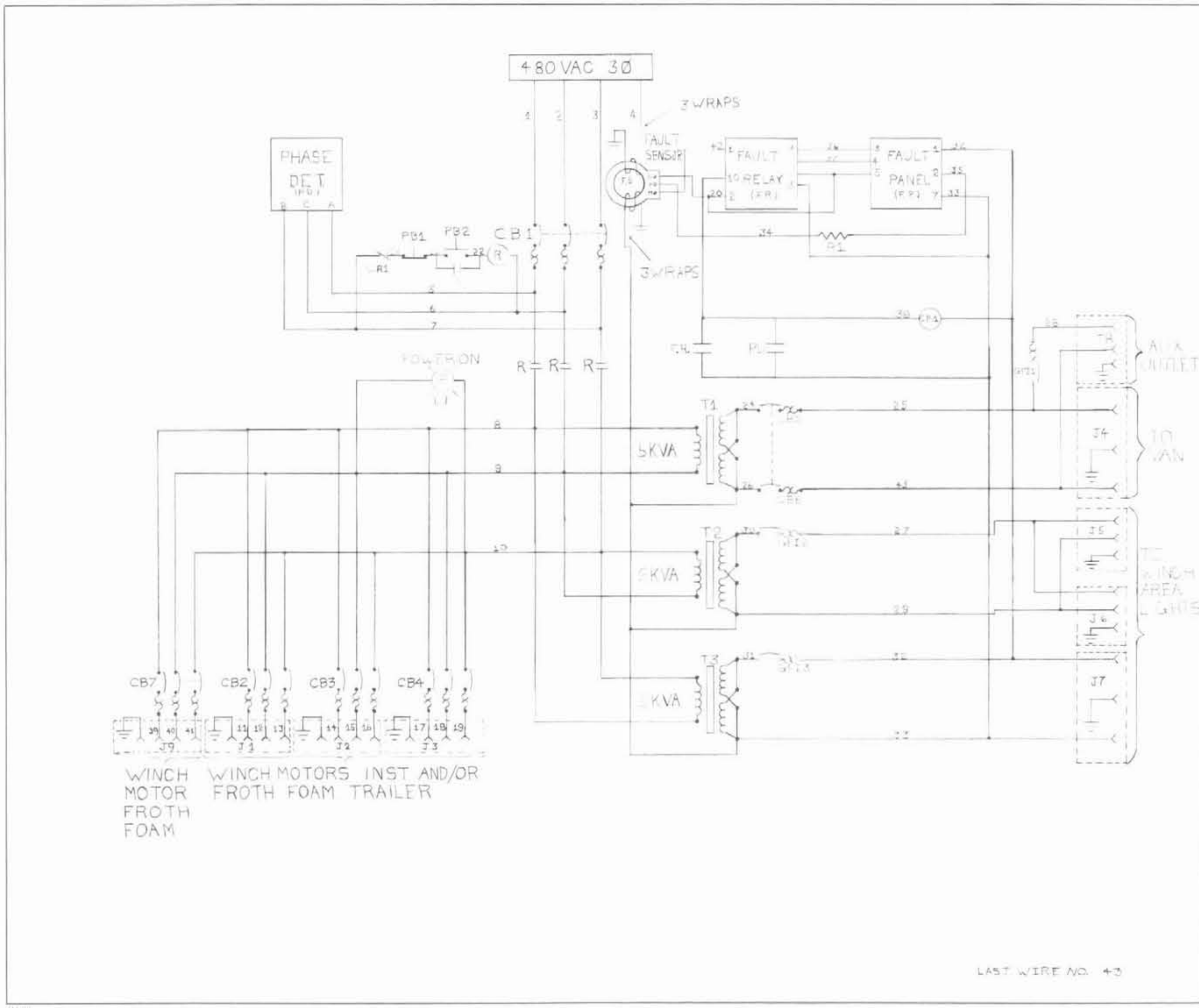


(a) Phase/Fault Detector



(b) Auxiliary Generator

Figure 34. Distribution Box and 110 Volt Generator



J8	5242	DUPLEX RECEPTACLE	BRYANT
CB7	TED134060WL	CIRCUIT BREAKER	GE
CB5-6	TQC2150	CIRCUIT BREAKER	GE 50A
CB2-3-4	FAL34030	CIRCUIT BREAKER	SQUARE D
CB1	EH3-B100	CIRCUIT BREAKER	ITE 100A
R1	VPR-5-F	RESISTOR 4KΩ	CLAROSTAT
J1-2-3-9	JRSB334H	CONNECTOR	RUSSELL-STOLL
J4-5-6-7	8304	CONNECTOR	RUSSELL-STOLL
CR1	76A86	RELAY	ALLEN-BRADLEY
GFI1-2-3	THQB1120GF	CIRCUIT BREAKER	GE 20A
LT	800TP46	PILOT LIGHT	ALLEN-BRADLEY
PB2	800TD6A	PUSH BUTTON	ALLEN-BRADLEY
PB1	800TA1A	PUSH BUTTON	ALLEN-BRADLEY
T2-3	81-2	TRANSFORMER	2KVA DONGAN
T1	81-5	TRANSFORMER	5KVA DONGAN
FP	TGSMP	PANEL	GENERAL ELEC.
FS	TGS0002	SENSOR	GENERAL ELEC.
FR	TGSR06P	RELAY	GENERAL ELEC.
PD	NOC263	PHASE DETECTOR	TIMEMARK CORP.
R	702-AC-D0B93	AC CONTACTOR	A-B 100A
ITEM/QTY	PART NO.	DESCRIPTION	SPECIFICATION

PARTS LIST

FOSTER-MILLER ASSOCIATES INCORPORATED
135 SECOND AVENUE WALTHAM MA 02154

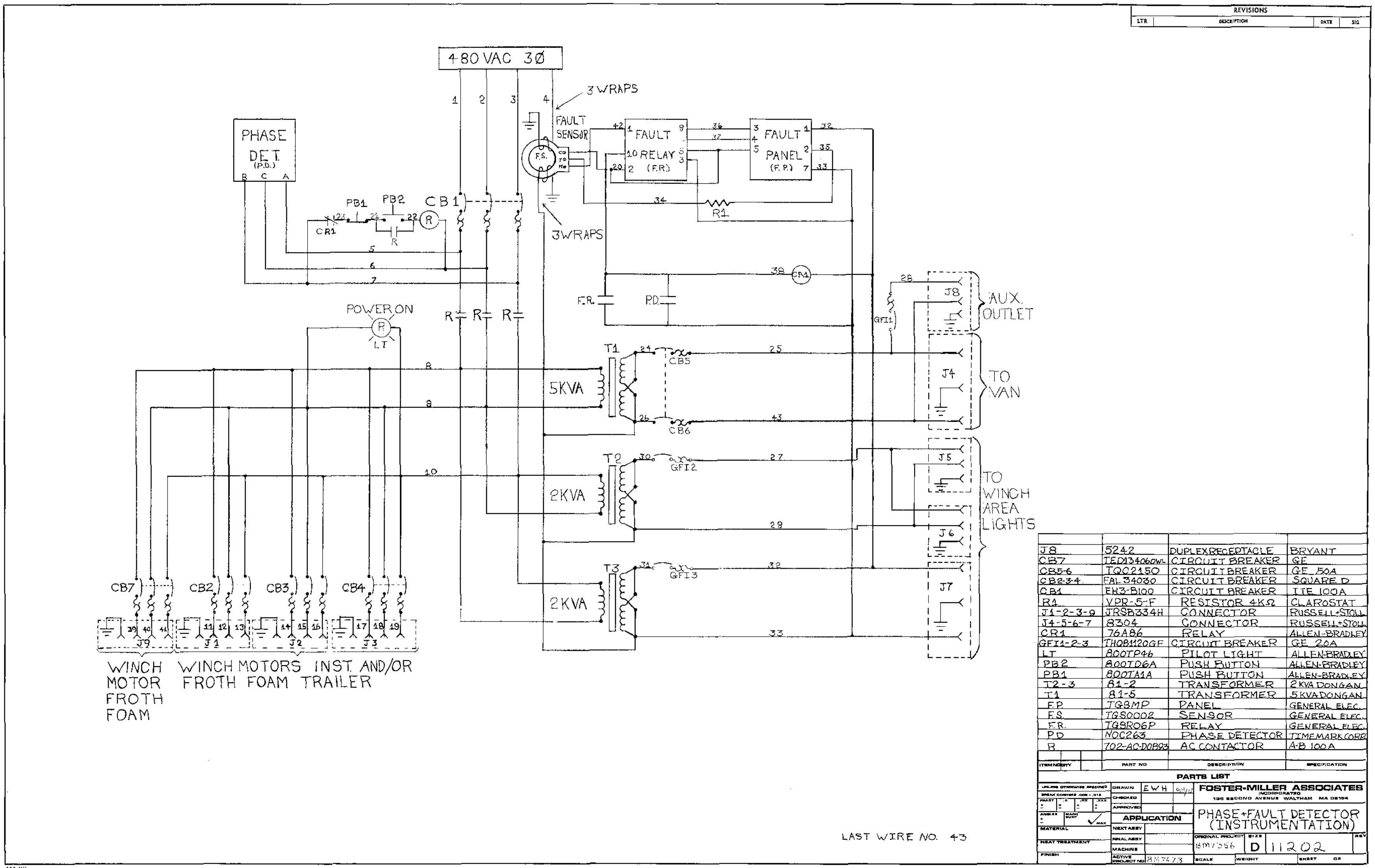
DRAWN E W H

APPLICATION

PHASE+FAULT DETECTOR (INSTRUMENTATION)

D 11202

Figure 35. Wiring Diagram of Power Distribution Box



ITEM NO	PART NO	DESCRIPTION	SPECIFICATION
J8	5242	DUPLEX RECEPTACLE	BRYANT
CB7	TED134060WL	CIRCUIT BREAKER	GE
CB5-6	TQC2150	CIRCUIT BREAKER	GE 50A
CB2-3-4	FAL 34030	CIRCUIT BREAKER	SQUARE D
CB1	EH3-B100	CIRCUIT BREAKER	ITE 100A
R1	VPR-5-F	RESISTOR 4KΩ	CLAROSTAT
J1-2-3-9	JRSB334H	CONNECTOR	RUSSELL+STOLL
J4-5-6-7	8304	CONNECTOR	RUSSELL+STOLL
CR1	76A86	RELAY	ALLEN-BRADLEY
GFI1-2-3	THQB1120GF	CIRCUIT BREAKER	GE 20A
LT	800TP46	PILOT LIGHT	ALLEN-BRADLEY
PB2	800TD6A	PUSH BUTTON	ALLEN-BRADLEY
PB1	800TA1A	PUSH BUTTON	ALLEN-BRADLEY
T2-3	81-2	TRANSFORMER	2 KVA DONGAN
T1	81-5	TRANSFORMER	5 KVA DONGAN
F.P.	TGSMP	PANEL	GENERAL ELEC.
F.S.	TGS0002	SENSOR	GENERAL ELEC.
F.R.	TGSR06P	RELAY	GENERAL ELEC.
P.D.	NOC263	PHASE DETECTOR	TIMEMARK CORP.
R	702-AC-D0B93	AC CONTACTOR	A-B 100A

Figure 35. Wiring Diagram of Power Distribution Box

The generator is an Onan Power Drawer Model No. 6 ONH-IR/9500,* rated for 50 amperes at 120 volts.

The van is equipped with a thermostatically controlled, propane fired Duo-Therm Heater, Model No. 65517-002.* The heater is a 17,000 Btu unit. The van also includes a Duo-Therm Cool Wind I Air Conditioning Unit, Model No. 54412-10,* a 14,000 Btu unit.

A small, four drawer work bench has been installed in the van and outfitted with a vise and the normal complement of hand tools required for field service of the instrumentation.

6.3 Van Equipment

A list of the electronic components, downhole probes and mechanical components available for remote sealing and normally carried in the instrument van are presented in Table 1. The preliminary probing and seal checker consoles are lashed to opposite sides of the truck at the rear where they can be operated with a minimum of effort. The consoles are shown in transport mode and in operating mode in Figures 36 and 37.

The probes are rack mounted and restrained along the left-side of the truck as shown in Figure 38. The rack supports the probes on complaint material to minimize mechanical shock. Removal of individual probes and addition of extra probes is easily accomplished.

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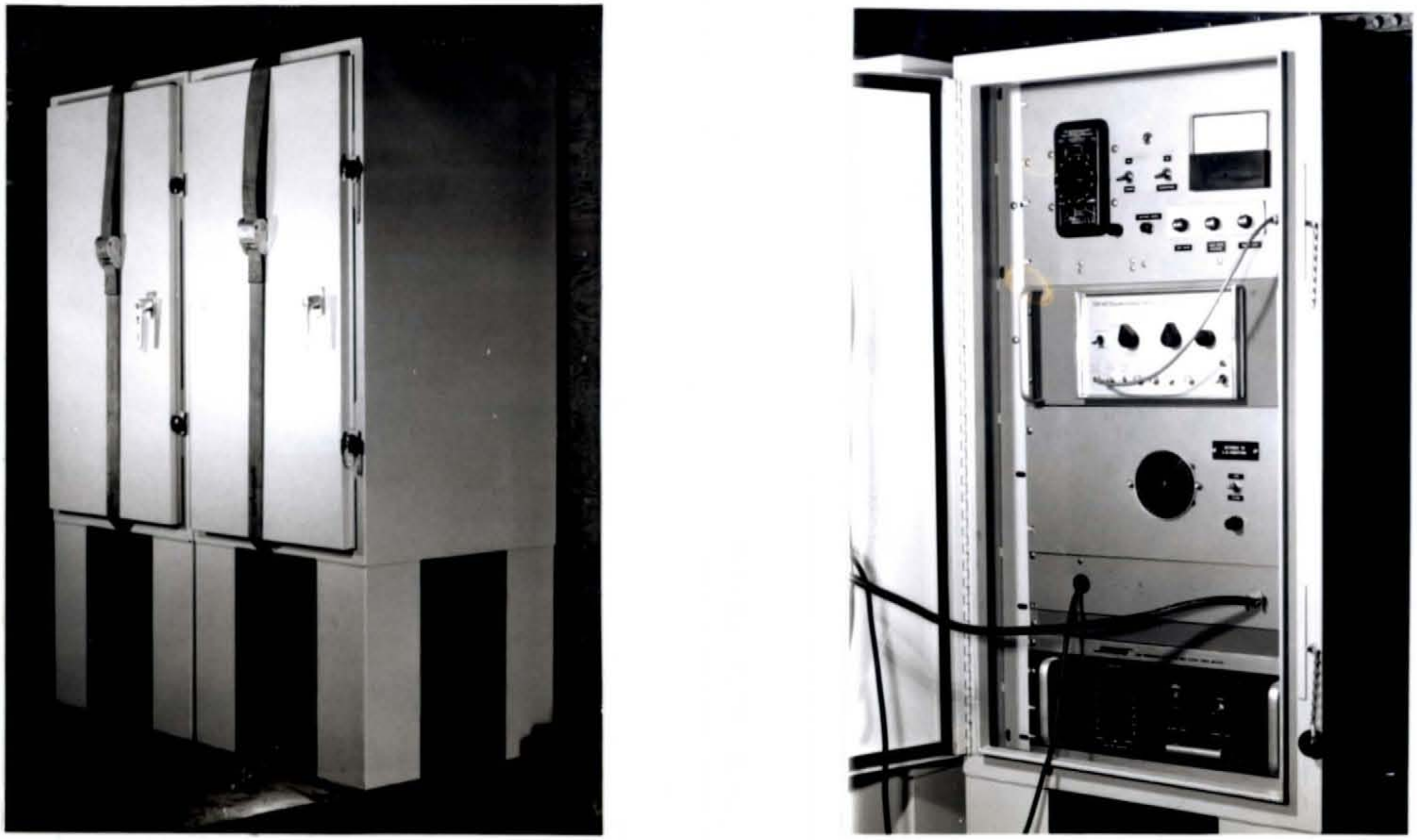
*Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

Table 1. Components Stored in Instrumentation Van

Description	Quantity
Preliminary probing consoles - CCTV, sonar and rotator and compass systems	2
Acoustic seal checker consoles - signal generator power amplifier, sound level meter, electronics	2
Preliminary probe rotators in housing	3
CCTV Camera probes in housing	2
Sonar probe in housing	3
Speaker Rotator in housing	3
Speaker in housing	2
Microphone housing - large	1
Microphone housing - small	1
Microphones	3
Preamplifiers	3
Video Tape Recorder	1
Portable CCTV system	1
Footage counters	4
Hydraulic spares - pump, motor, planetary gear	1 each

(a) Transport Mode (b) Operational Mode

Figure 36. Preliminary Probing Instrument Consoles



(a) Transport Mode (b) Operational Mode

Figure 37. Acoustic Seal Checker Instrument Consoles

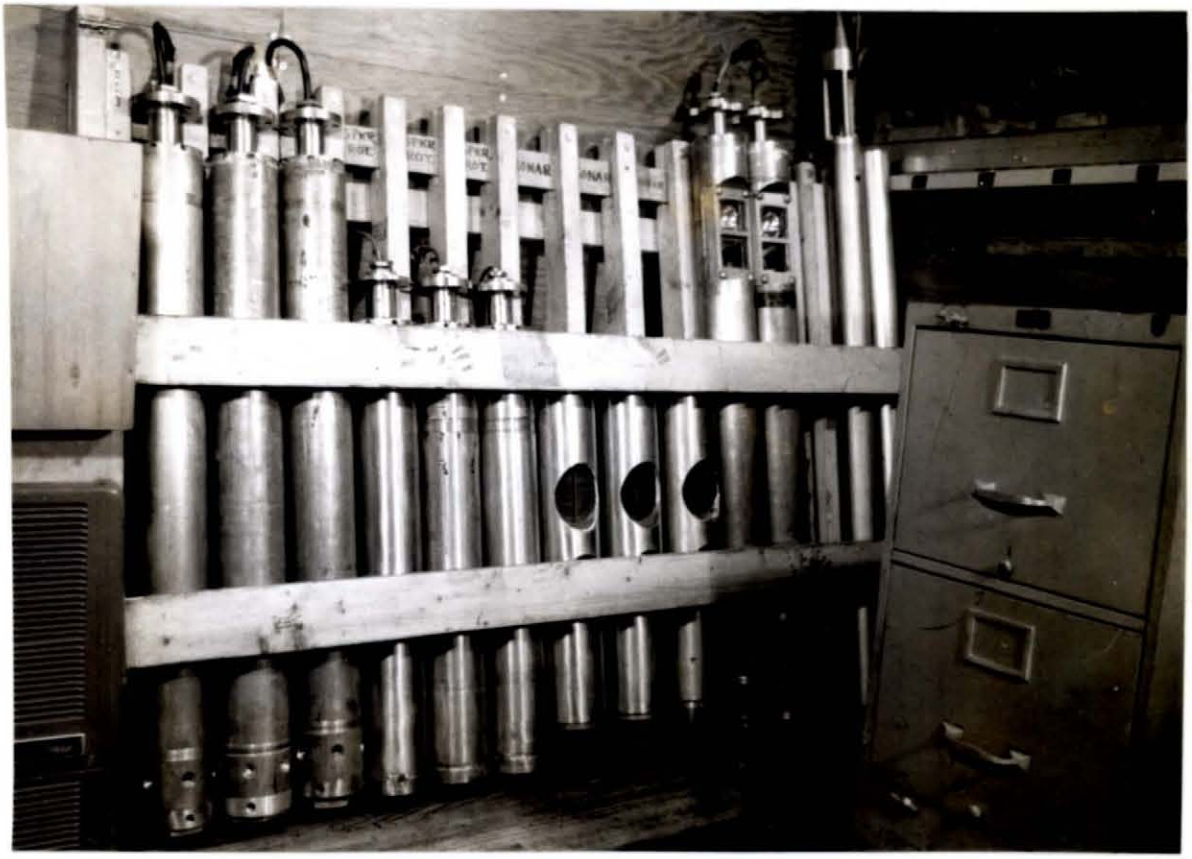


Figure 38. Probe Rack in Instrument Van

A video tape recorder is mounted adjacent to the preliminary probe console for ease in recording the CCTV output. A hinged, dustproof wooden cover has been made to permit the use of this area as a desk or storage space. It is shown in Figure 39. The portable CCTV and tape recorder are normally stored on this surface during field transport.

The footage counters and the hydraulic spares are stored in the extension over the cab as shown in Figure 40. This area also provides storage for other bulky components without restricting movement in the van or crowding the workbench area.

(a) Video Tape Recorder

(b) Recorder under Dustproof Cover

Figure 39. Video Tape Recorder Mounted in Van

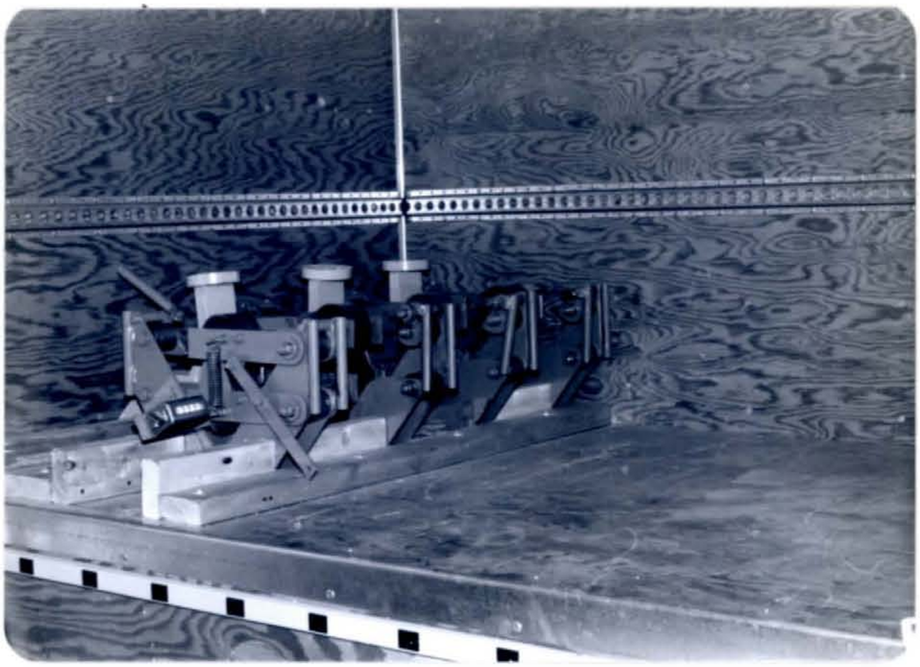


Figure 40. Footage Counters and Hydraulic Spares Mounted in Van

The van winch illustrated in Figure 41a is a Wrangler 8074 Winch* mounted on a specially fabricated bumper assembly. The winch provides additional off the road mobility and can be used to load or unload the acoustic seal checker winches from the low bed trailers.

The removable steps illustrated in Figure 41b provide additional safety and convenient access to the instrument area.

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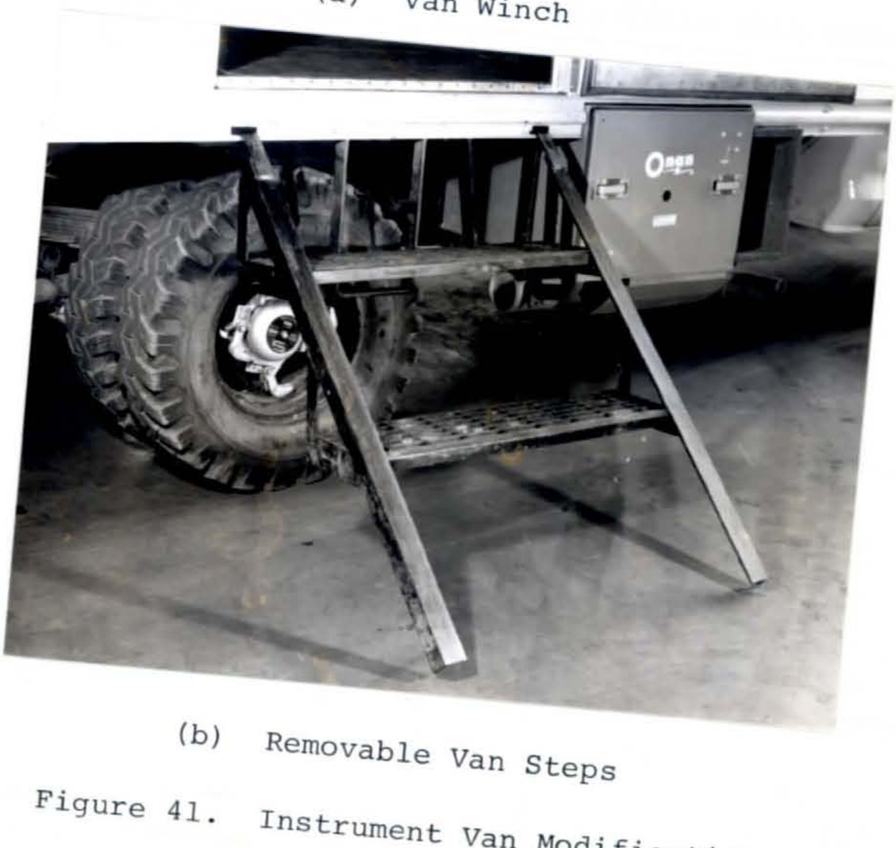
*Reference to specific trade names is made for identification only and does not imply endorsement by the Bureau of Mines.

(a) Van Winch



(b) Removable Van Steps

Figure 41. Instrument Van Modifications