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SUPPORT MANUAL
FOR
APOLLO LUNAR SURFACE DRILL (ALSD)

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FOREWORD

This document is prepared and submitted in accordance with the requirements of Contract NAS 9-6587, Article IV B. 5, 17, and Exhibit C, Paragraphs 2. 8 and 2. 14.

It includes the preliminary information established for the Apollo Lunar Surface Drill during the five month period of 26 September 1966 to 26 February 1967.

Photographs of the ALSD presented herein represent the early Development and EMI Test Model configuration. This manual will be updated when additional information and flight equipment photographs become available.

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GLOSSARY OF TERMS

ALSD	APOLLO LUNAR SURFACE DRILL
ALSEP	APOLLO LUNAR SURFACE EXPERIMENTS PACKAGE
ECS	ENVIRONMENTAL CONTROL SYSTEM
GFE	GOVERNMENT FURNISHED EQUIPMENT
GSE	GROUND SUPPORT EQUIPMENT
KSC	KENNEDY SPACE CENTER
LGE	LUNAR GEOLOGICAL EQUIPMENT
LM	LUNAR MODULE
RTG	RADIOISOTOPE THERMAL GENERATOR
SEB	SCIENTIFIC EQUIPMENT BAY

I. SUMMARY AND INTRODUCTION

1.0 GENERAL CONTENTS

The ALSD Support Manual contains the equipment descriptions, operating procedures and support instructions necessary to maintain the Apollo Lunar Surface Drill at a field level of operation. Major areas contained in the Support Manual include:

- . Equipment descriptions with major part number identifications
- . ALSD Operating Procedures
- . Service Instructions
- . KSC Prelaunch Operations
- . Transportation and storage requirements
- . Spares List

2.0 EQUIPMENT CHECKOUT AND MAINTENANCE CONCEPTS

The field level checkout and maintenance requirements for the ALSD have been minimized because of the relatively short service life, simplicity, and portability of the equipment. Elaborate GSE for the ALSD system was eliminated during concept definition. Extensive factory checkout requirements of the ALSD and the relatively short time interval between factory checkout and final prelaunch checkout and installation aboard the Apollo spacecraft at KSC provides a high degree of confidence that the equipment will function properly during the lunar mission.

Since the training model ALSD's will be subjected to greater usage than the flight models, a factory inspection and repair cycle has been established. After each ten (10) hours of field operation, the training models will be returned to the factory for detailed inspection and repairs as required. A spare parts inventory has been established to support this program.

The checkout and maintenance summary chart for both the flight and training model ALSD's is diagrammatically illustrated in Figure I-1.

3.0 SPARES

The spares provisioning and distribution system for the ALSD system is established in conformance with the checkout and maintenance concepts. Spares which are readily replaceable at the "black box" level are provided at the required field locations. Other more complex components requiring factory level installation, adjustments, and testing will be maintained in the factory GFE inventory until required. A tentative list of spares for the ALSD program is tabulated in a later section of this manual. This list may be revised if the expenditure rate during the development test program indicates that a reallocation of spares funding is desirable.

Figure I-2 diagrammatically illustrates the spares distribution system for the ALSD.

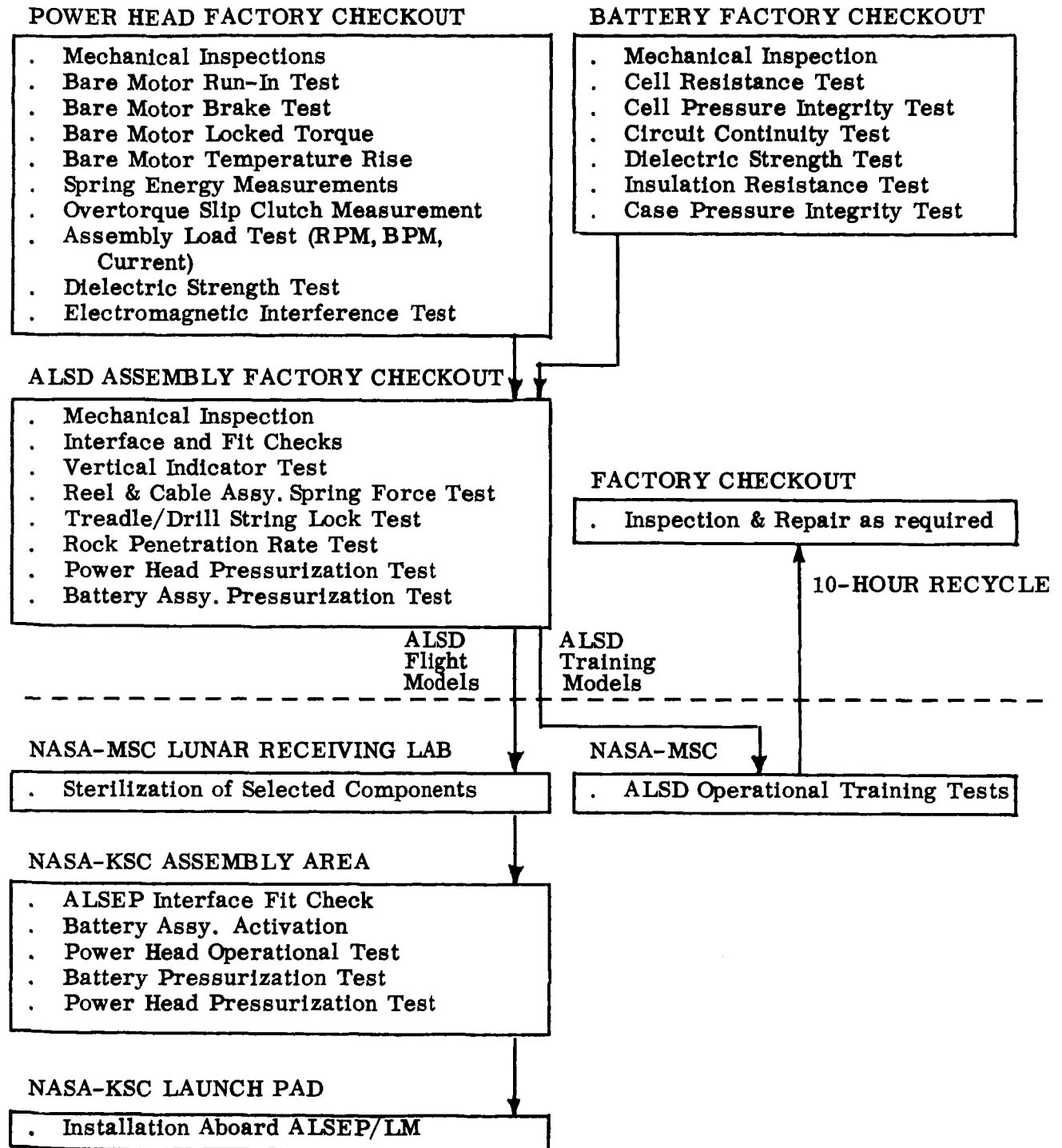


Figure I-1. ALSD Checkout and Maintenance Summary Chart

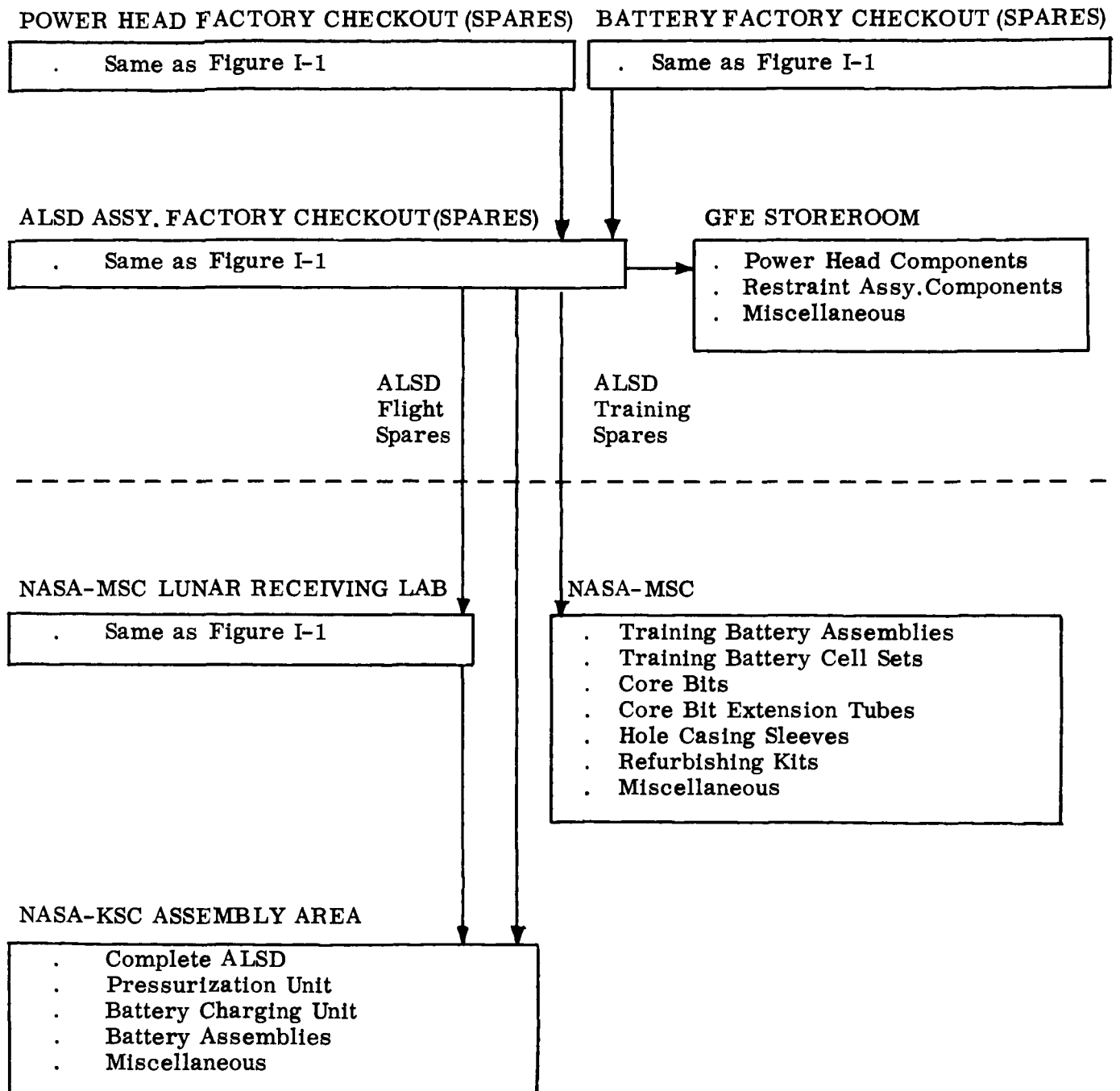


Figure I-2. ALSD Spares Distribution

II. GENERAL ALSD SYSTEM DESCRIPTION

1.0 INTRODUCTION

The purpose of the Apollo Lunar Surface Drill (ALSD) is to provide a means for a single astronaut to implant heat flow temperature probes below the lunar surface and collect subsurface cores.

The implanting of the temperature probes requires the drilling of two subsurface holes to a maximum depth of three meters. The holes are cased as necessary to prevent cave-in and to facilitate the insertion of the probes. After the probes are implanted, all drilling equipment is removed to preclude compromising the heat flow experiment.

Subsurface cores resulting from the drilling operation are to be collected over the entire length of the two holes. These cores will be removed from the drill string at the lunar location by the astronaut, representative samples selected, identified as to their original vertical orientation with the lunar surface, packaged, and stowed in the Sample Return Container for return to earth.

The drilling device which will be employed to produce the lunar subsurface holes is a hand-held, battery-powered, rotary-percussion drill. The rotary-percussion drilling principle was selected for this application because: (1) the axial bit pressure and rotary torque requirements for efficient drilling are considerably less than that required for rotary drilling; (2) the drill bit operating temperatures are sufficiently low to preclude the requirement for a drill bit coolant such as air or water; and (3) the tungsten-carbide bit cutters will drill with reasonable efficiency in the presence of a small dust layer in the bottom of the hole which is inherent with a mechanical cuttings transport system.

The ALSD is designed as a totally integrated system which interfaces with the ALSEP pallet located in the Lunar Module Scientific Equipment Bay during transit from earth to the moon's surface. The drill, with its various subsystems, can be removed as a single package from the ALSEP pallet and transported by the astronaut to the selected drilling site for subsequent assembly and operation.

The ALSD is capable of core drilling a 1.032 inch diameter hole in high density basalt at rates up to two inches per minute, or in 50 percent porosity rock up to six inches per minute.

The reliability design goal of the ALSD is 0.99, however, should a failure occur, a hand augering mode is provided to permit limited manual drilling in low density lunar materials.

The ALSD is pictorially illustrated in Figure II-1 and diagrammatically illustrated in Figure II-2. A brief description of the ALSD subsystems follows.

2.0 BATTERY PACK SUBSYSTEM

The battery pack subsystem consists of a magnesium case which houses the silver zinc battery cells and power switch for supplying and controlling the power to the ALSD power head subsystem. The battery case is sealed and pressure regulated

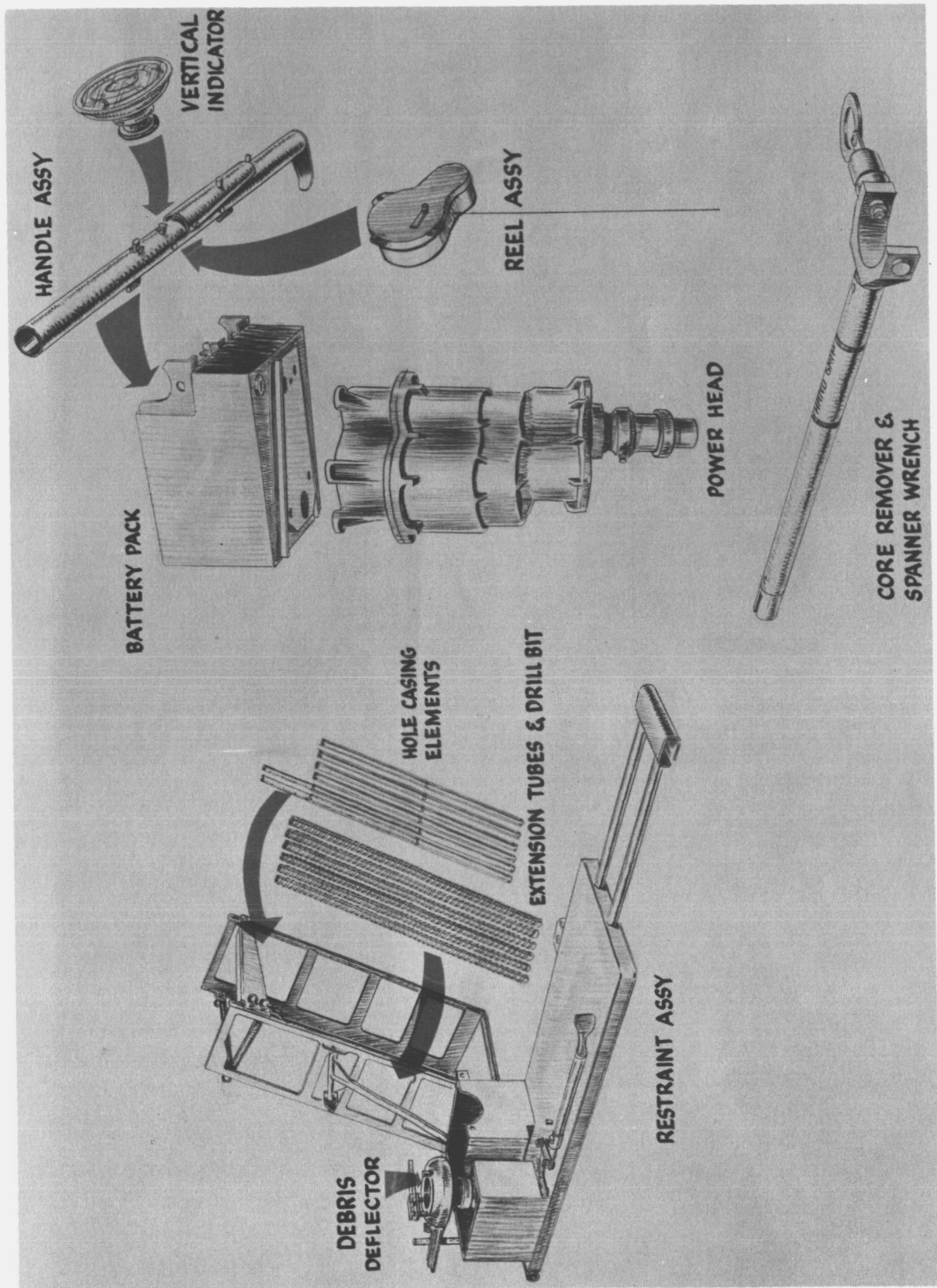


Figure II.1 ALSD Representation.

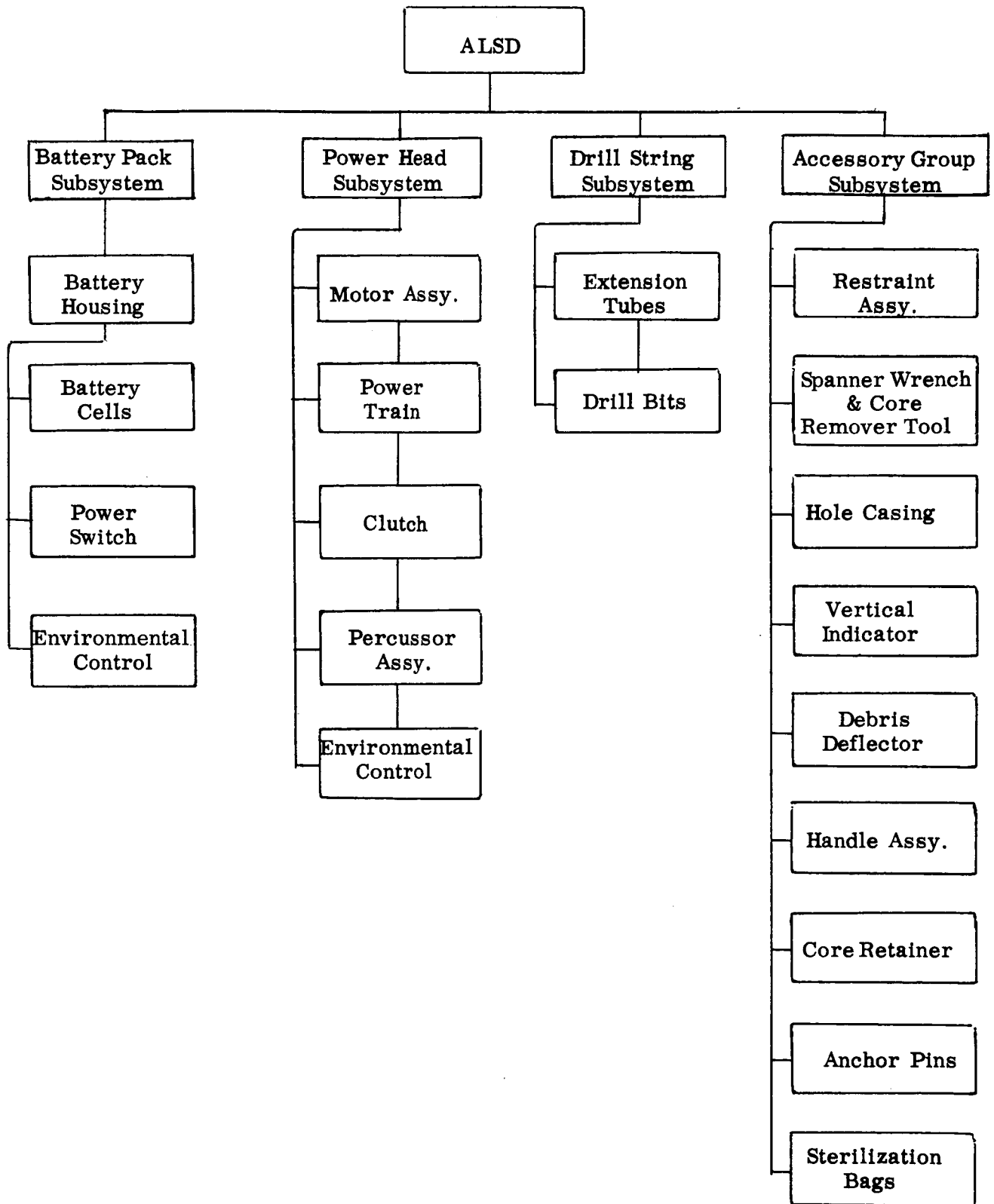


Figure II. 2 ALSD General Subsystem Breakdown

by a relief valve for environmental control under lunar mission conditions. A thermal coating is applied to the outer surfaces of the case.

3.0 POWER HEAD SUBSYSTEM

The power head subsystem is a self-contained device which converts the electrical energy supplied by the battery pack into mechanical energy for transmission to the drill string subsystem. The power head interfaces with the battery pack and drill string subsystems. For environmental control purposes, the power head housing is sealed and pressure controlled. A thermal coating is applied to the outer surfaces of the power head.

4.0 DRILL STRING SUBSYSTEM

The drill string subsystem consists of several lengths of tubing, a carbide cutter, and a flute-type dust transport system which is integral with the drill bit and extension tubes. The primary purpose of the extension tubes is to provide a means of transmitting the mechanical energy from the power head to the drill bit.

The drill string sections are added as required during the drilling operation. The drill bit provides the capability for cutting into various surface materials and producing, in addition to a hole, a core sample of the material being drilled. A core retainer inside the drill bit is employed to keep the core from falling back into the hole when the drill string is raised. Cuttings generated during drilling are transported up the hole by the transport system. This system consists of helical flutes on the exterior surface of the extension tubes and drill bit, and functions only when the drill string is rotating.

5.0 ACCESSORY GROUP

The accessory group includes items necessary for the success of the mission, but are not included as a subsystem of the basic drill. Items included in this group are: 1) restraint assembly, 2) cuttings collector, 3) hold-down anchor, 4) core remover, 5) hole casing, 6) vertical indicator, 7) debris deflector, 8) sterilization bags, and 9) handle assembly. A listing and description of each is provided in Section III of this manual.

6.0 LOADING AND UNLOADING

6.1 Loading - The ALSD system will be installed on the ALSEP Pallet in the LM Descent Stage SEB during the prelaunch operations.

6.2 Unloading - The ALSD is designed to be unloaded from the LM Descent Stage by one man and can be unloaded either independently or together with the Apollo Lunar Hand Tools or Apollo Lunar Surface Experiments Package (ALSEP).

6.3 Handling - The small size and weight of the packaged ALSD (approximately 7 inches by 9.6 inches by 22.68 inches; 26 pounds) permits handling for loading and unloading without the need for special handling equipment.

7.0 GROUND SUPPORT EQUIPMENT

The GSE for the ALSD is limited to three major items including a battery charging unit, pressurization unit, and ALSD transport and stowage case.

7.1 Battery Charging Unit - This equipment is employed predominately for recharging of training model battery assemblies. It can also be employed for "topping off" the charge on flight model batteries if required by unscheduled delays during launch countdowns. The unit consists basically of the circuitry and automatic controls necessary for converting 115V, 60 cps power into the low level direct current voltage required for battery charging.

7.2 Pressurization Unit - Both the battery assembly and power head of the ALSD are pressurized for use on the lunar surface. The pressurization unit is used to verify seal integrity and proper operation of pneumatic relief valves during factory and pre-launch testing.

7.3 Transport/Stowage Case - This equipment, which is essentially a modified aluminum suitcase, provides a convenient means for transporting the ALSD. The internal volume of the case is foamed to form-fit the ALSD to prevent damage.

III. ALSD DEVELOPMENT AND EMI TEST MODEL EQUIPMENT DESCRIPTION

A detailed description of the Development and EMI Test models follows. Figures III. 1 through III. 12 pictorially illustrate the ALSD subsystems.

1. 0 BATTERY ASSEMBLY SUBSYSTEM (TRAINING MODEL)

1. 1 General - The purpose of the battery assembly subsystem is to provide the electrical power necessary for operating the power head motor. It has the capability of being detached from the power head for activation, checkout and recharging. It comprises as major components a case, cells, power switch, electrical connector, pressure relief valve, and mounting brackets for the handle/reel assembly. All components have been designed for an optimum performance-to-weight ratio.

1. 2 Component Description

1. 2. 1 Case - The battery case consists of a stainless steel enclosure 6.28 inches by 5.86 inches by 3.9 inches, with provisions for a pressure relief valve, electrical receptacle, and power switch. Integral with the case are brackets for securing the case to the power head and the portable handles to the case. The top of the case incorporates bullet pin receptacles for securing the ALSD system to the ALSEP pallet during training exercises, and an access cover for battery activation. The case material provides shielding of active circuit elements and conductors for containment of potential electromagnetic interference radiating sources. The construction of the case is sufficient to support a pressure in excess of 5 psia in addition to the previously mentioned interface assemblies.

1. 2. 2 Battery Cells - The battery cell assembly is a rechargeable primary silver oxide-zinc battery consisting of sixteen cells (Yardney HR 5 DC-12X1) for a nominal output of 23.0 ± 1 VDC capable of delivering 18.75 amperes for sixteen minutes. Each cell has a vent valve to maintain cell pressure to safe limits while allowing relief of any excess gases. The dry charged battery is activated by filling the cells with a potassium hydroxide electrolyte.

1. 2. 3 Power Switch - The power switch is a single pole, single throw, heavy duty microswitch with a push-to-activate mechanism. The switch portion of the assembly is contained by the battery case with the push-to-activate mechanism protruding through the case for external operation. Seal integrity is maintained by means of an APM Hexseal boot. The Hexseal boot in turn interfaces with the handle trigger lever mechanism when the latter is installed on the battery pack.

1. 2. 4 Electrical Connector - The electrical connector is necessary to permit decoupling of the electrical power circuit when the battery pack subsystem is removed from the power head subsystem. The connector is a female, hermetically sealed, two pin, factory assembled unit. The shell of the connector is overlapped by the shell of the male connector on the power head when joined. This overlap serves as shielding to contain any electromagnetic interference emanating from the conductors. Case/connector seal integrity is maintained by a preformed "O" ring.

1. 2. 5 Pressure Relief Valve - The pressure relief valve is necessary to maintain an absolute pressure of 5 psi in the battery case to preclude electrolyte vaporization and to retain the nitrogen thermal medium during vacuum tests. The battery does not require pressurization during normal earth ambient training exercises.

1.2.6 **Handle Mounting Brackets** - The handle brackets extend from the battery case and are used to support the ALSD handle assembly during ALSD operation. Due to spacecraft stowage volume limitations, the handle is stowed separate from the mounting brackets during transit to the lunar surface. This function is retained on the Development and EMI Test models.

2.0 POWER HEAD SUBSYSTEM

2.1 **General** - The Power Head Subsystem converts the electrical energy from the battery pack subsystem into mechanical rotary-percussive energy for delivery to the drill string subsystem. A rotary-percussive ratio has been selected which will provide the ultimate in drilling efficiency consistent with the life parameters of the drill bit. The power head is self-contained by a round cast aluminum housing which will operate in any position and which interfaces with the battery pack subsystem and drill string subsystem. The power head is mechanically more complex than the other subsystems involved. However, only those components of importance in effecting a clear understanding of power head operation, such as motor, power train, clutch, percussor and environmental controls, will be discussed.

2.2 Component Description

2.2.1 **Motor Assembly** - The motor used in the power head is a 0.4 horsepower, brush commutated, direct current device employing as its field a permanent magnet for maximum reliability and efficiency. The armature is wound with copper wire with a coating possessing high temperature operating characteristics, and its shaft hollowed to minimize weight. Nominal speed of the armature is 9,300 rpm at 18.75 amperes d. c. A reduction gear couples the output shaft of the motor to the power train.

2.2.2 **Power Train** - The power train, driven by the motor, consists of reduction gears which provide the desired proportions of rotary motion and percussive action; 280 rpm at 2,260 blows per minute at the output shaft. Friction between the gear surfaces is minimized by a special Teflon base lubricant.

2.2.3 **Clutch Assembly** - The clutch assembly limits the torque load to a level which can be safely controlled by the astronaut. The clutch is designed for a nominal slip value of 20 foot-pounds, but can be preset to other values commensurate with the restraining capacity of the operating astronaut. The clutch assembly consists of a metal disc sandwiched between two bronze discs. Friction between the discs is maintained by a preloaded spring. The clutch assembly interfaces with the power train and the percussor assembly.

2.2.4 **Percussor Assembly** - The percussor assembly converts the uniform rotary output motion of the power train into pulsating, high energy, short duration, linear impact blows to the output shaft of the power head. The impact action is accomplished by a rotating cam against a cam follower, which also serves as the hammer. As the cam rotates, the follower raises, cocking a spring. The spring, by virtue of the cam shape is allowed to release its kinetic energy rapidly, thereby accelerating the hammer toward a transition section. This transition section or power head output shaft serves as the anvil for the hammer and as the receiver for the rotary motion output of the power train.

2.2.5 **Environmental Control** - Environmental control of the power head is accomplished passively. The environmental control elements consist of a sealed aluminum housing containing nitrogen or air under pressure, a laminated aluminized mylar shield,

insulating bushings, and a pressure relief valve. The nitrogen or air under pressure serves as a heat transfer medium for transferring internally generated heat to the walls of the housing. A small fan installed on the motor armature shaft increases the turbulence within the housing thus improving the efficiency of the heat transfer gas medium. Pressure is maintained by a pressure relief valve which permits outgasing when the differential pressure exceeds 25 psi. The aluminized mylar shield and thermal isolation bushings are employed between the power head housing and the battery pack housing to prevent the battery pack from absorbing heat generated by the power head through radiation or conduction.

Pressure integrity of the power head is maintained by nine static seals, one linear bellows dynamic seal, and two rotary dynamic seals. The static seals are employed between the three outer housing sections, and on the various components such as the electrical connector, pressure relief valve, and lubrication ports. The dynamic seals are employed with the rotary percussion output shaft. The aluminum housings are internally impregnated with a polyester resin to preclude leakage of the pressurizing gas.

3.0 DRILL STRING SUBSYSTEM

3.1 General - The drill string subsystem couples the rotary-percussive energy at the output of the power head to the drill bit. The drill string subsystem consists of a transport system, extension tubes, coupling joints, and a drill bit.

3.2 Component Description

3.2.1 Transport System - The transport system consists of helical flutes machined into the outer wall of the extension tubes and drill bit. The clockwise direction of the flutes is compatible with the direction of rotation of the power head so that the cuttings are carried up the hole to the surface.

3.2.2 Extension Tubes - The drill bit extension tubes are fabricated from steel tubes. Six tubes, 22 inches long and approximately one inch in diameter are required to drill a 3-meter hole. The inside diameter of the extension tubes are maintained throughout the assembled drill string to permit coring and collection of the entire three meters of sub-surface material.

3.2.3 Drill Bit - The drill bit is fabricated from a cylindrical steel matrix with four tungsten-carbide cutter tips brazed into the lower cylinder face. The upper face of the matrix is fitted with a thread to mate with the drill bit extension tubes. The drill bit produces a hole 1.032 inches in diameter and a core approximately 0.802 inch in diameter, and is designed to accomplish a complete mission cycle without replacement.

4.0 ACCESSORY GROUP

4.1 General - The accessory group includes items which are essential to the success of the mission but are not included in the basic drill subsystem. The components comprising the accessory group have been designed to provide the broadest coverage possible to ensure the success of the mission. It is possible, depending on the surface composition at the drilling site, that some of the accessories will not have to be used. The significant components of the accessory group are: 1) restraint assembly; 2) cuttings collector; 3) holddown anchor; 4) core remover; 5) hole casing; 6) vertical indicator; 7) debris deflector; 8) core catcher; and 9) handle assembly.

4.2 Component Description

4.2.1 **Restraint Assembly** - The restraint assembly in the folded configuration provides the structure and container in which the ALSD subsystems are secured during the stowage and transportation modes. In this packaged configuration, the restraint assembly also serves as a mounting interface between the ALSD pallet and the LGE and includes the ALSD storage and carrying provisions. Removal of the ALSD system from the LM SEB is accomplished by means of a bullet pin release device.

In the operational configuration, a section of the restraint assembly which restrains the drill string subsystem and accessories is pivoted to the vertical position for easy access by the astronaut. A treadle is provided that extends in length from approximately 22 inches to 32 inches on which the astronaut can stand to increase the pressure on the drill bit. This increased pressure is necessary to compensate for the reduced weight of the astronaut on the lunar surface. Coupling between the treadle and the cable storage reel on the handle assembly is accomplished by a lightweight cable. Foot pressure applied to the treadle is transmitted through the cable to the operating handle and down to the drill bit.

Two modes of treadle operation are provided; an "open" and "closed" loop. The "open" loop mode consists of using the treadle as a lever pivoted at the rear on the lunar surface which allows the astronaut to apply approximately 75 percent of his lunar weight (30 pounds minimum) to the drill bit. The alternate "closed" loop mode requires the astronaut to drive a small diameter anchor pin into the bedrock prior to the primary drilling operation. In this mode, the treadle is pivoted at the anchor pin, and the mechanical lever ratio permits bit pressures of 50 to 70 pounds to be obtained by the astronaut.

Integral with the treadle is a hole guide to prevent lateral movement of the drill bit prior to surface penetration, a cuttings collector box which stores the cuttings brought to the surface by the drill string transport system, and a foot-operated drill string locking device which is used in conjunction with the spanner wrench for disassembling drill string coupling joints.

4.2.2 **Spanner Wrench and Core Remover Tool** - Removal of core samples from the extension tubes is accomplished by means of a core remover. Frequently during removal of the core from the drill string, pieces of core and dust cause a slight jamming of the larger core samples. The core remover, which consists of a thin, 22-inch rod, is used to ram the cores from the tubes. The handle of the core remover serves as a spanner wrench used in conjunction with the treadle lock for disassembly of the drill string coupling joints. In the spanner mode, the push rod portion of the core remover becomes the spanner handle, and because of its length, adequately provides the leverage needed to loosen the coupling joints. The tool is also used for disassembly of the integrated ALSD in the stowage configuration and for securing the handle assembly to the battery assembly.

4.2.3 **Hole Casing** - To prevent cave-in of the hole which would jeopardize the emplacement of the heat probe, a series of thin-walled (.004-inch), fiberglass tubes are inserted down the hole concurrently with drilling. Sufficient casing clearance exists as a result of the drill bit cutting kerf and slight eccentricities of the hole during the drilling process.

4.2.4 Core Retainer - The core retainer is necessary to prevent the core contained within the drill string subsystem from falling back into the hole when the drill string is removed. It consists of a spring steel with flexible prongs, and is installed internal to the drill bit. The design of the core retainer is such that it permits core material to pass upward through the retainer but restricts core material from passing downward.

4.2.5 Vertical Indicator - The vertical indicator is a device to measure the degree of slant from lunar vertical of the drilled hole to a maximum of 15 degrees. The indicator consists of a concave dish with a one inch cylinder, 1.5 inches long, extending from its bottom. The dish has concentric circles calibrated in 5-degree increments from the center to its outer circumference. A hollow ball, filled with a heavy viscosity liquid to induce damping, is used as the indicator. A transparent cover over the dish restrains the ball without loss of visibility. The device is used prior to lifting the drill string from the hole. The indicator is slipped down over the top of the drill string, the indicator ball allowed to come to rest, and a reading in degrees obtained visually by noting the position of the ball relative to the concentric circles. An alternate mode of operation consists of attaching the vertical indicator to the drill handle for preliminary drill alignment. The device is capable of measuring vertical angles from 0 to 15 degrees with an accuracy of $\pm 2\text{-}1/2$ degrees.

4.2.6 Debris Deflector - The debris deflector is a formed fabric, toroidal shaped shield which attaches to the cuttings collector box. The purpose of the deflector is to prevent injury to the astronaut should the drilling operation release entrapped gas from the lunar material. Such outgassing could force drill chips or dust up the hole at high velocity. The chip deflector assures that these particles are deflected away from the astronaut.

4.2.7 Handle Assembly - The handle assembly provides the means for the astronaut to control the ALSD in the operational mode. The handle assembly incorporates a power on/off trigger, a trigger lock, and spring clips for coupling the handle to the battery pack case. Because of space limitations within the LM SEB, it is necessary that the handle be installed during the assembly operation at the drilling site. The core remover serves as a tool to depress the spring clips which secure the handle permanently to the battery pack. The trigger lever is coupled through a linkage system to interface with the power switch for activating the power head. The trigger lock protects the astronaut against inadvertant operation, and must be released before the trigger lever can be depressed.

4.2.8 Cable and Reel Assembly - The cable and reel assembly is used to mechanically couple the treadle to the drill bit via the handle assembly. This is accomplished through a cable which attaches to the treadle, a take-up reel, and a housing which attaches to the handle. A low and high energy negator spring is incorporated in the reel assembly. The low energy spring semi-automatically winds up the cable for stowage or removal of slack during operation, and the high energy spring serves to limit the holddown pressure on the bit to 60 pounds in the "closed" loop operating mode. A "load status" indicator is incorporated to inform the operator of the "loaded" or "unloaded" status of the high energy spring. The reel and handle assembly remain together until installed on the battery pack case during the initial assembly on the lunar surface. Thereafter, the cable and reel assembly is removed from the handle when necessary to facilitate the removal of the power head from the drill string.

4.2.9 Sterilization Bag - The sterilization bag prevents the ALSD system from carrying viable organisms or other contamination to the lunar surface. The ALSD system, once sterilized by heat and/or ethylene oxide, is packaged in a sterilized bag fabricated from FEP Teflon or similar material. The bag incorporates a relief valve to provide pressure equalization during transit to the moon.

4.2.10 Anchor Pins - The anchor pins consist of one-inch diameter aluminum tubes with incrementally spaced holes for locating and pivoting the treadle assembly in the "closed" loop restraint mode at the correct height above the surface. The bottom of the anchor pin includes four pivoted serrated hinge flaps which provide a positive locking action when inserted into a predrilled hole in hard rock.

5.0 OPERATING PARAMETERS

A tabulation summary of ALS Development and EMI Test Model operating parameters is presented in Table III. 1.

6.0 WEIGHT SUMMARY

A component weight breakdown for the Development and EMI Test Models is tabulated in Table III. 2.

7.0 ENGINEERING DRAWINGS

A tabulation of top assembly engineering drawings for the Development and EMI Test Models is presented in Table III. 3.



Figure III.1 Development Model ALSD With Carrying Case.

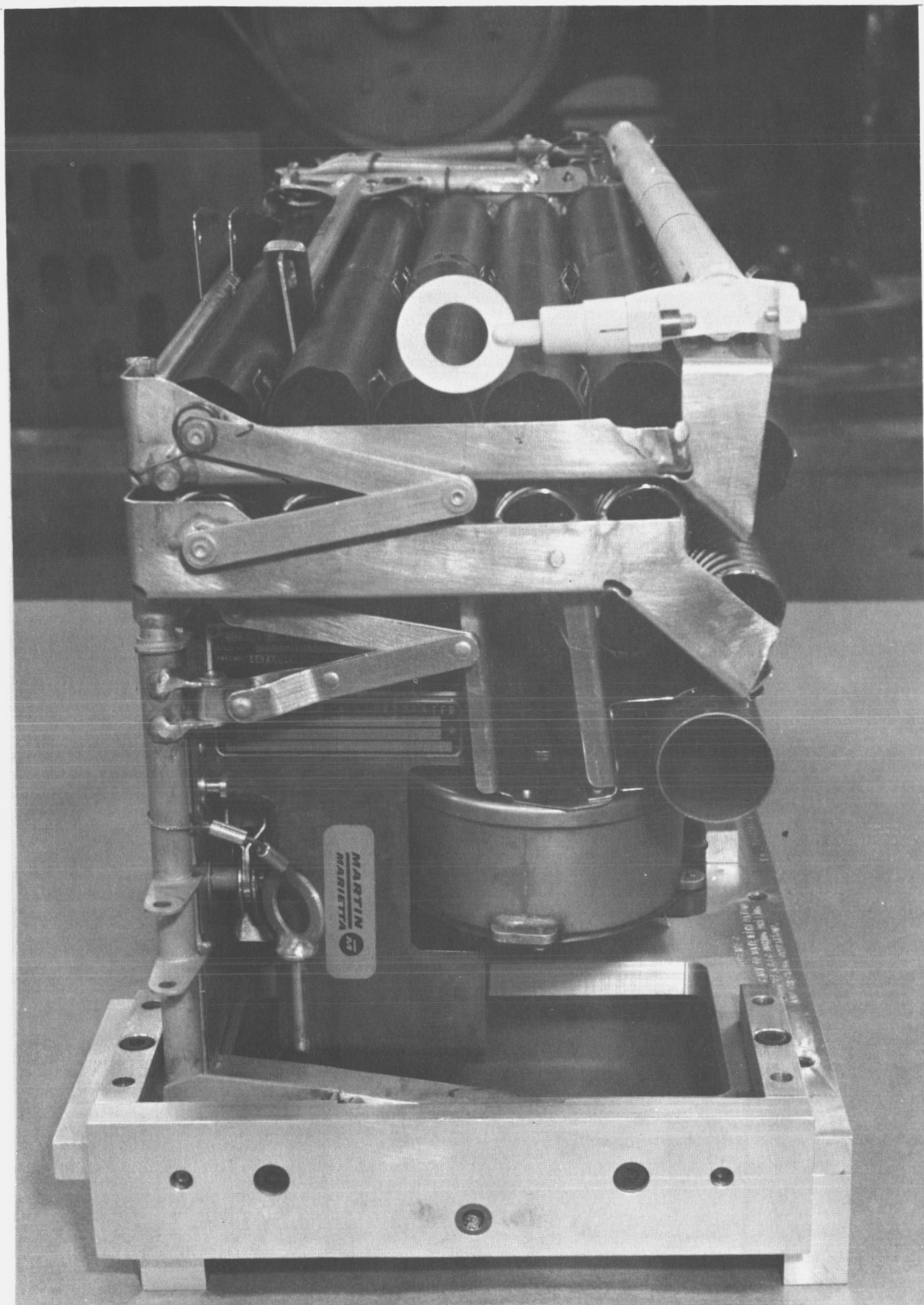


Figure III.2 Development Model ALSD/Interface Tool - Front View.

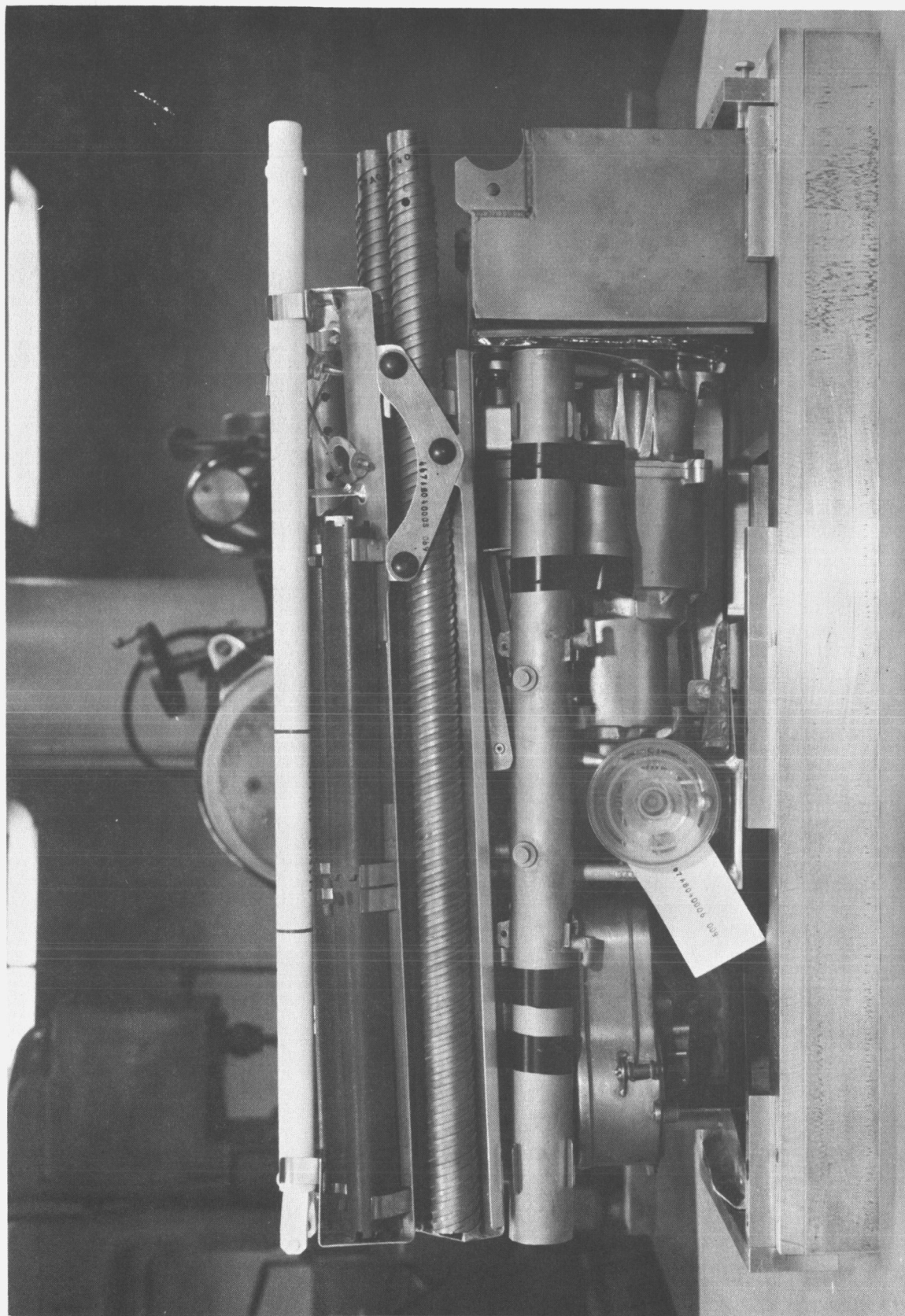


Figure III.3 Development Model ALSD/Interface Tool - Right View

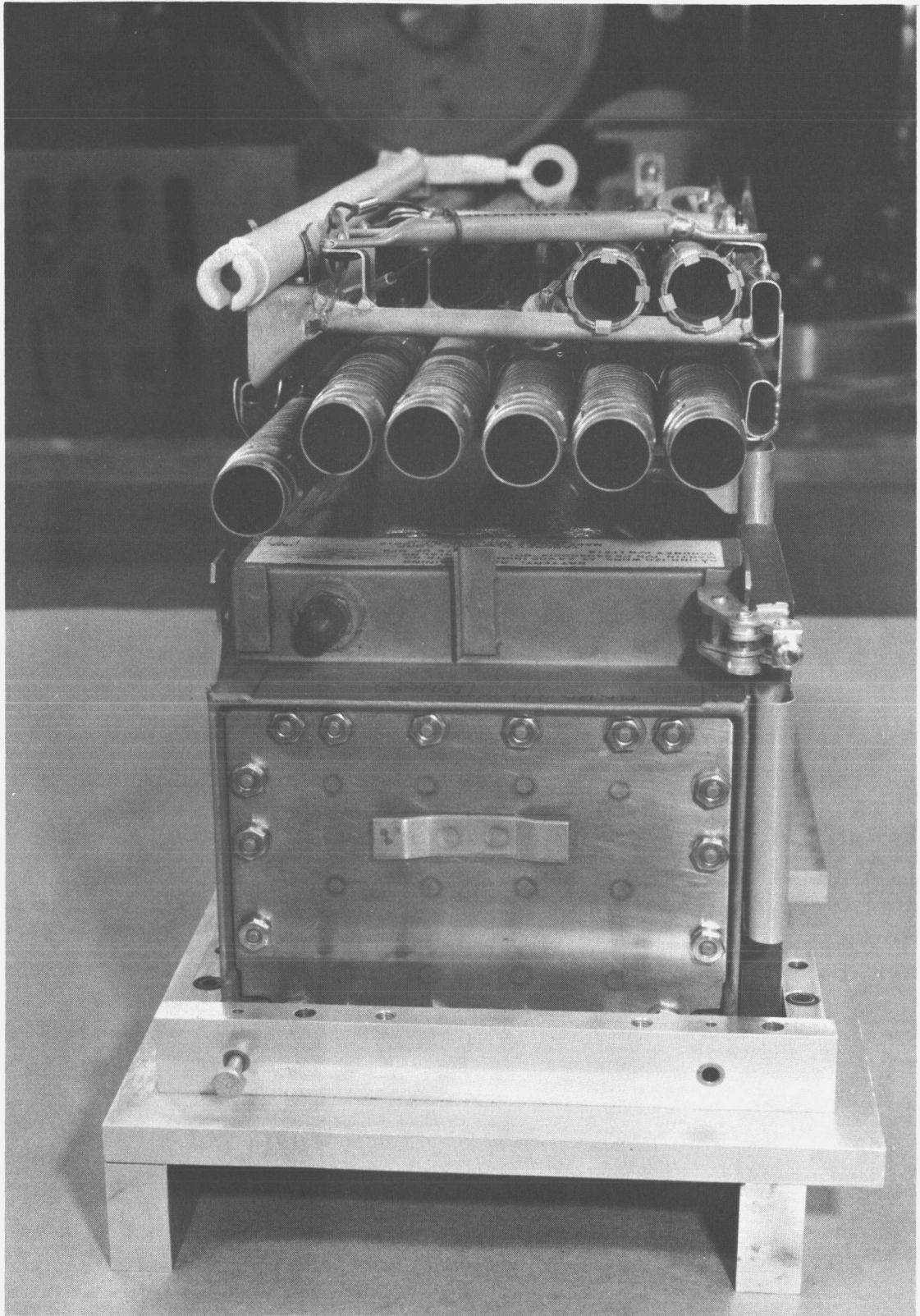


Figure III.4 Development Model ALSD/Interface Tool - Rear View

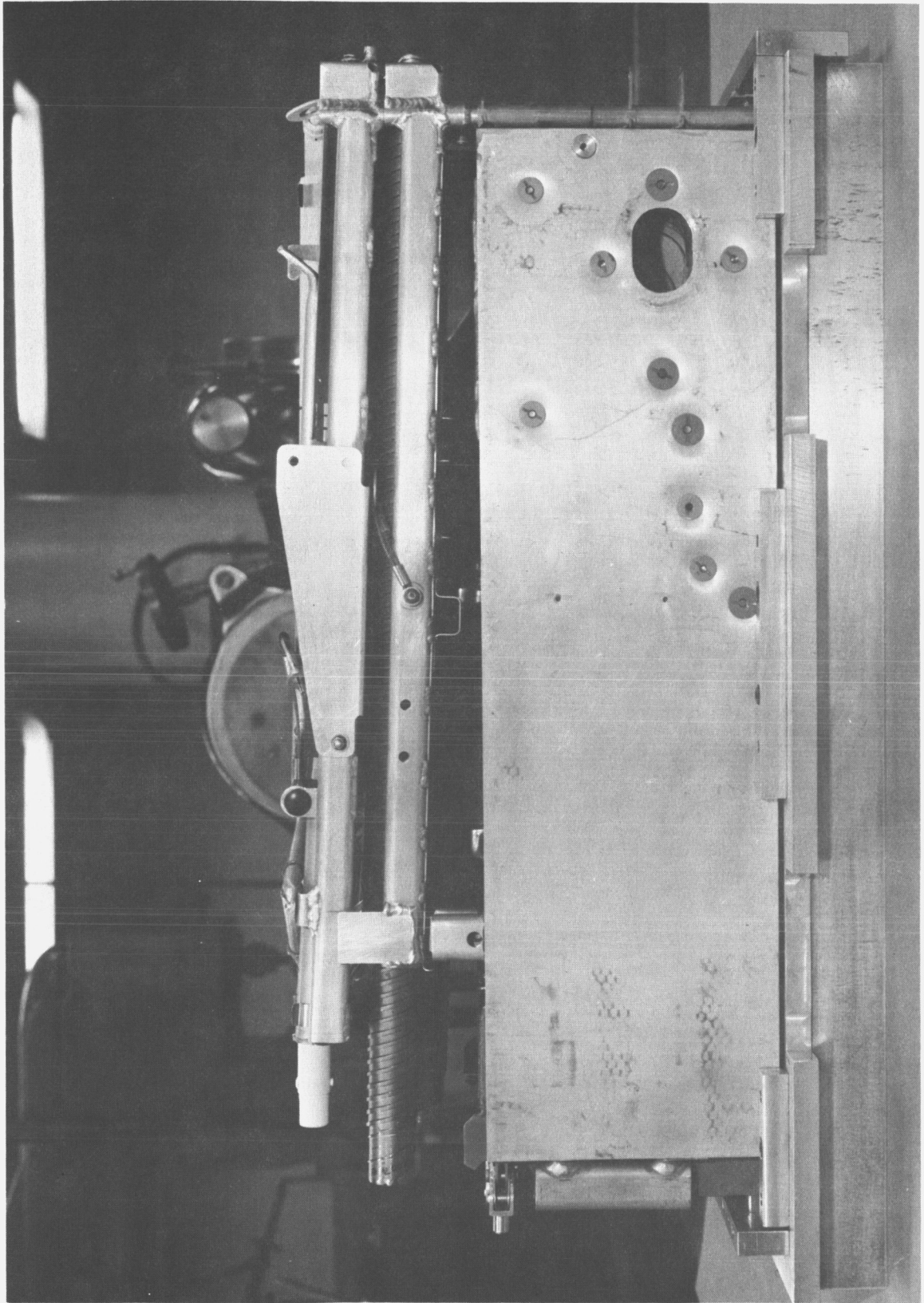


Figure III.5 Development Model ALSD/Interface Tool - Left View.

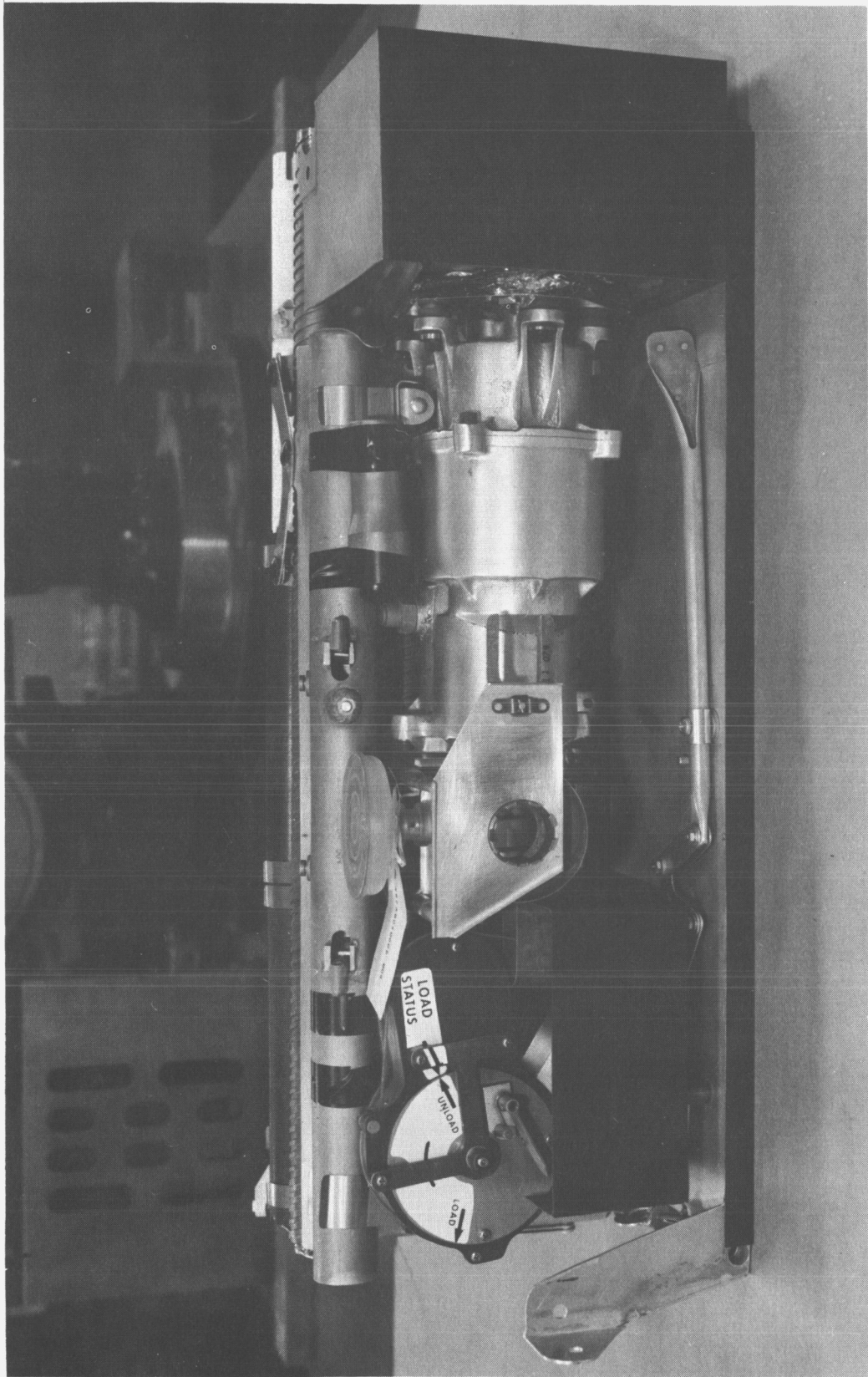


Figure III. 6 Development Model ALSD - Bottom View

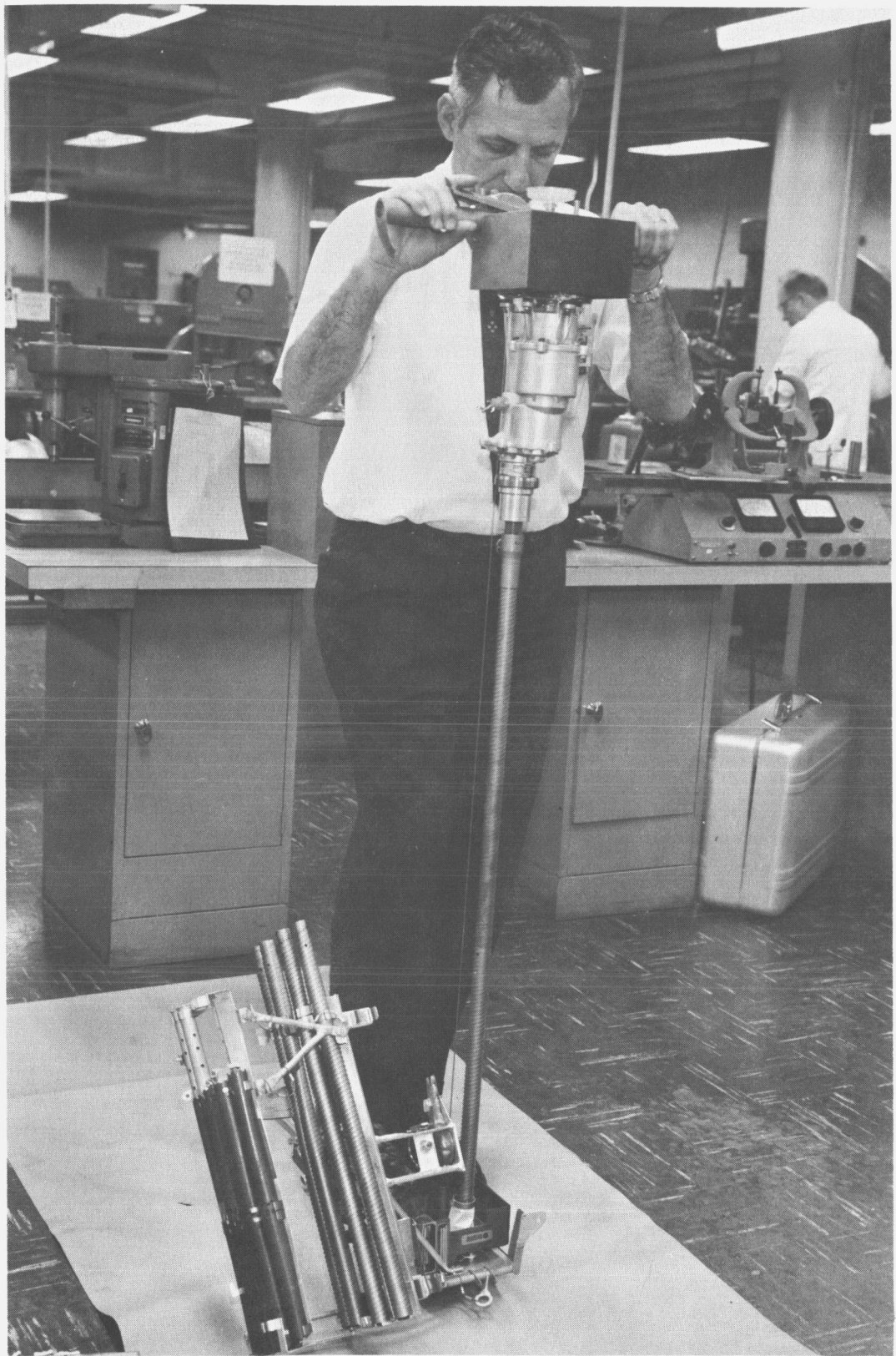


Figure III.7 Development Model ALSD - Operational Front View



Figure III. 8 Development Model ALSD - Operational Right View.

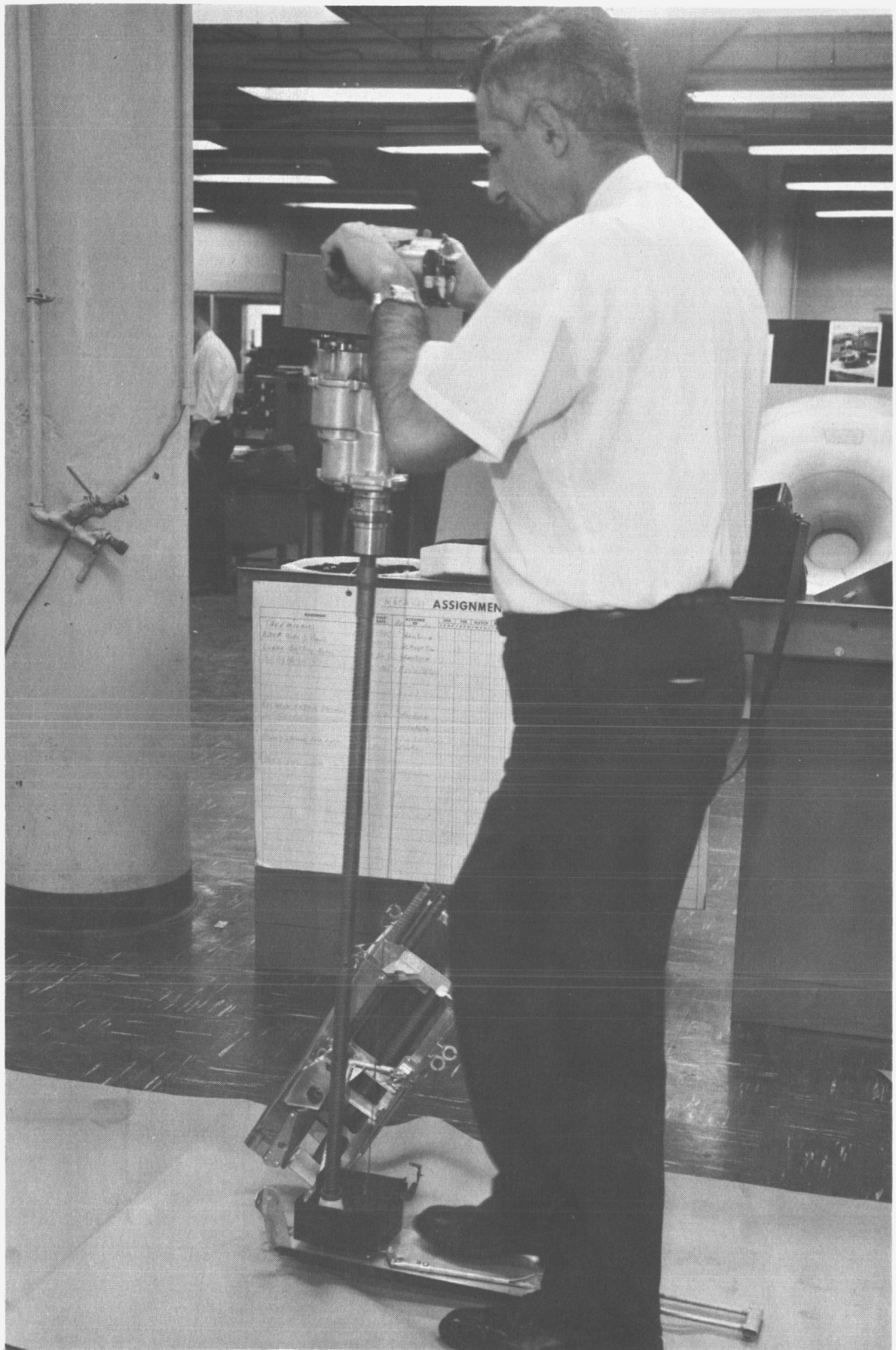


Figure III. 9 Development Model ALSD - Operational Left View.



Figure III. 10 Development Model Power Head and Battery Assembly.

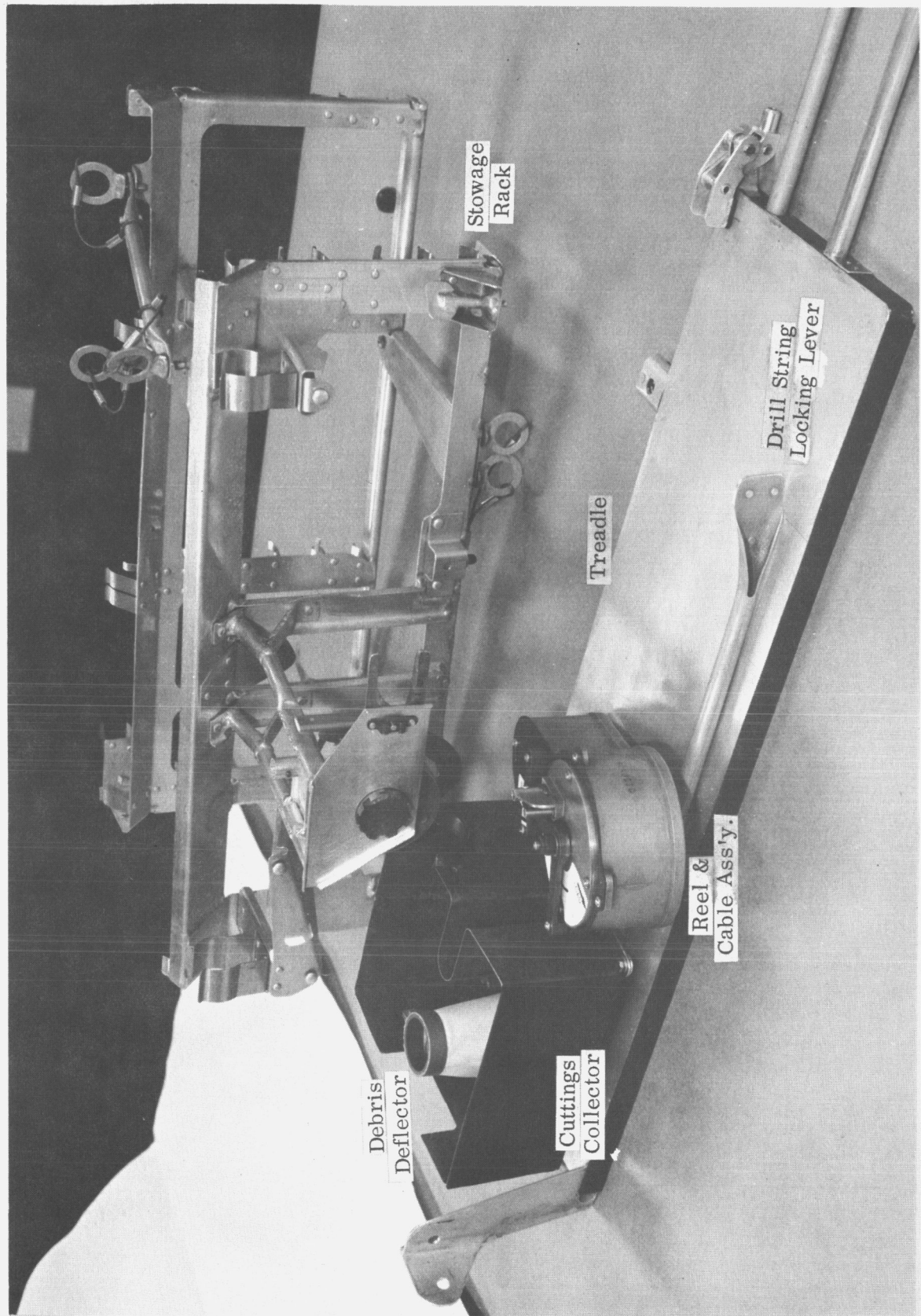


Figure III. 11 Development Model Treadle Assembly.

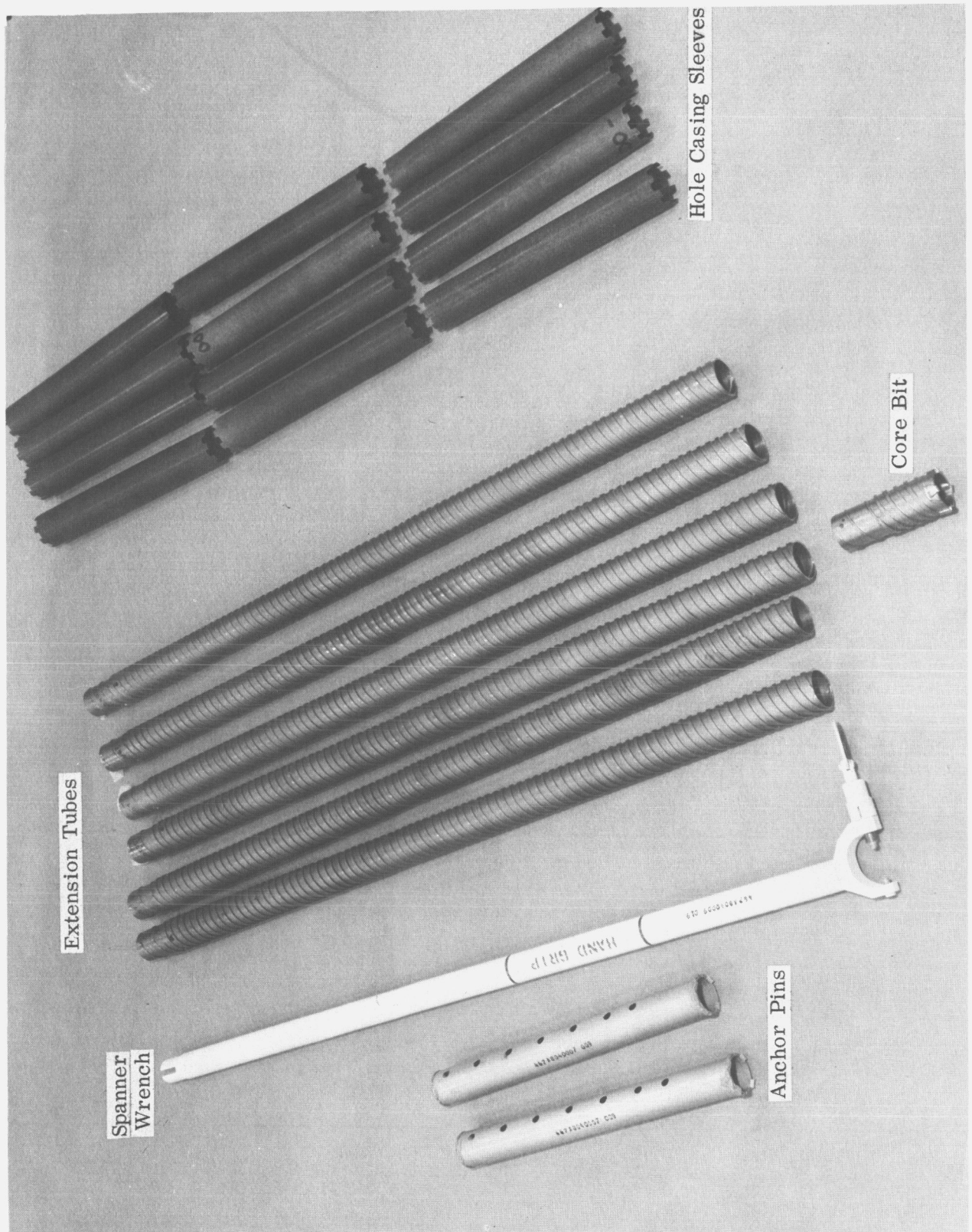


Figure III. 12 Miscellaneous Development Model Components.

TABLE III.1 ALSD DEVELOPMENT & EMI TEST MODEL OPERATING PARAMETERS

BATTERY ASSEMBLY

Silver-Zinc Cells (Yardney HR5DC-12X1)	16
Open Circuit Voltage	29.8 $\pm$ 1 VDC
Operating Voltage	23.0 $\pm$ 1 VDC
Nominal Operating Current	18.75 Amperes
Nominal Power Capacity	120 Watt-Hours
Activated Storage Life	6 Months
Recharge Capability	20 Cycles (Minimum)
Dry Storage Life	2 Years
Electrolyte	Potassium Hydroxide
Cell Pressure	8 psig
ECS (Case) Pressure	5 psia

POWER HEAD

MOTOR

Operating Voltage	23.0 $\pm$ 1 VDC
Load Speed	9300 RPM
Load Current	18.75 Amperes
No Load Current	2.5 Amperes
Efficiency	70%

PERCUSSOR

Blow Rate	2260 BPM
Energy Per Blow	30 In-Lbs.
Spring Energy	220 Lb/In.
Effective Hammer Weight	0.661 Lb.
Hammer Velocity	187 In/Sec.

POWER TRAIN

Motor-to-Cam Ratio	4.1
Motor-to-Drive Shaft Ratio	33.1
Drive Shaft Speed	280 RPM
Blows Per Bit Revolution	8.12

DRILL STRING ASSEMBLY

Integrated Length	126 Inches
Extension Tube Length	22 Inches
Drill Bit	
Cutting Diameter	1.032 Inch
Body Outside Diameter	0.982 Inch
Body Inside Diameter	0.802 Inch
Length	2.5 Inches
Number of Carbide Cutters	4

HOLE CASING SLEEVE

Wall Thickness	.004 Inch
Length	1.5 Meter
Nominal Diameter	1 Inch

TABLE III. 2 ALSD DEVELOPMENT & EMI TEST MODEL WEIGHT BREAKDOWN

<u>NOMENCLATURE</u>	<u>UNIT WEIGHT (LBS)</u>	<u>SUBSYSTEM WEIGHT (LBS)</u>
Battery Assembly		8.43
Power Head		9.46
Drill String		6.55
(6) Extension Tubes	6.17	
(1) Core Bit	0.10	
(1) Adapter	0.28	
Accessory Group		5.89
Handle Assembly	0.31	
Anchor Pins (2)	0.10	
Spanner Wrench	0.29	
Vertical Indicator	0.05	
Cable & Reel Assembly	1.04	
Treadle	1.32	
Cuttings Collector	0.25	
Debris Deflector	0.08	
Drill String Racks	1.83	
*Hole Casing Sleeves	0.19	
*Sterilization Bag	0.43	
TOTAL		30.33

* Deleted from EMI Model

TABLE III. 3 ALSD DEVELOPMENT & EMI TEST MODEL ENGINEERING DRAWINGS

<u>DRAWING NUMBER</u>	<u>NOMENCLATURE</u>
467A8040000	Assembly - Apollo Lunar Surface Drill
467A8040001	Treadle Assembly (ALSD) EMI and Development Units
467A8040002	Sterilization Bag - ALSD (Delete for EMI Model)
467A8040003	Shipping Container - ALSD
467A8040004	Handle and Switch Actuator Assembly
467A8040005	Actuator Arm Assembly
467A8040006	Vertical Indicator - ALSD
467A8040007	Support Pin - ALSD
467A8040008	Drill String Holder Assembly
467A8040009	Wrench, Spanner
467A8040010	Reel and Cable Assembly
467A8040011	Debris Collector, Details and Installation
467A8040012	Debris Seal - ALSD
467A8040013	Casing, Hole - ALSD (Delete for EMI Model)
467A8040014	Core Retainer - ALSD (Delete for EMI Model)
PS940300014-001	Battery - Apollo Lunar Surface Drill
PS955000002-003	Power Head, Apollo Lunar Surface Drill
CL-1477	Body for 1" Lunar Core Drill
CL-1479	Extension Tube for Lunar Core Drill
CL-1480	Extension Tube Adapter for Lunar Core Drill

IV. ALSD DEVELOPMENT AND EMI TEST MODEL OPERATIONAL PROCEDURES

The following procedure is representative of a two-hole drilling operation with the development type ALSD.

1.0 Complete drilling of two holes.

Note: For the purpose of this task summary, it is assumed that the first hole is drilled in dense basalt with overburden and the second hole in 50% porosity vesicular basalt with no overburden.

2.0 Complete drilling of first hole.

2.1 Deploy ALSD mechanism at drill site.

2.1.1 Tear open and remove sterilization bag and discard.

2.1.2 Remove multipurpose wrench from outboard stowage rack.

Note: This tool is restrained only by spring clips and is readily removable.

2.1.3 Holding wrench by spanner end, insert other end into stowage rack lock and turn lock to release stowage rack. Both racks are now free to rotate about the pivot together.

Note: This lock is located between the power head and inboard stowage rack in the vicinity of the battery/power head interface.

2.1.4 Stow multipurpose wrench in original location.

2.1.5 Holding the inboard stowage rack near the pivot point, and the treadle with the other hand, separate inboard rack from treadle by pulling along the axis of the pivot point.

Note: The outboard rack remains attached to the inboard rack at this point by a clip at the top end of both racks.

2.1.6 Remove lower stowage rack brace.

Note: This is located on the outboard stowage rack near the center.

2.1.7 Install brace by holding cross bar and aligning slot in opposite end with stud which is located on top of the treadle near the treadle hinge point. Drop brace slot over stud and rotate brace about stud 90° to lock.

2.1.8 Complete lower brace installation by aligning upper end of brace with attachment points on inboard side of inboard stowage rack and installing pins.

Note: Pins are attached by lanyards to brace and are installed with a simple pushing action.

- 2.1.9 Remove stowage rack end restraint clip and discard.

Note: This clip bridges the upper end of both racks and will snap out with a slight pull. This clip frees the outboard rack from the inboard rack.

- 2.1.10 Holding the treadle near the hinge point, separate the outboard rack from inboard rack by pulling on outboard rack along pivot point.

- 2.1.11 Rotate shear tie 90° and align with holes in inboard rack. Insert two pins attached to inboard rack by lanyards into holes in shear tie.

Note: Shear tie permanently attached to outboard rack near top.

- 2.1.12 Remove upper brace from outboard rack by pulling loose from snaps.

- 2.1.13 Install brace by placing it in proper position across both racks and inserting three locking pins.

Note: This brace installed near top of racks on opposite side from shear tie. Pins for this brace installation are attached by lanyard to the brace.

- 2.1.14 Remove multipurpose tool from outboard stowage rack.

- 2.1.15 Insert tool into rear power head locking clamp and release clamp by prying tool downward.

Note: This clamp located on rear of treadle.

- 2.1.16 Stow multipurpose tool.

- 2.1.17 Manually release forward power head restraint clamp.

Note: This clamp is located over power head near the output shaft. Releasing this clamp frees the power head assembly from the treadle.

- 2.1.18 Place treadle down and remove first drill string section from inboard rack.

Note: Section is removed by rotating ccw approximately 90° .

- 2.1.19 Install first drill string section on power head output shaft by rotating cw.

- 2.1.20 Repeat 2.1.18 and 2.1.19 for second drill string section.

Note: This section contains an integral bit.

- 2.1.21 Remove ALSD handle from inboard stowage rack and place in position on power head.

- 2.1.22 Remove multipurpose tool from stowage position and engage handle locking pin.

- 2.1.23 Snap both handle locking pins into holes provided using tool for leverage.

2.1.24 Stow multipurpose tool.

2.1.25 Turn assembled drill upside down and park by placing battery case lid on lunar surface.

2.1.26 Remove debris shield from inboard stowage rack.

Note: The debris shield is located near the bottom of the inboard stowage rack, making it necessary to lift the rack and treadle to a comfortable working height prior to removal of the shield. The shield is removed by releasing a cam lever which is part of the shield.

2.1.27 Place debris shield over drill bit and slide along drill string to power head.

2.1.28 Lock debris shield to power head by operating debris shield cam lever.

Note: Drill may be lifted to working height for this operation.

2.1.29 Place six (6) hole casing sleeves over drill string.

Note: Hole casings are stowed in outboard stowage rack. As some of the casings are located on the lower portion of this rack, it will be necessary to raise the rack and treadle assembly to a convenient height to facilitate their removal. Casings may require rotation during installation for proper interlocking.

2.1.30 Deploy treadle extension by pulling it from rear of treadle.

2.1.31 Unstow cable and reel assembly.

Note: This assembly is initially stowed near bottom of inboard stowage rack, requiring the rack and treadle to be raised for convenient access.

2.1.32 Place cable and reel assembly in operating stowage near top of inboard stowage rack.

Note: To raise reel and cable it will be necessary to pay out cable, which requires release of the ratchet. This is accomplished by actuating the ratchet release lever on the cable and reel assembly. Location of this lever is such that the release and raising operation can be accomplished with one hand.

2.1.33 While standing on treadle, pick up assembled drill by drill string and turn over to normal operation position and insert bit through collaring hole in treadle, being careful not to lose hole casing sleeves.

2.1.34 Holding assembled drill in one hand, obtain cable and reel assembly from operating stowage and install on power head assembly.

Note: Mounting provision is located on center of battery case.

2.1.35 Lift foot from treadle to allow treadle to raise approximately three inches.

2.1.36 Re-apply foot pressure to treadle.

2.1.37 Release trigger bar lock.

Note: ALSD now completely assembled and ready for commencement of drilling.

2.2 Drill hole.

2.2.1 Depress trigger bar.

2.2.2 Continue drilling until solid rock is reached.

Note: This step will require making decision as to if and when rock anchor should be deployed to increase drilling efficiency. If, for example, solid rock is not encountered, anchor deployment will not be required. The remainder of this sequence assumes rock anchor deployment is necessary.

2.2.3 Remove cable and reel assembly and return to operating stowage.

2.2.4 Remove drill from hole by carefully pulling drill string and bit over hole casings below lunar surface.

2.2.5 Park drill with remaining casings still on drill string.

2.2.6 Remove rack and treadle assembly from over hole and emplaced casing.

2.2.7 Before returning rack and treadle to lunar surface, acquire from outboard rack sufficient hole casing sections to replace on the drill string those casings remaining in the hole.

2.2.8 Unstow anchor pin and multipurpose tool and place rack and treadle assembly near hole.

2.2.9 Slide anchor pin into hole within casing.

Note: This operation is performed low to the lunar surface requiring the astronaut to depart from the standing position.

2.2.10 Set anchor by tapping lightly with multipurpose tool, holding tool by spanner end.

Note: Leave tool inserted in center of anchor for later use with debris shield.

2.2.11 Remove treadle hinge pin and position treadle over anchor pin.

2.2.12 Replace hinge pin.

2.2.13 Place power head through collaring hole in treadle.

- 2.2.14 Install cable and reel assembly, while standing on treadle.
- 2.2.15 Raise foot from treadle to allow treadle to raise approximately three inches.
- 2.2.16 Re-apply foot pressure, forcing treadle flat to the lunar surface.
Note: This applies a 60-pound axial force to the drill bit.
- 2.2.17 Drill until rock is reached, pumping treadle as required.
- 2.2.18 Remove cable and reel assembly and return to operating stowage.
- 2.2.19 Carefully remove drill from hole so as not to disturb casing in hole and park.
- 2.2.20 Remove remaining hole casing sleeves from drill string and stow on outboard stowage rack.
- 2.2.21 Replace bit of assembled drill through collaring hole and casing.
- 2.2.22 Release cam lock lever on debris shield and allow to drop down to level of hole casing.
Note: This prevents hole casing from rotating by reacting torque against multipurpose tool.
- 2.2.23 Install cable and reel assembly while standing on treadle.
- 2.2.24 Commence drilling by releasing lock and depressing trigger bar.
- 2.2.25 Drill until a surface to handle height of 24 inches is reached, pumping treadle as required to maintain axial drill pressure.
- 2.2.26 Lock drill string by actuating treadle vise with foot.
- 2.2.27 Remove and stow reel and cable assembly.
- 2.2.28 Remove power head by rotating ccw.
- 2.2.29 Remove single additional drill string section from inboard stowage rack and attach to power head.
- 2.2.30 Attach power head and drill string to drill string in hole.
- 2.2.31 Install cable and reel assembly.
- 2.2.32 Release treadle vise with foot.
- 2.2.33 Drill 8 to 10 inches pumping treadle as required.

Note: This places joint between second and third tube at surface level.

- 2.2.34 Remove vertical indicator from stowage and install on handle.
- 2.2.35 Read inclination of drill string and stow vertical indicator.
- 2.3 Disassemble drill.
 - 2.3.1 Lift drill upward until joint between second and third drill string section is above treadle vise.
 - 2.3.2 Lock drill string by actuating treadle vise with foot.
 - 2.3.3 Remove multipurpose tool from anchor.
 - 2.3.4 Use spanner wrench to break loose drill string joint between second and third drill string sections.
 - 2.3.5 Remove power head and third drill string section by turning ccw, and park.
 - 2.3.6 Unlock drill string by releasing vise.
 - 2.3.7 Using spanner wrench on upper end of second drill string section, pull drill string up to comfortable height.
 - 2.3.8 Lock drill string.
 - 2.3.9 Using spanner wrench, break joint between second and first sections.
 - 2.3.10 Place spanner wrench inside stowed drill string section for temporary stowage.
 - 2.3.11 Unlock drill string and remove first and second drill string section from hole.
 - 2.3.12 Complete uncoupling of drill string and dump out core, using multipurpose tool as required for core pushing.
 - 2.3.13 Stow first and second drill string sections in inboard stowage rack.
 - 2.3.14 Retrieve debris shield from hole casing and remove treadle hinge pin.
 - 2.3.15 Place debris shield over third drill string section.
 - 2.3.16 Remove rack and treadle assembly from over drill hole.
 - 2.3.17 Insert thermal probe.
 - 2.3.18 Pick up drill and rack and treadle assembly and transport to new drill site.

- 3.0 Complete drilling of second hole.
- 3.1 Deploy ALSD mechanism.
 - 3.1.1 Remove drill string section (with bit) from stowage rack and couple to drill string section presently connected to power head.
 - 3.1.2 Place assembled drill through collaring hole in treadle.
 - 3.1.3 Attach cable and reel assembly standing on treadle.
 - 3.1.4 Raise treadle by removing foot pressure.
 - 3.1.5 Re-apply foot pressure and commence drilling by releasing safety and depressing trigger bar.
- 3.2 Drill hole.
 - 3.2.1 Continue drilling, pumping treadle as required until a handle to surface distance of 24 inches is reached.
 - 3.2.2 Remove and stow cable and reel assembly.
 - 3.2.3 Lock drill string by actuating treadle vise.
 - 3.2.4 Remove power head by rotating ccw.
 - 3.2.5 Remove drill string section from stowage and attach to power head and park power head.
 - 3.2.6 Remove additional drill string section from stowage and attach to drill string remaining in hole.
 - 3.2.7 Attach power head to drill string in hole.
 - 3.2.8 Attach cable and reel assembly.
 - 3.2.9 Release treadle vise.
 - 3.2.10 Repeat steps 3.2.1 and 3.2.2.
 - 3.2.11 Remove vertical indicator from stowage and install on handle.
 - 3.2.12 Read inclination.
- 3.3 Disassemble drill.
 - 3.3.1 Pull up on drill until comfortable height is reached.
 - 3.3.2 Lock drill string by actuating treadle vise.

- 3.3.3 Remove power head and park.
- 3.3.4 Using spanner wrench, break joint between fifth and sixth drill string sections.
Note: Do not completely uncouple drill string.
- 3.3.5 Unlock vise.
- 3.3.6 Lift drill string to convenient height.
- 3.3.7 Lock vise.
- 3.3.8 Complete uncoupling of sixth drill string.
- 3.3.9 Remove core from drill string section using core pusher if required.
- 3.3.10 Repeat steps 3.3.4 through 3.3.8 for fifth drill string section.
- 3.3.11 Repeat steps 3.3.4 through 3.3.8 for fourth drill string section.
- 3.3.12 Repeat steps 3.3.4 through 3.3.8 for third drill string section.
- 3.3.13 Repeat steps 3.3.4 through 3.3.8 for second drill string section.
- 3.3.14 Unlock vise and remove first drill string section.
- 3.3.15 Repeat step 3.3.8.
- 3.3.16 Stow multipurpose tool.
- 3.3.17 Insert thermal probe.
- 3.3.18 Remove ALSD and debris from drill site.

V. ALSD FLIGHT AND TRAINING MODEL EQUIPMENT DESCRIPTION

To Be Supplied When Available.

VI. ALSD FLIGHT AND TRAINING MODEL OPERATIONAL PROCEDURES

To Be Supplied When Available.

located pilot lights on the upper panel assembly indicate whether the battery is "on charge" or "off charge".

2.2 Battery Adapter Unit - This unit consists of a small chassis for mechanically restraining the ALSD battery during the charging process. The unit also contains a battery mating electrical connector, and a charging cable for routing the electrical power from the VC 24-10 charger to the ALSD battery.

3.0 PRESSURIZATION UNIT

The pressurization unit (Martin-Marietta Part No. 467A8090000) is used to perform leak tests and relief valve cracking pressure tests on both the ALSD battery case and power head. The unit is a bench-type tester consisting of the necessary valves, tubing and gauges to control and monitor the pressures in the unit under test. The pressurization gas (nitrogen) is supplied from an external source. Figures VII.3 through VII.5 illustrate the pressurization unit.

3.1 Unit Controls and Function - The following describes the function of the various controls and monitoring instruments located on the pressurization unit.

- Supply Valve - Controls entrance of gas to pressurization unit from the external source.
- Regulator Valve - Regulates gas pressure from source (150 psig max.) to operating pressure (0 to 30 psig).
- Isolation Valve - Used to isolate the unit under test from the pressure source after pressurization but prior to leak testing.
- Bleed Valve - Used to dump gas after test but prior to disconnecting pressurization unit.
- Pressure Gauge - Monitors pressure in unit under test during pressurization and in the power head during leak test. The range of this gauge is 0 to 30 psig.
- Manometer - Monitors pressure in battery case during leak testing. The manometer reads from 0 to 8 inches of mercury.
- Manometer Isolation Valve - Isolates the manometer during all tests on the power head and during pressurization of the battery case.
- Low Pressure Relief Valve Control - This control when opened connects a low pressure (6 psig) relief valve to the pressurization loop to prevent over pressurization of the battery case during test. A second relief valve of a higher (30 psig) relief setting is always in the loop for over-pressure protection during testing of the power head.

3.2 Power Head Pressure Test - The external nitrogen gas source is connected to the tester inlet valve and 150 psig regulator valve. The tester outlet is connected to the power head relief valve port. The relief valve is removed from the power head and installed in a "T" in the tester outlet line during test.

Pressure is applied to the power head until the relief valve cracks at approximately 25 psig. The actual pressure is noted and verified to be within prescribed limits.

VII. ALSD GROUND SUPPORT EQUIPMENT DESCRIPTION

The ALSD Ground Support Equipment consists of a transport/storage case, battery charging unit, and a pressurization unit. A description of these units follows.

1.0 TRANSPORT/STORAGE CASE

The transport/storage case, as illustrated in Figure VII. 1, is employed predominately for transporting the ALSD prior to final KSC checkout and installation aboard the LM. It consists of a commercial aluminum carrying case modified by the installation of urethane foam (Fome Bond-78) molded to conform with the outline of the complete ALSD package. The foam restrains the ALSD in a semi-rigid condition sufficient to preclude damage during transit.

2.0 BATTERY CHARGING UNIT

The battery charging unit (Martin-Marietta Part No. 467A8080000) is used for two major purposes: 1) to provide a multiple recharge capability for the ALSD training model batteries; and 2) to support the flight model battery activation requirements during KSC prelaunch checkout of the ALSD.

The battery charging unit consists of two major subassemblies; a Yardney Electric Corporation SILVERCEL charger, Model VC 24-10, and a battery adapter unit. Figure VII. 2 illustrates the charging unit with a battery assembly.

2.1 VC 24-10 SILVERCEL Charger - The VC 24-10 unit, which operates from a 105 to 120 VAC, 60 cps single phase power source, is capable of charging any number of silver-zinc cells from 1 to 24, at any charging rate up to 10 amperes. For ALSD operation, the unit is operated in the 16-cell mode.

The charger consists of a lower panel assembly containing a power supply and variable transformer, and an upper panel assembly containing a cell selector switch, ammeter, voltage cutoff meter and charging circuit.

The power supply consists of a transformer and a full wave, selenium rectifier circuit. A variable transformer is used in the AC input circuit for fine control of the DC output.

The ammeter on the upper panel assembly has a dual scale and a selector switch for use on a 1 or 10 ampere operating range.

Charge termination is controlled by a voltage cutoff meter which interrupts the charging power when the battery terminal attains its predetermined level. In conjunction with the cutoff meter, the cell selector switch must be set to the 16-cell position for the ALSD battery. The selector switch inserts an appropriate multiplier resistance in series with the cutoff meter, which assures termination of charge at the proper battery "end" voltage.

If a failure of the AC voltage occurs, the battery automatically resumes charging when power is restored. Since the cutoff circuit is of the relay type, a reset circuit with a panel-mounted push button switch is provided to ensure convenient recycling of the battery in the event a power line surge activates the cutoff meter prematurely. Conveniently

The pressure is then reduced to approximately 20 psig and the tester isolation valve closed. The barometric pressure, gauge pressure, temperature, and time are noted. After a specified soak period these readings are repeated, and after temperature and barometric pressure corrections, the leakage rate is determined and verified to be within a specified tolerance.

3.3 Battery Assembly Pressure Test - Pressure test of the battery case is similar to the power head test, except the relief valve is verified to crack at 5 psig and the manometer is used to verify leakage rates rather than the pressure gauge.

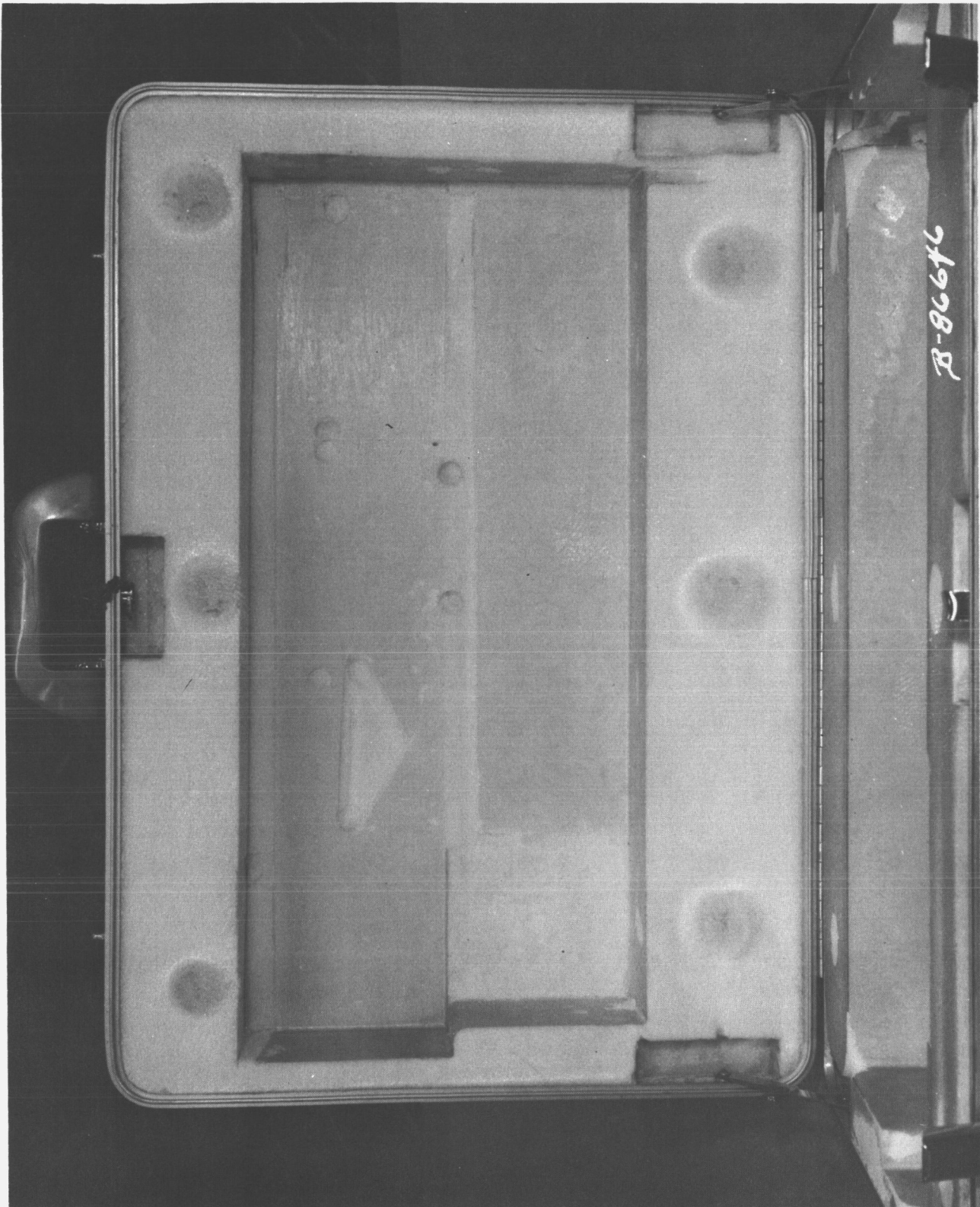


Figure VII.1 ALSD Transport/Storage Case.

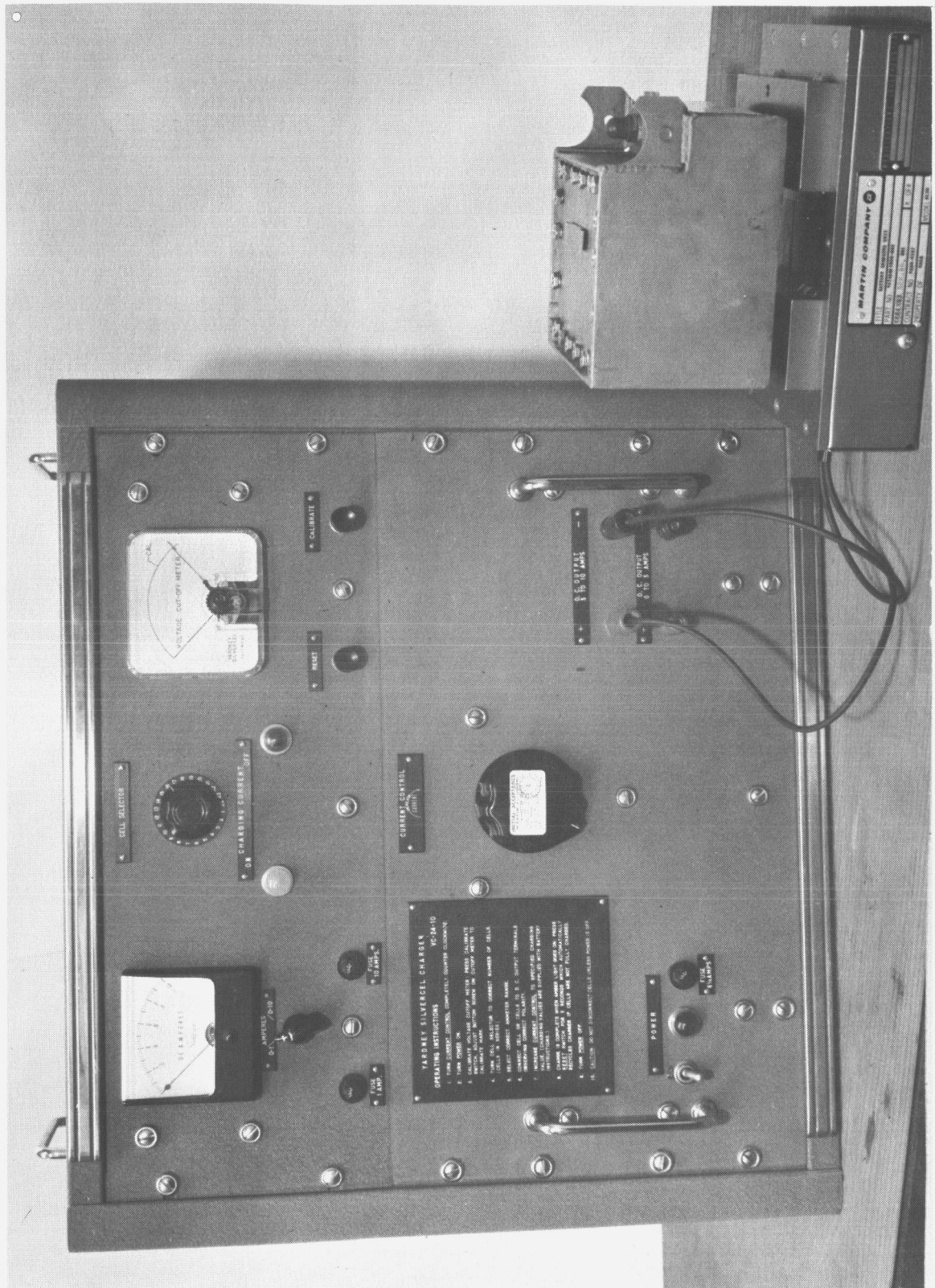


Figure VII.2 Battery Charging Unit.

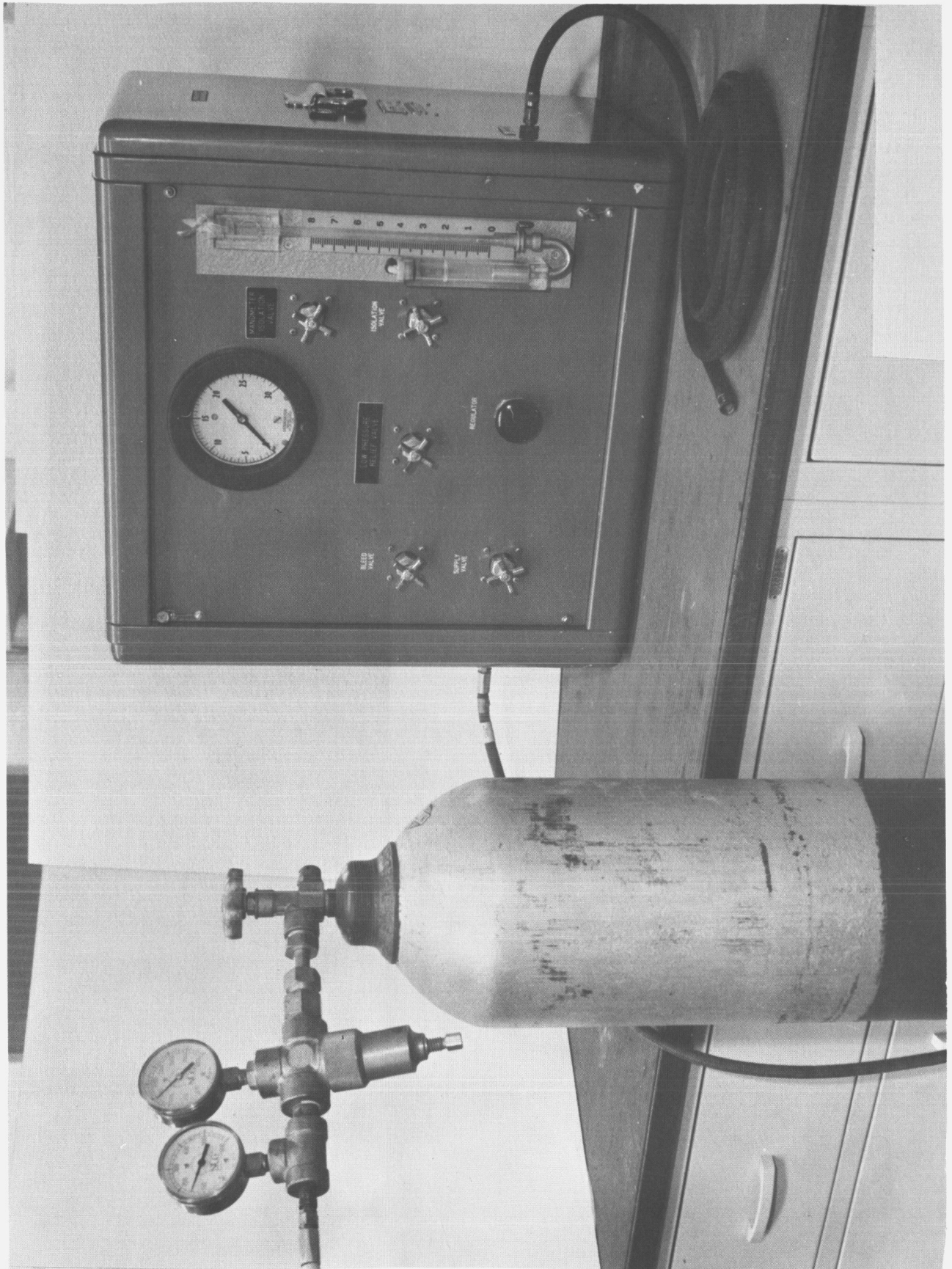


Figure VII.3 ALSD Pressurization Unit and External Gas Source.

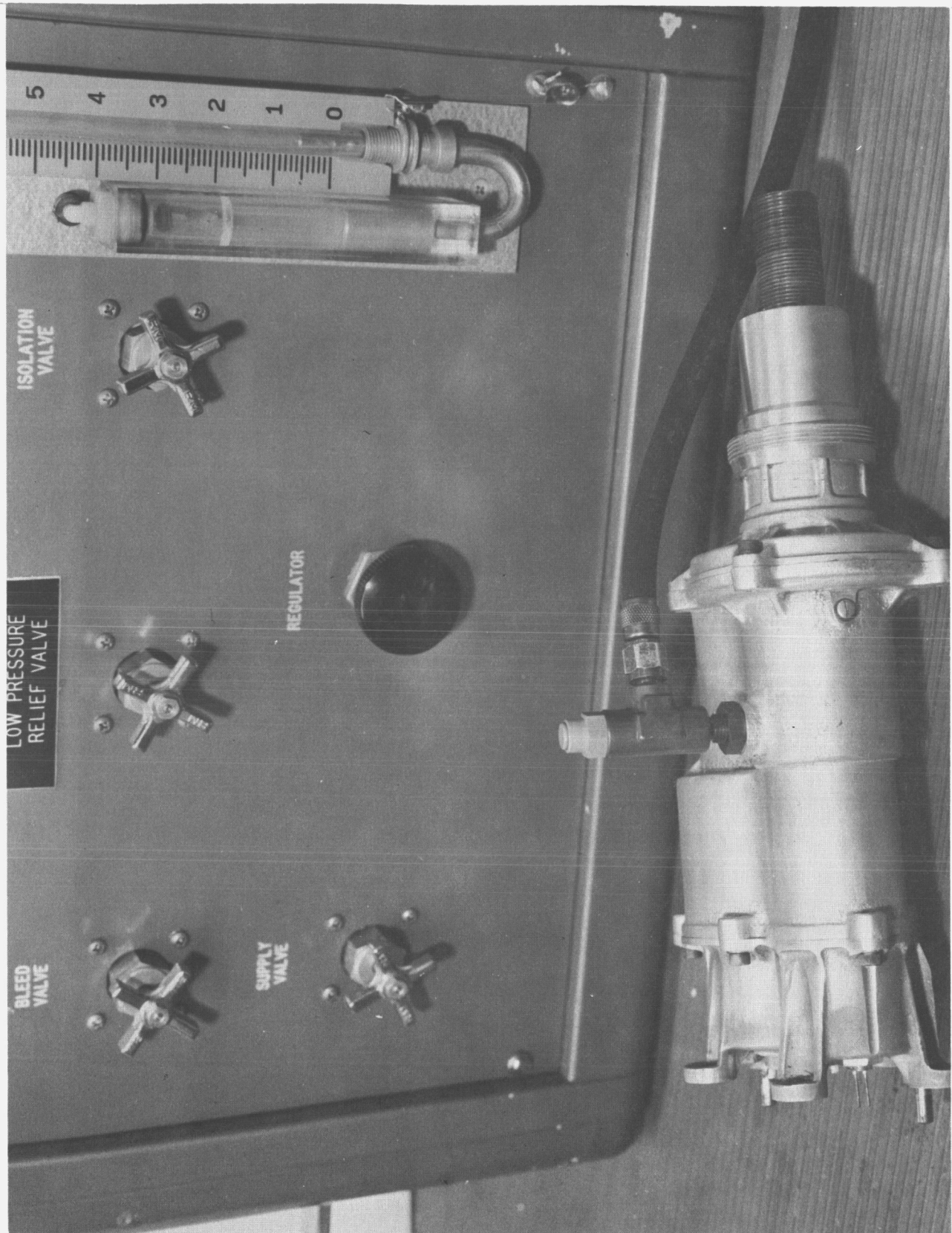


Figure VII.4 Power Head Pressurization Test Setup.



Figure VII.5 Battery Assembly Pressurization Test Setup.

VIII. ALSD AND GSE SERVICE INSTRUCTIONS

1.0 ALSD PRESSURIZATION UNIT OPERATIONAL READINESS VERIFICATION

1.1 Purpose - This procedure establishes the inspection and test requirements for detecting any malfunctioning or defective components within the ALSD Pressurization Unit.

1.2 Operational Readiness Verification Time Interval - This procedure shall be performed in accordance with the following schedule.

- a. Upon receipt of equipment at the field location.
- b. At intervals thereafter not exceeding ninety (90) days.

1.3 Test Equipment Requirements

- a. Gaseous nitrogen source to conform with MIL-P-27401B, Type I.
- b. Source regulator and gauge system capable of 0-150 psi range.
- c. Source-to-Pressurization Unit hose capable of attaching to inlet port fitting, AN 832-4D.
- d. Calibration Lab capable of calibrating 0-30 psi pressure gauge.
- e. Manometer, Standard (0-8 inches Hg range).

1.4 Failure/Malfunction Criteria - Failure of the unit to meet the performance requirements specified herein shall constitute a malfunction. Each malfunction will require an investigation to determine cause.

1.5 Visual Examination - This unit shall be visually examined for cleanliness. Particular attention shall be given to the following:

- a. Condition of material finishes.
- b. Satisfactory tightness of assembly bolts and screws.
- c. Freedom from contamination, such as corrosion products, scale, grease, etc.

1.6 Equipment Description - The ALSD Pressurization Unit is a manifold assembly consisting of a pressure regulator, pressure gauge, manometer, and relief valve for purging, sequentially pressurizing and verifying seal integrity of the power head and battery assembly of the ALSD. Nitrogen is supplied to the unit by a standard gas cylinder. A schematic of the unit is presented in Figure VIII. 1.

1.7 Performance Requirements

1.7.1 Initial Conditions

1.7.1.1 Pressure Gauge - The 0-30 psi pressure gauge shall be calibrated to an accuracy conforming to acceptable laboratory standards.

1.7.2 Initial Connections

1.7.2.1 Connect low pressure outlets of standard nitrogen dolly to inlet of Pressurization Unit.

1.7.2.2 Close all valves on unit and plug outlet line. Turn regulator hand wheel counter-clockwise to closed position.

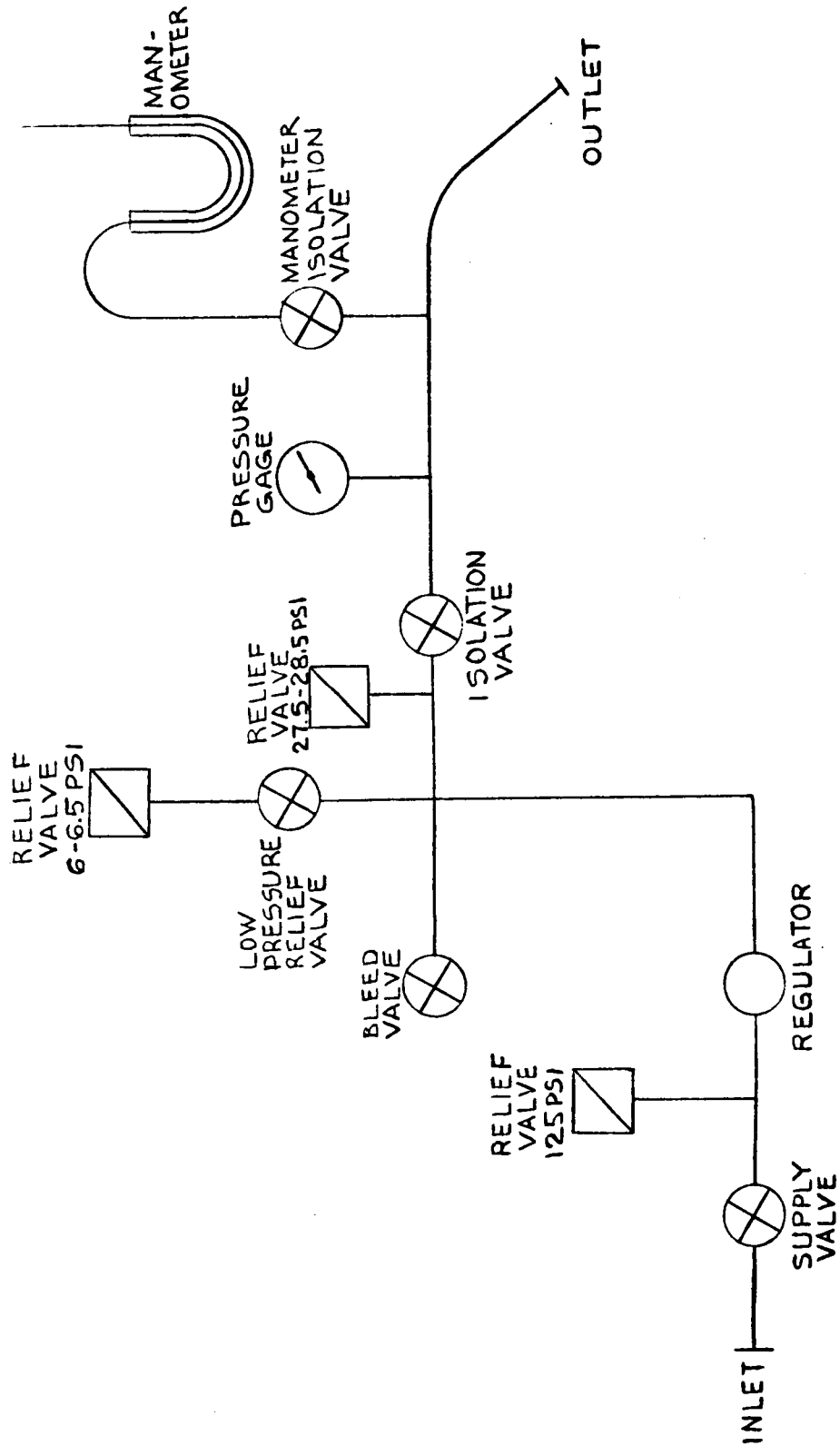


Figure VIII.1 ALSD Pressurization Unit Schematic

- 1.7.3 Adjustment of Relief Valves
 - 1.7.3.1 Open supply valve.
 - 1.7.3.2 Adjust nitrogen supply regulator on cylinder and apply pressure to unit for setting relief valve.
 - 1.7.3.3 Set relief valve to relieve between 115 to 125 psi.
 - 1.7.3.4 Reduce supply pressure to 75 psig.
 - 1.7.3.5 Open low pressure relief valve and isolation valve.
 - 1.7.3.6 Adjust regulator on unit and set relief valve to relieve at 6.0 to 6.5 psig, as read on the pressure gauge.
 - 1.7.3.7 Close low pressure relief valve.
 - 1.7.3.8 Adjust regulator and set relief valve to relieve at 27.5 to 28.5 psig. Check pressure indication on pressure gauge.
 - 1.7.3.9 Adjust regulator to 24 to 26 psi as indicated on the pressure gauge. Close supply valve and regulator. Note and record pressure. Allow unit to remain pressurized for six (6) hours with no leakage.
 - 1.7.3.10 Open isolation valve and bleed valve to relieve pressure in system. Close isolation valve and bleed valve.
- 1.7.4 Manometer Verification
 - 1.7.4.1 Connect a standard manometer to outlet line of unit.
 - 1.7.4.2 Open supply valve, low pressure relief valve, isolation valve and manometer isolation valve.
 - 1.7.4.3 Adjust regulator by turning slowly clockwise until 7 to 7.5 inches of mercury is obtained on standard manometer.
(CAUTION: Do not exceed 8 inches of mercury on unit manometer)
 - 1.7.4.4 Compare readings on two manometers.
 - 1.7.4.5 Adjust unit manometer to agree with standard manometer if required.
 - 1.7.4.6 Close isolation valve. Close supply valve and regulator. Note and record pressure on unit manometer. Allow unit to remain pressurized six (6) hours with no leakage.
 - 1.7.4.7 Open isolation valve and bleed valve to relieve pressure in system. Close all valves. Remove nitrogen supply from unit and cap inlet and outlet ports.

2.0 ALSD PRESSURIZATION SYSTEM VERIFICATION

2.1 Purpose - This procedure provides detailed instructions for purging, pressurizing and verifying seal integrity of the ALSD Power Head and/or Battery Assembly.

2.2 ALSD Pressurization System Verification Test Interval - The ALSD Battery Assembly and Power Head will be purged, pressurized and seal integrity verified in accordance with the following schedule.

- a. At time of receipt at field location.
- b. At intervals thereafter not exceeding ninety (90) days.
- c. In accordance with launch countdown procedures.

2.3 Test Equipment

- a. Gaseous nitrogen source to conform with MIL-P-27401B, Type I.
- b. Source regulator and gauge system capable of 0-150 psi range.
- c. Source-to-Pressurization Unit hose capable of attaching to inlet port fitting, AN 832-4D.
- d. ALSD Pressurization Unit (467A8090000-009).

2.4 Failure/Malfunction Criteria - Failure of the unit to meet the performance requirements specified herein shall constitute a malfunction. Each malfunction will require an investigation to determine cause.

2.5 Test Preparations

- 2.5.1 Enter assembly serial number and date of test in Table VIII. 1.
- 2.5.2 Obtain local barometric reading and temperature and enter in Table VIII. 1.
- 2.5.3 Select a test site which will provide minimal ambient temperature variations.
- 2.5.4 Inspect hoses, fittings, and seals for cleanliness and functional discrepancies.

2.6 Special Considerations

- 2.6.1 Special precautions shall be observed to prevent contamination of the unit under test, the test unit, and the test unit accessories.
- 2.6.2 Safety precautions applicable to low pressure equipment shall be observed.
- 2.6.3 Special care should be exercised in the assembly and disassembly of fittings and relief valves to prevent damage to threads, seals, and sealing surfaces.
- 2.6.4 Seal verification tests shall be made at ambient temperatures.
- 2.6.5 Barometric readings shall be corrected to ambient temperatures, using the Correction Chart, Table VIII. 2.
- 2.6.6 Test data shall be recorded in Table VIII. 1 and verified by Quality Assurance.

2.7 Performance Requirements

2.7.1 Power Head Purging, Relief Valve, and Pressure Decay Test

- 2.7.1.1 Remove pressure relief valve from power head.
- 2.7.1.2 Assemble relief valve and test components as illustrated in Figure VIII. 2.
- 2.7.1.3 Disengage regulator on Pressurization Unit by turning counterclockwise several turns. Close all remaining valves.
- 2.7.1.4 Set regulator on nitrogen tank to approximately 75 psig.
- 2.7.1.5 Remove power head oil filler screw and slowly open the supply and isolation valves.
Note: Pressure gauge on pressurization unit should indicate zero pressure. Open manometer isolation valve.
- 2.7.1.6 Position power head so that oil port is vertical and very slowly close regulator while monitoring oil port for escaping nitrogen. Set regulator so that nitrogen escapes without ejecting oil (approximately .5 inches on manometer). Allow power head to purge for approximately five (5) minutes. Record time.
- 2.7.1.7 Wipe away any oil residue which may have collected and replace oil port screw and seal. Close manometer isolation valve.
- 2.7.1.8 Close regulator slowly until the power head relief valve cracks. Note reading on gauge and record. Pressure reading should be 25 ± 2 psig.
- 2.7.1.9 Reduce pressure to 23 psig with regulator. Close the isolation valve and then the supply valve.
- 2.7.1.10 Allow power head pressure to stabilize for fifteen (15) minutes. Record. A rapid drop in pressure indicates a leak. Check for leakage using a liquid leak detector.
- 2.7.1.11 Record starting time, gauge pressure, and temperature.
- 2.7.1.12 Allow three (3) hours plus-or-minus ten (10) minutes to elapse before making final readings of temperature and gauge pressure.
- 2.7.1.13 Any decrease in pressure shall be less than 0.20 psig of the pressure recorded in paragraph 2.7.1.11 as computed by the following formula:

$$\frac{\text{Initial Pressure} \times (459.6 + ^\circ\text{F at end of test})}{(459.6 + ^\circ\text{F at start of test})}$$
- 2.7.1.14 Disassemble test components, place in bags and restow with the unit.
- 2.7.1.15 Screw relief valve into power head until it bottoms tightly on boss.

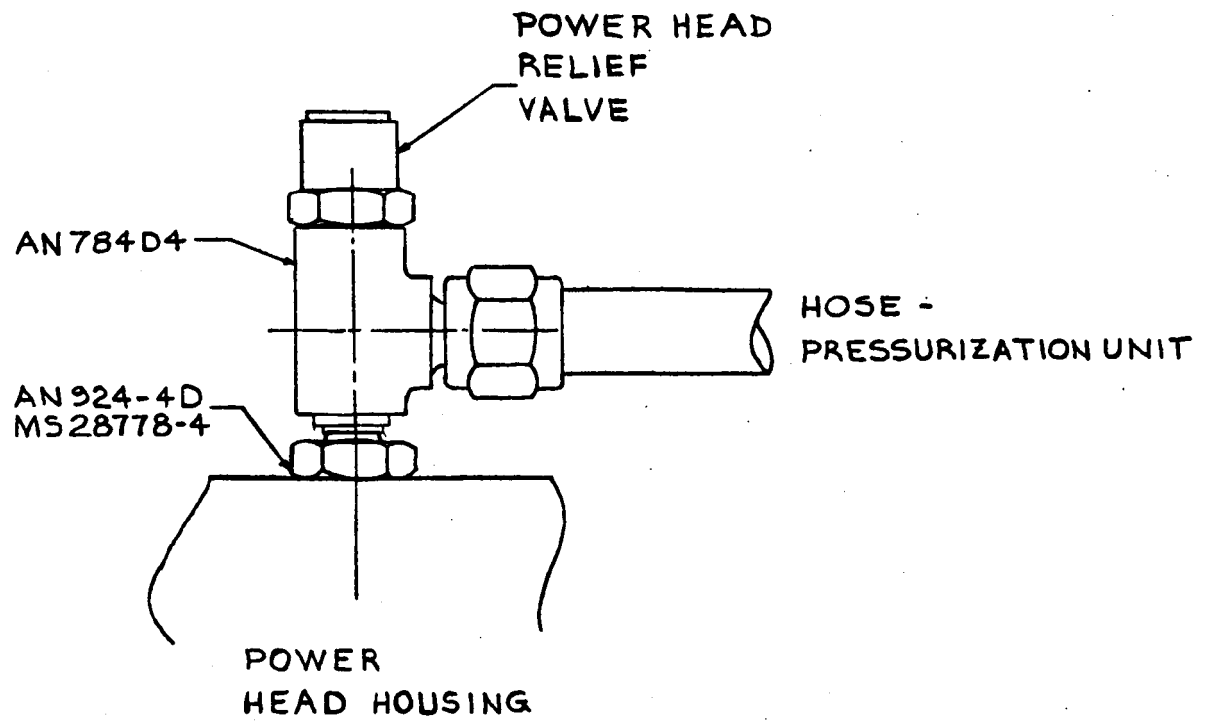


Figure VIII.2 Power Head/Pressurization Unit Interface

- 2.7.2 Battery Assembly Purging, Relief Valve and Pressure Decay Test
 - 2.7.2.1 Disassemble pressure relief valve from Battery Assembly housing.
 - 2.7.2.2 Assemble relief valve and test components as illustrated in Figure VIII. 3.
 - 2.7.2.3 Loosen screws consecutively on Battery Assembly cover plate.
 - 2.7.2.4 Disengage pressurization unit regulator by turning counterclockwise several turns and close all remaining valves.
 - 2.7.2.5 Set regulator on nitrogen tank to approximately 75 psig. Open the low pressure relief valve.
 - 2.7.2.6 Open the supply valve and isolation valve and slowly adjust regulator for a gauge indication of 3 psig. Nitrogen gas should be escaping around Battery Assembly cover.
 - 2.7.2.7 Allow Battery Assembly to purge for approximately one (1) minute. Record time. While still under pressure, retighten Battery Assembly cover screws consecutively to 8-12 inch-pounds in 4-6 inch-pound increments.
 - 2.7.2.8 Adjust regulator (clockwise) until relief valve on Battery Assembly housing cracks. Gauge should read $4.5 \pm .5$ psi. Record cracking pressure.
 - 2.7.2.9 Adjust regulator for a gauge indication of 3.0 psi.
 - 2.7.2.10 Slowly open manometer isolation valve. Close the isolation valve, and then the supply valve.
 - 2.7.2.11 Allow pressure to stabilize for a minimum of fifteen (15) minutes. Record elapse time.
Note: Any rapid decrease in pressure indicates a leak. Check for leaks using a liquid leak detector.
 - 2.7.2.12 Record starting time, temperature, barometric pressure and manometer pressure (read at crown of mercury column). Use Table VIII. 2 for temperature correction of barometer reading.
 - 2.7.2.13 Allow three (3) hours $\pm$ ten (10) minutes to elapse before taking final readings. Record elapsed time, barometric pressure, manometer pressure and temperature.
 - 2.7.2.14 Using the chart below which takes into account temperature and barometer changes during the test, compute for a result in Line 11. This result shall be no more than 0.1 inches of manometer reading recorded in 2.7.2.12 above. Record on Table VIII. 1.
 - 2.7.2.15 Reduce pressure to zero by turning regulator counterclockwise.
 - 2.7.2.16 Disassemble Battery Assembly relief valve and quickly screw into Battery Assembly housing until it bottoms tightly on boss. Lockwire as required.

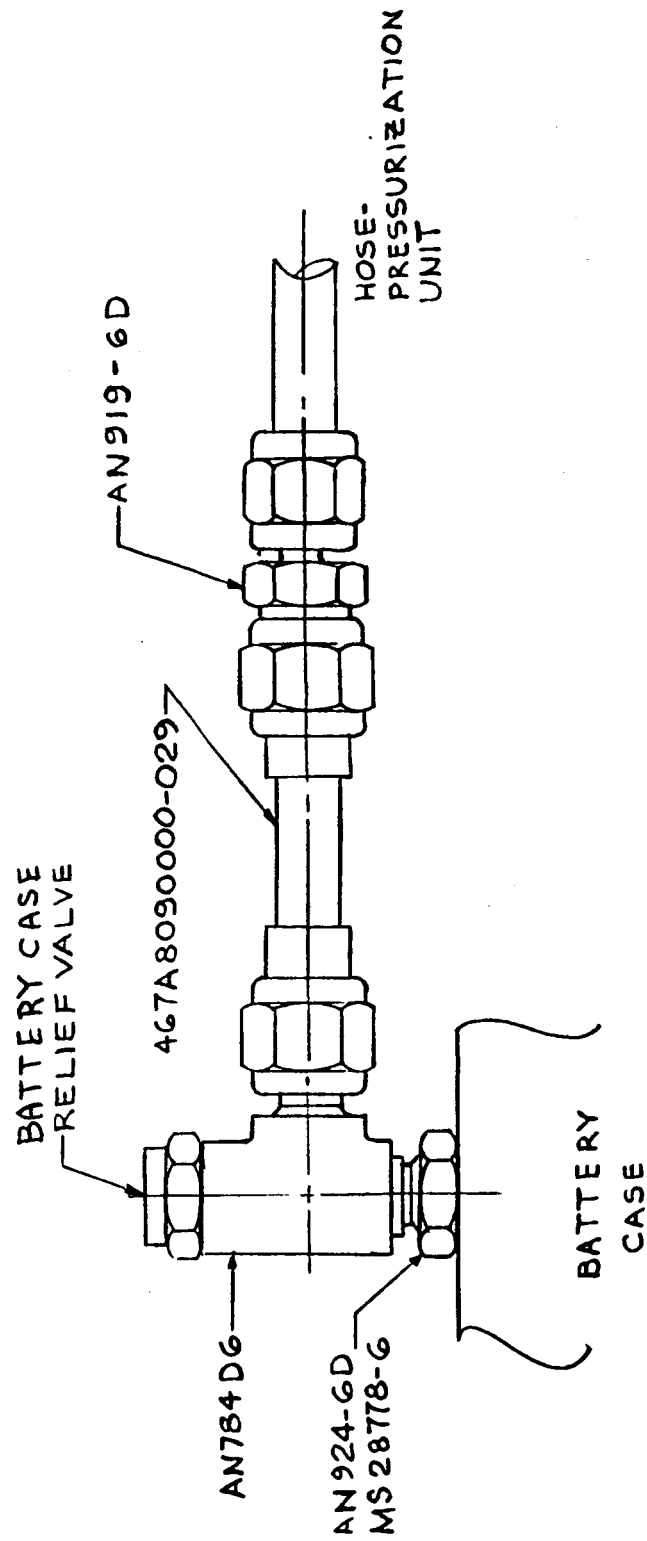


Figure VIII.3 Battery Case/Pressurization Unit Interface

2.7.2.17 Disassemble remaining test components, place in bags and restow with the Pressurization Unit.

- | | | |
|-----|-------------------------------------|--|
| 1) | Manometer reading at start of test | () |
| 2) | Barometer reading at start of test | (+)
<hr/> |
| 3) | Absolute Pressure (start) | () |
| 4) | Temperature (start) °F + 459.6 | () |
| 5) | Temperature (completion) °F + 459.6 | () |
| 6) | Divide Line 5 by Line 4 | () |
| 7) | Multiply Line 6 by Line 3 | () |
| 8) | Barometer reading (completion) | () |
| 9) | Manometer reading (completion) | (+)
<hr/> |
| 10) | Absolute Pressure (completion) | () |
| 11) | Subtract Line 10 from Line 7 | <div style="border: 1px solid black; width: 100px; height: 20px;"></div> |

Table VIII. 1 ALSD Pressurization System Verification Data Sheet

POWER HEAD			
REF. PARA.	DATA DESCRIPTION	DATA ENTRY	QUALITY CONTROL
2.5.1	Serial Number		
2.5.1	Test Date		
2.5.2	Local Barometer Pressure		
2.5.2	Ambient Temperature		
2.7.1.6	Purging Time		
2.7.1.8	Cracking Pressure		
2.7.1.10	Stabilization Time		
2.7.1.11	Gauge Pressure		
2.7.1.11	Starting Time		
2.7.1.11	Ambient Temperature		
2.7.1.12	Elapse Time		
2.7.1.13	Pressure Change		
NOTE: Temperature in °F.			
BATTERY ASSEMBLY			
REF. PARA.	DATA DESCRIPTION	DATA ENTRY	QUALITY CONTROL
2.5.1	Serial Number		
2.5.1	Test Date		
2.5.2	Local Barometer Pressure		
2.5.2	Ambient Temperature		
2.7.2.7	Purging Time		
2.7.2.8	Cracking Pressure		
2.7.2.11	Stabilization Time		
2.7.2.12	Manometer Reading		
2.7.2.12	Starting Time		
2.7.2.12	Ambient Temperature		
2.7.2.12	Local Barometer Pressure		
2.7.2.13	Elapse Time		
2.7.2.13	Local Barometric Pressure		
2.7.2.13	Manometer Pressure		
2.7.2.13	Ambient Temperature		
2.7.2.14	Pressure Change		
NOTE: Temperature in °F.			

Table VIII.2 Barometer Correction Chart (Sheet 1 of 2)

CORRECTION FOR BAROMETER OBSERVED HEIGHT IN INCHES																	
TEMP OF	27.5 IN.	27.75 IN.	28.0 IN.	28.25 IN.	28.5 IN.	28.75 IN.	29.0 IN.	29.25 IN.	29.5 IN.	29.75 IN.	30.00 IN.	30.25 IN.	30.5 IN.	30.75 IN.	31.00 IN.	31.25 IN.	31.50 IN.
60	.078	.079	.080	.0805	.081	.0815	.082	.083	.084	.0845	.085	.086	.087	.0875	.088	.089	.090
61	.080	.081	.082	.083	.0835	.084	.085	.086	.0865	.087	.088	.0885	.089	.090	.091	.092	.093
62	.083	.084	.085	.0855	.086	.087	.088	.0885	.089	.090	.091	.0915	.092	.093	.094	.0945	.095
63	.085	.086	.087	.088	.089	.0897	.090	.091	.092	.093	.0935	.094	.095	.096	.0965	.097	.098
64	.088	.089	.090	.091	.092	.0925	.093	.094	.095	.0955	.096	.097	.098	.0985	.099	.100	.101
65	.090	.091	.092	.093	.094	.095	.0955	.096	.097	.098	.0985	.099	.100	.101	.102	.103	.104
66	.093	.094	.095	.096	.097	.0975	.098	.099	.100	.1005	.101	.102	.103	.104	.105	.106	.107
67	.095	.096	.097	.098	.099	.100	.1005	.101	.102	.103	.104	.105	.106	.107	.108	.109	.110
68	.098	.099	.100	.101	.102	.1025	.103	.104	.105	.106	.107	.108	.109	.1095	.110	.111	.113
69	.100	.101	.102	.103	.104	.105	.106	.107	.108	.109	.110	.111	.112	.1125	.113	.114	.115
70	.103	.104	.105	.106	.107	.108	.109	.110	.111	.1115	.112	.113	.115	.1155	.116	.117	.118
71	.105	.106	.107	.108	.109	.110	.111	.112	.113	.114	.115	.116	.117	.118	.119	.120	.121
72	.108	.109	.110	.111	.112	.113	.114	.115	.116	.117	.118	.119	.120	.121	.122	.123	.124
73	.110	.111	.112	.113	.114	.115	.116	.117	.118	.119	.120	.121	.123	.124	.125	.126	.127
74	.113	.114	.115	.116	.117	.118	.119	.120	.121	.122	.123	.124	.126	.1265	.127	.128	.130
75	.115	.116	.117	.118	.119	.120	.121	.122	.124	.1245	.125	.127	.128	.129	.130	.131	.132

Table VIII.2 Barometer Correction Chart (Sheet 2 of 2)

CORRECTION FOR BAROMETER OBSERVED HEIGHT IN INCHES																	
FEET OF	27.5 IN.	27.75 IN.	28.0 IN.	28.25 IN.	28.5 IN.	28.75 IN.	29.0 IN.	29.25 IN.	29.5 IN.	29.75 IN.	30.00 IN.	30.25 IN.	30.5 IN.	30.75 IN.	31.00 IN.	31.25 IN.	31.50 IN.
76	.118	.119	.120	.121	.122	.123	.124	.125	.127	.1275	.128	.129	.131	.132	.133	.134	.135
77	.120	.121	.122	.123	.125	.126	.127	.128	.129	.130	.131	.132	.134	.135	.136	.137	.138
78	.123	.124	.125	.126	.128	.1285	.129	.130	.132	.133	.134	.135	.137	.1375	.138	.139	.141
79	.125	.126	.127	.129	.130	.131	.132	.133	.134	.135	.136	.138	.139	.140	.141	.142	.144
80	.128	.129	.130	.131	.133	.134	.135	.136	.137	.138	.139	.140	.142	.143	.144	.145	.147
81	.130	.131	.132	.134	.135	.136	.137	.138	.140	.141	.142	.143	.145	.146	.147	.148	.149
82	.133	.134	.135	.136	.138	.139	.140	.141	.143	.144	.145	.146	.148	.149	.150	.150	.152
83	.135	.136	.137	.139	.140	.141	.142	.144	.145	.146	.147	.149	.150	.151	.152	.153	.155
84	.138	.139	.140	.141	.143	.144	.145	.146	.148	.149	.150	.151	.153	.154	.155	.156	.158
85	.140	.141	.142	.144	.145	.146	.147	.149	.150	.151	.152	.154	.156	.157	.158	.159	.161
86	.143	.144	.145	.146	.148	.149	.150	.151	.153	.154	.155	.157	.159	.160	.161	.162	.164
87	.145	.146	.147	.149	.150	.151	.152	.154	.156	.157	.158	.159	.161	.162	.163	.165	.166
88	.148	.149	.150	.151	.153	.154	.155	.157	.159	.160	.161	.162	.164	.165	.166	.167	.169
89	.150	.151	.152	.154	.155	.156	.158	.159	.161	.162	.163	.165	.167	.168	.169	.170	.172
90	.153	.154	.155	.156	.158	.159	.161	.162	.164	.165	.166	.168	.170	.171	.172	.173	.175

3.0 ALSD BATTERY CHARGING UNIT OPERATIONAL READINESS VERIFICATION

3.1 Purpose - This procedure establishes the inspection and test requirements for detecting any malfunctioning or defective components within the ALSD Battery Charging Unit.

3.2 Operational Readiness Verification Time Interval - This procedure shall be performed in accordance with the following schedule.

- a. Upon receipt of equipment at field location.
- b. At intervals thereafter not exceeding ninety (90) days.

3.3 Test Equipment Requirements

- a. Multimeter, Simpson Model 260 or equivalent.
- b. Voltmeter, DC 0-50 Volts, Weston Model 901 or equivalent.
- c. Ammeter, DC 0-10 Amperes, Weston Model 901 or equivalent.
- d. Resistor, $10 \pm 20\%$ Ohms, 200 Watts.
- e. Power source, 105 to 120 VAC, 60 cps, single phase.

3.4 Failure/Malfunction Criteria - Failure of the unit to meet the performance requirements specified herein shall constitute a malfunction. Each malfunction will require an investigation to determine cause.

3.5 Visual Examination - This unit shall be visually examined for cleanliness. Particular attention shall be given to the following:

- a. Condition of material finishes.
- b. Satisfactory tightness of assembly bolts and screws.
- c. Freedom from contamination, such as corrosion products, scale, grease, etc.
- d. Condition of connector pins and jacks.

3.6 Equipment Description - The ALSD Battery Charging Unit consists of a Yardney Electric Corporation SILVERCEL Charger, Model VC 24-10 and a battery adapter unit. The VC 24-10 employs a full wave AC-to-DC bridge rectifier and automatic control circuitry required for providing the ALSD battery charging current. The charging current is routed through a charging cable to the adapter unit, which contains the necessary electrical and mechanical hardware for interfacing with the ALSD battery assembly. A schematic of the unit is presented in Figure VIII. 4.

3.7 Performance Requirements

3.7.1 Adapter Unit Continuity

- 3.7.1.1 Adjust Simpson 260 for R x 1 continuity test. Measure resistance between battery adapter unit red charging cable jack and pin A of receptacle. Simpson meter shall read less than 0.2 ohms.
- 3.7.1.2 Adjust Simpson 260 for R x 1 continuity test. Measure resistance between battery adapter unit black charging cable and pin B of receptacle. Simpson meter shall read less than 0.2 ohms.

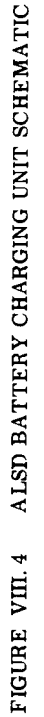


FIGURE VIII. 4 ALSD BATTERY CHARGING UNIT SCHEMATIC

3.7.2 VC 24-10 Charging Circuit Checkout

3.7.2.1 Position switches as follows:

- a. Power switch to Off.
- b. Current control completely counterclockwise.
- c. Cell selector switch to position 16.
- d. Ammeter selector switch to 0-10 position.

3.7.2.2 Connect 10 ohm 200 watt resistor and Weston 901 ammeter (0-10 amps) in series across the 5-10 amps output jacks observing correct polarity.

3.7.2.3 Connect a Weston 901 voltmeter (0-50 volts) across the 5-10 amps output jacks observing correct polarity.

3.7.2.4 Connect VC 24-10 power cable to 105-120 VAC, 60 cps source.

3.7.2.5 Place power switch on. Red power on and charging current on indicators shall illuminate.

3.7.2.6 Depress calibrate switch and adjust bottom screw on cut-off meter until indicator aligns with CAL mark. Release calibrate switch.

3.7.2.7 Align red pointer on cut-off meter with the red line on the dial by adjustment of the small knob on the front of the cut-off meter.

3.7.2.8 Rotate current control slowly clockwise until Weston 901 ammeter indicates 2.0 amperes. VC 24-10 ammeter shall indicate 2.0 ± 0.2 amperes.

3.7.2.9 Rotate current control slowly clockwise until charging current on indicator goes out and charging current off indicator illuminates. At switch-over, the Weston 901 voltmeter shall indicate 32 ± 0.65 VDC.

3.7.2.10 Depress reset switch. Charging current off indicator shall go out. Release reset switch.

3.7.2.11 Turn power switch to off. Disassemble test setup.

4.0 ALSD BATTERY ACTIVATION PROCEDURES

4.1 Purpose - This procedure establishes the operating procedures for activating the dry charged ALSD Training (PS9403000014-001) and Flight (PS9403000014-003) Model Battery Assemblies.

4.2 Activation Time Intervals - This procedure shall be performed in accordance with the following schedule.

- a. Flight model batteries shall be activated in accordance with the Apollo countdown schedule specified in another section of this manual.
- b. Training model batteries shall be activated at the beginning of ALSD operational training and when cell set replacements are required.

4.3 Test Equipment Requirements

- a. Voltmeter, DC 0-3 volts, Weston Model 531 or equivalent.
- b. Torque Wrench, 0-50 inch-pounds.
- c. Battery Filler Kit (Yardney Part No. 11294 for training models and No. 11310 for flight models).

4.4 Failure/Malfunction Criteria - Failure of the unit to meet the performance requirements specified herein shall constitute a malfunction. Each malfunction will require an investigation to determine cause.

4.5 Visual Examination - This unit shall be visually examined for cleanliness. Particular attention shall be given to the following:

- a. Condition of material finishes.
- b. Freedom from contamination, such as corrosion products, scale, grease, etc.
- c. Satisfactory tightness of assembly bolts and screws, electrical receptacle, relief valve, and switch cover.
- d. Condition of electrical connector pins.

4.6 Equipment Description - The ALSD Battery Assembly contains sixteen (16) silver-zinc cells, pressure relief valve, control switch with sealing boot, electrical receptacle, interconnecting wiring and mechanical hardware required to interface with the ALSD Power Head and Handle Assembly.

4.7 Precautions

4.7.1 Electrolyte Characteristics - The electrolyte (a strong solution of potassium hydroxide) is alkaline and corrosive, and should be handled with care. If neglected, the electrolyte will cause serious burns when it is permitted to come in contact with the eyes or skin. Alkali-proof apron, rubber gloves and splash-proof goggles or a face mask are recommended for personnel engaged in filling and servicing SILVERCEL batteries.

4.7.2 Antidotes, Internal - Give large quantities of water and a weak acid solution such as vinegar, lemon juice or orange juice. Follow with one of the following: white-of-egg, olive oil, starch water, mineral oil, or melted butter. Obtain medical attention at once.

4.7.3 Antidotes, External - For the skin: wash the affected area with large quantities of water. Neutralize with vinegar, lemon juice, or 5% acetic acid and wash with water. Obtain medical attention at once. For the eyes: wash with saturated solution of boric acid or flood with water. Use this first aid treatment until medical aid can be summoned.

4.7.4 Washing Glassware - The electrolyte is somewhat corrosive to glass. All beakers and syringes used should be thoroughly washed with water following their contact with the electrolyte.

4.7.5 Carbon Dioxide Absorption - Store the electrolyte in closed alkali resistant containers as it absorbs carbon dioxide from the air. Prolonged exposure to the air will impair the properties of the electrolyte.

CAUTION: Do not, under any circumstances, attempt to use any type of electrolyte other than the special electrolyte furnished with the SILVERCEL battery. Other types of electrolyte may damage or destroy the battery.

4. 7. 6 Handling Precautions - This battery is capable of supplying unusually high currents if it is accidentally short circuited. A prolonged short circuit may cause serious burns to personnel and may destroy the battery. To avoid accidental short circuits, all tools used in connection with the battery or within close vicinity of the battery must be properly insulated with a double layer of electrical tape or varnish.

CAUTIONS:

- a. The battery shall be kept in an upright position under normal handling and operating conditions.
- b. In fastening the battery cover to the case, tighten the 18 hex head nuts (in increments of 4-6 inch-pounds) to a total torque of 12-16 inch-pounds. The hex head nuts should be tightened in a consecutive clockwise order. Do not use the criss-cross method of tightening nuts.

4. 8 Battery Activation Procedures

4. 8. 1 Filler Kit Items - Each battery is furnished with a battery filler kit containing the following items:

<u>Quantity</u>	<u>Description</u>
16	One ounce polyethylene filling bottles containing 21 cc of 42% KOH electrolyte (18 cc for flight batteries).
2	Filler caps for 1-ounce bottles.
6	Vent cleaners
1 Pr.	Tweezers
1/4-Oz.	Absorbent cotton
5	Cell screw valve assembly (spares).
1 Set	Operating Instructions

4. 8. 2 Cell Filling Procedure - To properly fill each cell of the battery with electrolyte, proceed as follows:
4. 8. 2. 1 Remove the battery cover and rubber sealing gasket by removing the 18 hex head nuts.
 4. 8. 2. 2 Remove the cell screw valve from each cell of the battery. Retain for re-insertion after filling.
 4. 8. 2. 3 Remove the cap from an electrolyte bottle containing the proper amount of electrolyte for one cell.
 4. 8. 2. 4 Screw one of the polyethylene filling caps securely onto the electrolyte bottle.
 4. 8. 2. 5 Screw the filling cap tip into the cell vent threaded hole, turning clockwise to a flush fit.
 4. 8. 2. 6 Squeeze the electrolyte bottle gently, maintaining the pressure for a few seconds to avoid drawing back electrolyte into the bottle. Repeat this operation slowly until all of the electrolyte has been transferred into the cell. If the electrolyte

is repeatedly drawn back into the bottle, wait for a few minutes until the level in the cell decreases; then introduce the remaining electrolyte into the cell. Do not remove the filling bottle from the cell until all the electrolyte is transferred into the cell.

- 4.8.2.7 After filling is completed, remove any excess electrolyte from the vent hole by using the vent cleaner. Insert a vent cleaner, up to the knot, into the cell vent hole and turn for one complete revolution. Use a new vent cleaner for each cell.
- 4.8.2.8 Remove any excess electrolyte from around the outside of the vent holes with a piece of cotton, using tweezers.
- 4.8.2.9 Replace the cell screw valve into the cell vent hole after the removal of the excess electrolyte is completed. Tighten to a flush fit.

WARNING: It is recommended that the cell screw valves be positioned in the cell vent immediately after the filling of each cell in order to minimize the possibility of filling one cell twice or not filling a cell at all.

- 4.8.2.10 After the filling operation of one cell has been completed, the polyethylene filling cap should be removed from the empty filling bottle, the filling bottle discarded and the filling cap placed on a full bottle for filling of the next cell. This process shall be continued until each of the sixteen (16) cells has been serviced.

SOAKING PERIOD: After filling the battery with electrolyte, allow the battery to soak for a minimum of 48 hours before continuing test. Battery cover and sealing gasket shall be installed on the battery and 18 hex head nuts finger-tightened on studs during soaking period. Record serial number and activation date on Table VIII. 3.

4.9 Battery Voltage Checks

- 4.9.1 Cell Voltage Check - Remove battery cover by removing the 18 hex head nuts. Using the Weston Model 531 voltmeter, measure the terminal voltage of each cell for 1.85 ± 0.03 VDC. Record cell voltages in Table VIII. 3.
- 4.9.2 Voltage Leakage Check - Depress Hexseal boot switch cover. Using the Weston Model 531 voltmeter, sequentially measure the voltage between Pin A and case, and Pin B and case of the electrical receptacle. Voltmeter shall read 0 volts. Record on Table VIII. 3.
- 4.9.3 Battery Voltage Check - Depress Hexseal boot switch cover. Using the Weston Model 901 voltmeter, measure the voltage between Pins A and B of the electrical receptacle. Pin A shall be $+29.6 \pm 0.5$ VDC with respect to Pin B.

Table VIII. 3 ALSD Battery Assembly Activation Data Sheet

REF. PARA.	DATA DESCRIPTION	TOLERANCE	DATA ENTRY	QUALITY CONTROL
4. 8. 2. 10	Battery Serial Number	N/A		
4. 8. 2. 10	Activation Date	N/A		
4. 9. 1	Cell No. 1 Voltage	$1.85 \pm .03$ VDC		
"	" No. 2 "	"		
"	" No. 3 "	"		
"	" No. 4 "	"		
"	" No. 5 "	"		
"	" No. 6 "	"		
"	" No. 7 "	"		
"	" No. 8 "	"		
"	" No. 9 "	"		
"	" No. 10 "	"		
"	" No. 11 "	"		
"	" No. 12 "	"		
"	" No. 13 "	"		
"	" No. 14 "	"		
"	" No. 15 "	"		
"	" No. 16 "	"		
4. 9. 2	Leakage Pin A to Case	0 VDC		
4. 9. 2	Leakage Pin B to Case	0 VDC		
4. 9. 3	Battery Voltage Check	$29.6 \pm .5$ VDC		
4. 9. 3	Pin A Positive	N/A		

4.9.4 Final Battery Inspection

- 4.9.4.1 Visually inspect top of battery cells to ensure that cell cases and terminals are free of corrosion and electrolyte. Clean top of cells if required.
Note: During reinspection cycles of training batteries, vent holes and caps should be inspected to assure that they are not clogged.
- 4.9.4.2 Replace the rubber sealing gasket and battery cover on case. Fasten cover to the case with the 18 hex head nuts previously removed, tightening them (in increments of 4-6 in-lbs) to a torque of 12-16 inch-pounds. The hex head nuts should be tightened in a consecutive clockwise order. Do not use the criss cross method of tightening nuts.

5.0 ALSD BATTERY CHARGING PROCEDURE

5.1 Purpose - This procedure establishes the operating procedures for charging the ALSD Training (PS9403000014-001) and Flight (PS9403000014-003) Model Battery Assemblies.

5.2 Charging Time Intervals - This procedure shall be performed in accordance with the following schedule.

- a. Training model batteries shall be recharged after each 16-minute operational discharge period.
- b. Flight model batteries shall not be recharged unless directed by the ALSEP countdown controller.

5.3 Test Equipment Requirements

- a. ALSD Battery Charging Unit
- b. Power Source, 105 to 120 VAC, 60 cps, single phase.

5.4 Failure/Malfunction Criteria - Failure of the unit to meet the performance requirements specified herein shall constitute a malfunction. Each malfunction will require an investigation to determine cause.

5.5 Visual Examination - The ALSD battery shall be visually examined for cleanliness. Particular attention shall be given to the following:

- a. Condition of material finishes.
- b. Freedom from contamination, such as corrosion products, scale, grease, etc.
- c. Satisfactory tightness of assembly bolts and screws, electrical receptacle, relief valve, and switch cover.
- d. Condition of electrical connector pins.

5.6 Equipment Description - The ALSD Battery Charging Unit (described in paragraph VIII. 3.0) shall be used to charge the battery assembly described in paragraph VIII. 4.0.

5.7 Battery Charger Calibration

- 5.7.1 Position switches

- 5.7.1.1 Power switch to off.
- 5.7.1.2 Current control knob completely counterclockwise.
- 5.7.1.3 Cell selector switch to position 16.
- 5.7.2 Connect battery charger power cable to 105-120 VAC, 60 cps source.
- 5.7.3 Turn power switch to on. Red power on indicator shall illuminate.
- 5.7.4 Depress calibrate switch and adjust bottom screw on cutoff meter until indicator aligns with CAL mark. Release calibrate switch.
- 5.7.5 Align red pointer on the cutoff meter with the red line on the dial by adjustment of the small knob on the front of the cutoff meter.
- 5.7.6 Turn power switch to off. Red power on indicator shall go out.
- 5.8 Battery Charging
- 5.8.1 Install battery assembly on battery charger adapter unit. Ensure careful engagement of mechanical alignment pins and electrical receptacle pins to prevent damage.

Note: For best results, all charging should be done at an ambient temperature of 65°F to 90°F.
- 5.8.2 Connect battery charger adapter leads (red and black) to their respective 10-ampere output jacks on the charger.
- 5.8.3 Verify that current control knob is completely counterclockwise and cell selector switch is in position 16.
- 5.8.4 Turn power switch to on and depress Hexseal boot switch cover on battery assembly. Red power on indicator and white charging current on indicator shall illuminate.
- 5.8.5 Slowly rotate current control knob clockwise until the following current level is indicated on the current meter:
 - a. Training battery initial charging current to be adjusted to 1.0 amperes.
 - b. Flight battery initial charging current to be adjusted to 2.0 amperes.

Note: When charging is complete (approximately 12-16 hours for a fully discharged battery) the current will automatically shut off. At this time, the white charging current on indicator shall go out and the amber charging current off indicator shall illuminate.
- 5.8.6 Turn power switch to off and remove battery assembly from adapter box.

6.0 ALSD POWER HEAD INSPECTION AND SERVICE INSTRUCTIONS

6.1 Purpose - This procedure establishes the field level inspection and service instructions for the ALSD Power Head, Part No. PS95500000-001, -003, -005, and -007.

6.2 Inspection Time Intervals (Training Models) - This procedure shall be performed in accordance with the following schedule.

- a. Percussor cam lubrication through external port shall be accomplished after each 0.5 hours of operation.
- b. Internal lubrication and inspection shall be accomplished after each 2.0 hours of operation, or after any operating period which is to be followed by non-operating storage for a period exceeding one month.
- c. Battery assembly internal inspection and checkout shall be accomplished monthly or after each sixth discharge cycle, whichever occurs first.
- d. Power head to be returned for factory inspection and checkout after each 10.0 hours of operation.

6.3 Inspection Time Intervals (Flight Models) - This procedure shall be performed in accordance with the following schedule.

- a. Internal lubrication and inspection shall be accomplished during Apollo flight countdown as described elsewhere in this manual.

6.4 Test Equipment Requirements

- a. DuPont 143 AC Krytox fluorinated oil (supplied in Lube Kit).
- b. DuPont 240 AC Krytox fluorinated grease (supplied in Lube Kit).
- c. Oil filler cap (supplied in Lube Kit).

6.5 Failure/Malfunction Criteria - Failure of the unit to meet the performance requirements specified herein shall constitute a malfunction. Each malfunction will require an investigation to determine cause.

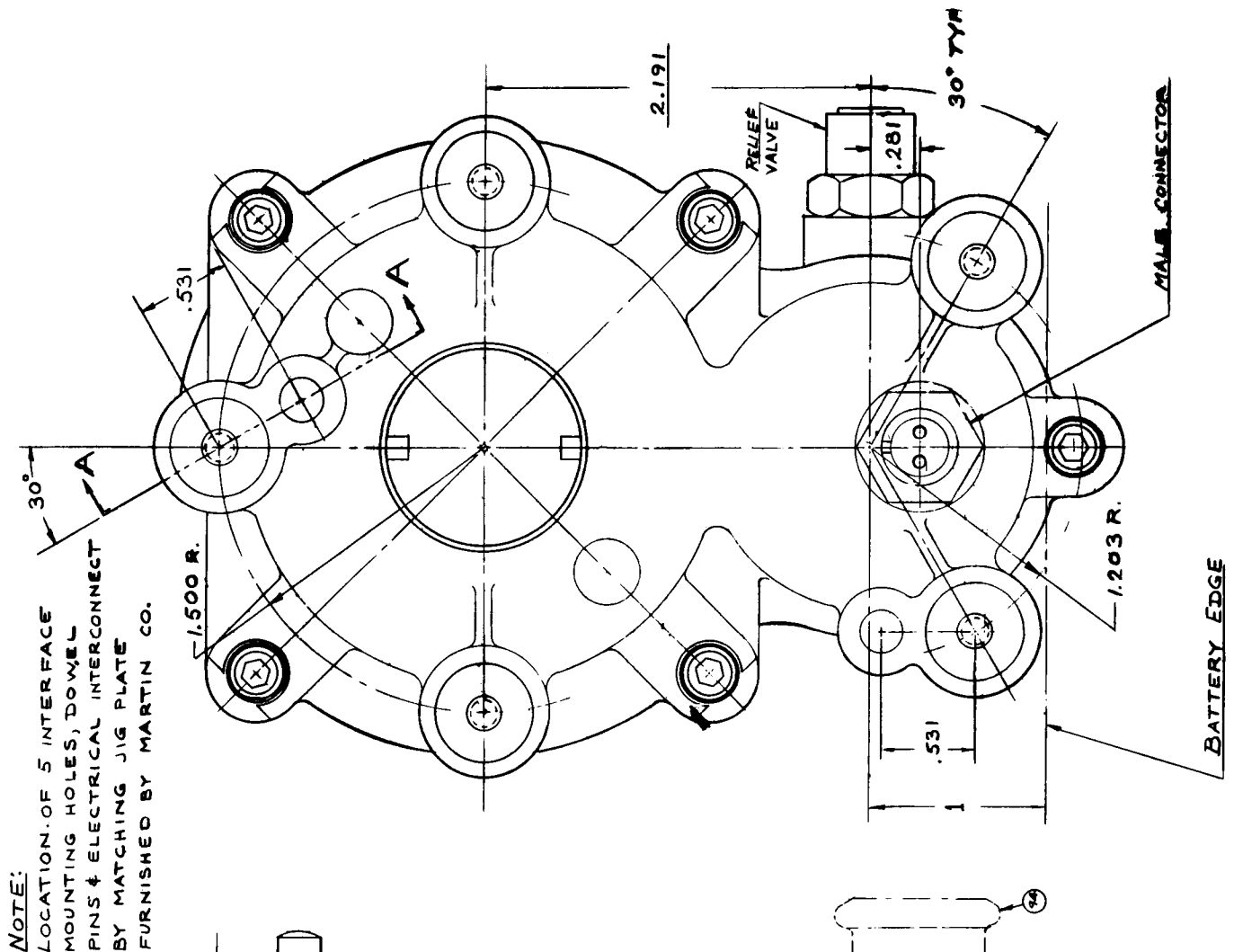
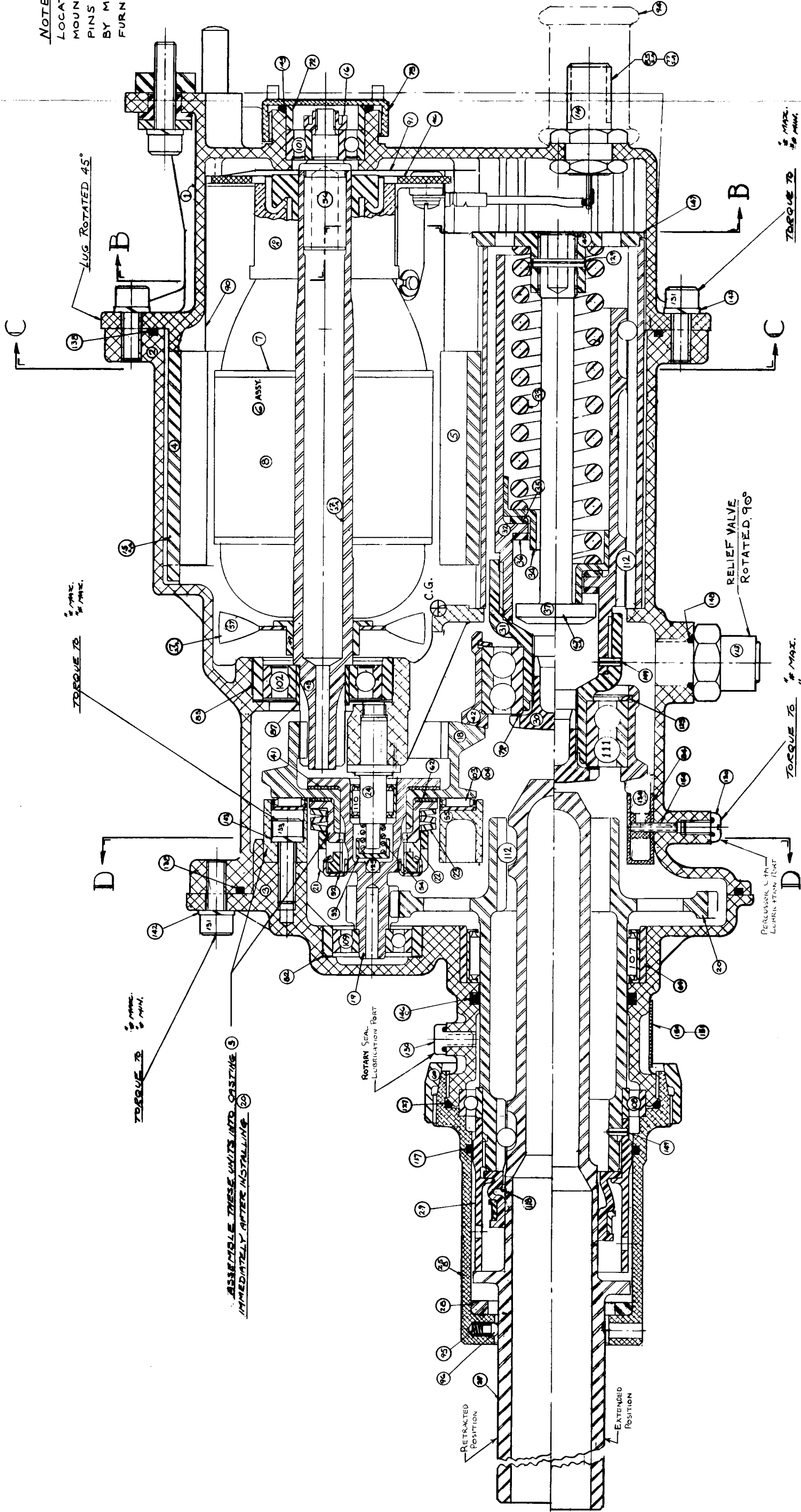
6.6 Visual Examination - The ALSD power head shall be visually examined for cleanliness. Particular attention shall be given to the following:

- a. Condition of material finishes.
- b. Freedom from contamination, such as corrosion products, scale, grease, etc.
- c. Satisfactory tightness of assembly bolts and screws, electrical receptacle, and relief valve.
- d. Condition of electrical connector pins.

6.7 Equipment Description - The ALSD power head is an electric motor-driven, rotary-percussion machine capable of core drilling rock materials ranging in hardness from loose debris to high density basalt. A cut-away assembly drawing of the power head is illustrated in Figure VIII. 5.

6.8 Percussor Cam Lubrication (External Port)

6.8.1 Remove lubrication port screw (Part 130, Figure VIII. 5).



VIII-24A

VIII-24B

FOLDOUT FRAME

FOLDOUT FRAME

FOLDOUT FRAME

VIII-24C

- 6.8.2 Assemble oil filler cap to Krytox 143 AC oil bottle.
- 6.8.3 Apply five (5) drops of oil through lubrication port to cam lubrication pad (Part 134).
- 6.8.4 Replace lubrication port screw and torque to 8-10 inch-pounds.
- 6.9 Internal Lubrication and Inspection
- 6.9.1 Remove five (5) hex head screws and washers (Parts 131, 142) which bolt the front end housing (Part 3) to center housing (Part 2).
- 6.9.2 Manually disengage front end housing from center housing.
- 6.9.3 Remove spring (Part 54) from cup (Part 53) and temporarily stow in safe location.
- 6.9.4 Inspect interior of front and center housings for the following:
 - a. Gear teeth (Parts 18, 19, 20, 45) for evidence of breakage or chipping.
 - b. Evidence of metal chips or other foreign materials.
 - c. Evidence of scouring, abrasion or excessive temperatures.
 - d. Excessive deterioration of cam lubricating pad (Part 134).
- 6.9.5 Using a clean cloth, remove excess grease deposits or other foreign materials from housing walls.
- 6.9.6 Apply a light coat of Krytox 240 AC grease to the following components.
 - a. Gear teeth (Parts 18, 19, 20, 45).
 - b. Thrust bearing (Part 103).
 - c. Cam mating surface (Part 18).
 - d. Cam follower mating surface (Part 42).
 - e. Cam follower bearing (Part 111).
- 6.9.7 Saturate cam lubricating pad with Krytox 143 AC oil. (Replace pad if excessively deteriorated.)
- 6.9.8 Insert spring (Part 54) into cup (Part 53).
- 6.9.9 Assemble front end housing to center housing. Tap front end housing lightly with a soft hammer to seat bearings if required.
- 6.9.10 Replace five (5) hex head screws and washers (Parts 131, 142) and torque to 18-20 inch-pounds.
- 6.9.11 Remove seal lubrication port screw (Part 130).
- 6.9.12 Assemble oil filler cap to Krytox 143 AC oil bottle and apply five (5) drops of oil through lubrication port to seal reservoir.
- 6.9.13 Replace lubrication port screw and torque to 8-10 inch-pounds.

6.10 Battery Removal, Inspection, Activation or Recharge

- 6.10.1 Remove five (5) hex head screws and washers (Parts 136, 142) which attach battery assembly to power head.
- 6.10.2 Restrain power head and detach battery assembly by applying separation pressure parallel to the longitudinal axis of the battery/power head assembly. Temporarily stow EMI shield (Part 94) and thermal shield.
- 6.10.3 Examine power head and battery electrical receptacles for possible damage.
- 6.10.4 Perform required inspection, checkout, or activation of battery assembly as follows:
 - a. Battery Activation - Proceed to Paragraph VIII. 4.0
 - b. Battery Charging - Proceed to Paragraph VIII. 5.0
 - c. Battery Checkout and Inspection - Proceed to Paragraph VIII. 4.9

6.11 Installation of Battery to Power Head

- 6.11.1 Ensure that thermal isolation bushings (Part 135) are positioned correctly on power head and that EMI shield and thermal shield are positioned around power head connector.
- 6.11.2 Install battery assembly on power head, ensuring careful engagement of mechanical alignment pins and electrical receptacle pins.
- 6.11.3 Install and tighten five (5) hex head screws and washers (Parts 136, 142) to 18-20 inch-pounds.

IX. KSC PRELAUNCH OPERATIONS

1.0 INTRODUCTION

A preliminary tabulation of KSC prelaunch checkout procedures for the ALSD is presented in Table IX.1. This data will be updated as additional information becomes available.

TABLE IX.1

KSC PRELAUNCH CHECKLIST

<u>Time</u>	<u>Event</u>	<u>Para. Ref.</u>
T - 90 days	Perform Pressurization Unit Operational Readiness Verification.	VIII - 1.0
T - 90 days	Perform Battery Charging Unit Operational Readiness Verification.	VIII - 3.0
T - 90 days	If more than sixty (60) days have elapsed since factory checkout of power head, return ALSD to Martin Marietta Corporation. (Flight Unit and Backup)	N/A
T - 60 days	Perform ALSD Pressurization System Verification. (Flight Unit and Backup)	VIII - 2.0
T - 58 days	Verify ALSD/ALSEP Interface. (Flight Unit and Backup)	N/A
T - 9 days	Perform Power Head Internal Lubrication and Inspection Requirements. (Flight Unit and Backup)	VIII - 6.9
T - 8 days	Perform ALSD Pressurization System Verification - (Power Head only). (Flight Unit and Backup)	VIII - 2.7.1
T - 7 days	Remove and activate Flight Unit Battery	VIII - 4.0
T - 5 days	Install battery. Operate ALSD Power Head for 10 seconds.	N/A
T - 5 days	Perform ALSD Pressurization System Verification.	VIII - 2.0
	NOTE: If any malfunctions are encountered, activate ALSD backup unit battery and resume checkout.	
T - 1 day	Remove power head and battery identification nameplates and install ALSD on-board ALSEP/LM.	N/A

X. ALSD SPARE PARTS DISTRIBUTION

1.0 INTRODUCTION

The following tables present a current tabulation of spares and their distribution as provisioned by the basic contract, NAS 9-6587.

TABLE X. 1

MARTIN MARIETTA GFE STOREROOM SPARE PARTS LEVEL - ALSD

<u>Nomenclature</u>	<u>Quantity</u>
Power Head Percussor Assembly	1 ea.
Power Head Motor Assembly	1 ea.
Power Head Power Train Assembly	1 ea.
Seal Refurbishment Kit	7 ea.
Power Head Casting Sets	2 ea.
Power Head Cam	1 ea.
Power Head Bearing Set	2 ea.
Power Head Gear Set	1 ea.
Power Head Magnet Set	1 ea.
Power Head Motor Brush Set	4 ea.
Power Head Motor Armature	3 ea.
Power Head Percussor Spring	1 ea.
Battery Ass'y./Power Head Electrical Connector Set	2 ea.
Pressure Relief Valve	2 ea.
Battery Electrical Switch	2 ea.

TABLE X. 2

NASA-MSC SPARE PARTS LEVEL - ALSD

<u>Nomenclature</u>	<u>Quantity</u>
Accessory Group	1 ea.
Hole Casing Sleeves	11 ea.
Drill Bits	30 ea.
Drill Bit Extension Tube Sets	3 ea.
Battery Cell Sets (Training)	6 ea.

TABLE X. 3

NASA-KFC SPARE PARTS LEVEL

<u>Nomenclature</u>	<u>Quantity</u>
ALSD Flight Backup Unit	1 ea.
Flight Battery Assemblies	4 ea.

UNITED STATES GOVERNMENT

2-Way Memo

Ag... Goldman

Subject: Conversion to Low Number CR of Support Manual
for Apollo Lunar Surface Drill (ALSD) by
Martin Company NAS 9-6587

DATE OF MESSAGE
7-20-67
DATE OF REPLY
INSTRUCTIONS
Use routing symbols whenever possible.
SENDER:
Forward original and one copy.
Conserve space.
RECEIVER:
Reply below the message, keep one copy, return one copy.

To:

TD2/Mr. McComb

Please supply glossy prints of the following figures to Mr. David N. Holman/BM5, extension 2611:

II.1

III.1 through III.12

VII.1 through VII.5

From:

David N. Holman/BM5

XI. TRANSPORTATION AND STORAGE REQUIREMENTS

1.0 PRESERVATION AND PACKING

1.1 Flight and Training Model ALSD's

The ALSD's will be packaged by the contractor in suitcase-type shipping containers as described in Chapter VII of this manual. The ALSD within the container will be placed in a plastic bag to maintain cleanliness of the unit. A battery will be installed on all ALSD's; spare battery assemblies will be packaged separately for shipment to KSC. Electrolyte filling kits for both the flight and spare battery assemblies will be packaged separately.

No special environmental control devices or environment recording equipment will be required for the ALSD shipping containers. Acceptable humidity levels within the shipping containers will be maintained by use of desiccants.

Over-packing of flight unit shipping containers will not be required due to hand-carrying requirements. Overpacking of training units for shipment by air transportation will be accomplished by the contractor to the extent required to ensure safe delivery.

1.2 Ground Support Equipment

No special environmental control devices or environment recording equipment will be required for the GSE. Equipment will be packaged by the contractor to the extent required to ensure safe air transport to any destination within the continental United States.

2.0 TRANSPORTATION

2.1 Flight Model ALSD's

Flight model ALSD's will be hand-carried by air transportation from the contractor's facility to NASA-MSC for sterilization, and from NASA-MSC to KSC for final checkout and installation aboard the Apollo spacecraft. Temperature extremes during ALSD transport shall not exceed -20°F to $+100^{\circ}\text{F}$.

2.2 GSE and Training Model ALSD's

GSE and Training model ALSD's will be packaged for normal commercial air transportation. Temperature extremes during equipment transport shall not exceed -20°F to $+100^{\circ}\text{F}$.

3.0 STORAGE

3.1 Temperature and Humidity

The ALSD and GSE shall be stored in an area where the temperature is maintained within the range of 30°F to 90°F , with occasional excursions in the range of 0°F to 120°F allowed. The relative humidity shall be maintained within the range of 20 to 80% with occasional excursions up to 95% allowable.

As the cognizant technical representative for the cited contract, it is your responsibility to review the enclosed report and decide whether it should be reported in one of several NASA publications as listed on the enclosed Facility Form No. 545. It is within your authority to either decide that the enclosed report should be reported or to decide that it not be reported for one of several reasons. For example, the document may be excluded from further dissemination if it contains primarily financial information, or organizational structures, or other management type information. It may be excluded because of its preliminary nature, or because it is inaccurate or misleading. The fact that the material is classified or contains sensitive information is not in itself considered to be a sufficient reason for excluding a report from further dissemination, since some of the documents announcing NASA publications are distributed to limited audiences.

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