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TECHNICAL MANUAL

OPERATION, MAINTENANCE AND DATA

APOLLO DOCKING TEST DEVICE

AMF PART NUMBER

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GENERAL RESEARCH PROCUREMENT BRANCH

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York, Pennsylvania

TECHNICAL MANUAL
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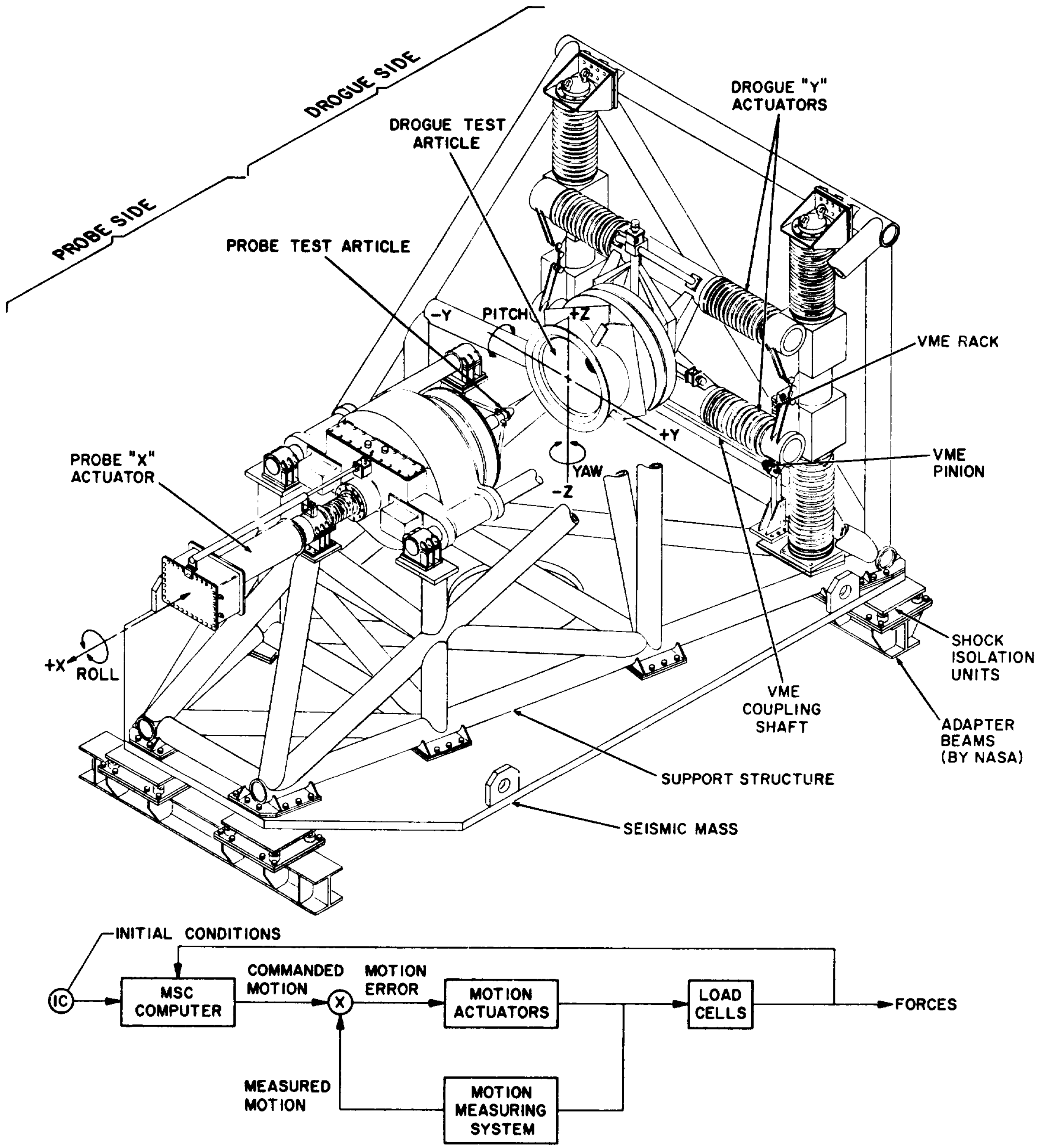


Figure 1. The Apollo Docking Test Device (ADTD)

SECTION I

INTRODUCTION

1.0 GENERAL.

1.1 The Apollo Docking Test Device (ADTD), was designed, manufactured, assembled and installed by the Engineering Division of the American Machine & Foundry Company's Industrial Products Group, York, Pennsylvania, according to Contract NAS 9-4300, for the Manned Spacecraft Center, Houston, Texas.

1.2 This manual is presented in three parts, consisting of an Introduction, an Operations, and a Maintenance section. The Introduction section is developed into two parts, Part A and B. Part A is a general over-all system description and Part B a detailed description of systems and individual components including a data section which contains detailed manufacturers data. The Operations Section is written primarily for operator personnel. It contains step-by-step procedures for shipment, handling, installation, interfacing with applicable subsystems, calibration, system checkout of both individual and systems' combinations, system startup, normal operation, emergency operation and system shutdown. The Operating Procedures are prepared in two parts. Part A covers normal operating procedures and Part B contains emergency operating procedures. The Maintenance Section covers the maintenance, repair and replacement procedures for the ADTD. Included in this section are detailed instructions for storage of the test device. Symbols used in the text are explained in Table 1.

TABLE 1. NOMENCLATURE

X-HF Actuator	ADTD X-axis High Frequency Servo Actuator
X-LF Actuator	ADTD X-axis Low Frequency Servo Actuator
Y-HF Actuator	ADTD Y-axis High Frequency Servo Actuator
Y-LF Actuator	ADTD Y-axis Low Frequency Servo Actuator
Z-HF Actuator	ADTD Z-axis High Frequency Servo Actuator
Z-LF Actuator	ADTD Z-axis Low Frequency Servo Actuator
FMS	Force Measurement System
GCS	Guidance Control System
RCS	Reaction Control System
VAPE	Vertical Actuator Position Equalizer

1.3 OVER-ALL SYSTEM DESCRIPTION - PART A.

1.4 The ADTD, figure 1, is used for simulation of the three docking maneuvers required in the Apollo mission - one in earth orbit, one after insertion into a translunar trajectory, and one in lunar orbit, each involving different docking vehicle dynamic characteristics. The Apollo Command Module and the Lunar Excursion Module docking system components are called the probe and the drogue respectively. The probe and drogue are the components to be tested by the ADTD. Before actual use on flight vehicles, the probe and drogue will require testing and the ADTD's function will be to perform these system tests.

1.5 The probe and drogue are required to perform the following functions while exposed to the thermal-vacuum environment of space (hence, the ADTD is designed for use in a ±250 degree Fahrenheit, 10^{-5} Torr environment).

1.5.1 Non-destructively dissipate energy, caused by the relative motions between the docking spacecraft, for all contact conditions within an allowable envelope.

1.5.2 Control the relative translatory and rotational motions between the docking spacecraft during the contact and post contact phase of the three aforementioned docking maneuvers.

1.5.3 Provide adequate structural integrity at the interface between the docking vehicles.

1.5.4 Permit satisfactory separation of the docking vehicles.

1.5.5 Allow repeated docking maneuvers.

1.6 The docking system testing method will use the ADTD hydraulic servo systems to achieve six relative degrees of freedom between the two test articles, the probe and the drogue. The ADTD servo system is designed to function in a thermal-vacuum environmental chamber (± 250°F, 10^{-5} Torr) and receives motion commands from a NASA-MSC supplied analog computer. The computer yields solutions to the rigid body equations of motions, bending mode equations, fuel slosh equations, GCS, and RCS equations that describe the docking vehicles, in response to measured (by the ADTD) forces and moments generated by the impacting test articles.

1.7 The ADTD is designed to safely withstand impact loads of 3000 pounds axial and 3200 pounds lateral at the probe tip and on the drogue surface. The probe tip may contact any point on the drogue surface, but the acute angle between the probe centerline and the major axis of the drogue is limited to 22 degrees normally (30 degrees are possible, with slight electrical and mechanical modifications to the ADTD).

1.8 The ADTD is composed of the following major components:

1.8.1 General Assembly - composed of a seismic mass, shock mount assembly, support structure, and hydraulic servo systems to impart the required six relative degrees of freedom to the docking system test articles.

1.8.2 Transmission System - Long (building 13 to 32) and short (building 13, room 147, to high bay, building 13). Transmission lines and signal conditioning equipment.

1.8.3 Vacuum System, including high (12 torr) and low (.01 torr) systems.

1.8.4 Hydraulic Installation including a hydraulic power pack, and accumulator racks.

1.8.5 Electrical Installation including control console.

1.8.6 Miscellaneous accessories and special fittings required for rapid handling and installation (such as Chamber B penetration plates).

1.9 DETAILED DESCRIPTION - PART B.

1.10 GENERAL ASSEMBLY (AMF DWG 359-60004).

1.10.1 The general assembly (see figure 2) is composed of the following major components:

1.10.1.1 Seismic Mass

1.10.1.2 Shock Mount Assembly

1.10.1.3 Support Structure

1.10.1.4 Probe Side Assembly (gives roll and X-axis high and low frequency motion)

1.10.1.5 Drogue Side Assembly (gives Y and Z axis high and low frequency motions and pitch and yaw motions)

1.10.2 Seismic Mass (AMF DWG 359-40101).

1.10.2.1 The seismic mass (see figure 2) is a stainless steel plate approximately 19 feet long, 12 feet wide and 3 inches thick, weighing about 30,000 pounds. Four lifting lugs are provided for rigging and handling. The seismic mass is attached to the lunar plane of MSC chamber B by shock mounts which are bolted to the MSC furnished lunar plane adaptor beams (per AMF DWG 359-09007). The seismic mass underlies and secures the support structure and the hydraulic and vacuum manifolds.

1.10.3 Shock Mount Assembly (AMF DWG 359-30101).

1.10.3.1 The shock mount assembly (see figure 3) is a mechanical spring assembly designed to attenuate shock and vibration coupling between the ADTD and the Chamber B lunar plane. See DWG 359-30101, for characteristics of shock mounts.

Photo

ADTD with Seismic Mass
and Manifolds

(To be supplied)

Figure 2

Photo

Shock Mount Assembly

(To be supplied)

Figure 3

1.10.4 Support Structure (Reference AMF DWG 359-60004).

1.10.4.1 The test device support structure (see figure 2) is fabricated primarily of welded AIS1304 stainless steel built-up from two triangular braced side trusses. The entire device is approximately 18 feet long and is 10 feet high at one end. The assembly is cross braced to form a trapezoidal box, weighing about 10,000 pounds. The support structure mounts all the motion systems, actuators and actuating mechanisms and is attached to the seismic mass. A pair of tubular guide rails are mounted on the support structure to support and guide the probe side assembly.

1.10.5 Probe Side Assembly (AMF DWG 359-60201).

1.10.5.1 The major components of the probe side assembly are listed as follows:

1.10.5.1.1 Probe guide support

1.10.5.1.2 FMS Transducer support

1.10.5.1.3 X-HF Actuator

1.10.5.1.4 Probe roll servo actuator

1.10.5.1.5 LEM docking ring and adapter ring

1.10.5.1.6 X-LF Actuator

1.10.5.2 The probe test article is mounted on the LEM docking ring which in turn is mounted on the probe side FMS. This assembly is given motion by the X-HF Actuator, roll actuator, and the X-LF Actuator. The probe roll and X-HF assembly are mounted on the traverse guide rails and are driven 42 inches in the X-direction by the probe X-LF actuator. The roll servo actuators drive the LEM docking ring and probe test article through the geared roll drum, imparting plus or minus 90 degrees rotation through the transducer support. The FMS transducer support in turn is excited by the X-HF servo actuator to ± 1/4 inch motion along the X-axis. The combined motion is transmitted through the probe force measurement system to the LEM docking ring. The X-HF servo actuator is mounted within the probe guide support by means of a pair of tapered roller bearings preloaded against each other to provide a rigid restraint against the induced loads. See table in the Data Section for leading characteristics of the probe actuator assembly.

1.10.6 Probe Guide Support (AMF DWG 359-40213). The probe guide support rides on guide rails attached to the support structure and is attached to and moved by the X-LF servo actuator. The probe guide support mounts the probe side force measurement system, the LEM docking ring and the probe test article. The probe guide support consists of a cast aluminum (type QQ-A-601c, Class 17M) housing which mounts the X-HF actuator, roll drive mechanism, X-HF and LF feedback transducers the probe side FMS (see figure 4) and flexure ring. Motion of the probe traverse low frequency actuator moves the probe support a total linear distance of 42 inches along the X-axis. The probe guide support provides accurate (within .020-inch) vertical and lateral positioning of the test article.

1.10.7 Probe X-LF Servo Actuator (AMF DWG 359-61201).

1.10.7.1 The X-LF servo actuator (see figure 5) provides X-axis low frequency motion (0-42 inches) to the Probe X-HF actuator and roll assembly. It is a double-acting, hydraulically operated, piston-type cylinder mounted on the support structure (AMF DWG 359-40114) and attached at the rod end to the Probe Guide Support. Actuating the X-LF servo actuator will translate the probe guide support up to 42 inches along the X-axis. The piston rod of the actuator moves in the annulus between a compensator rod and inside diameter of the cylinder barrel, ensuring accurate positioning of the probe test article during horizontal translation. Should any leakage occur past the seals located on the inside diameter of the piston rod, the fluid (see hydraulic fluid data sheet in Data Section) will enter the barrel of the compensator rod and be removed through a low-vacuum drain line. A single-seal bellows assembly (see reference data section) covers the piston rod between the cylinder barrel and the probe guide support. Should any leakage from the cylinder enter the high-vacuum barrier (.01 torr) of the bellows assembly, the fluid will be vaporized and removed through the high-vacuum line located on the probe guide support.

Photo

Force Measurement System Probe
and Drogue Sides

(To be supplied)

Figure 4

Photo

Probe Traverse Servo Actuator

(To be supplied)

Figure 5

1.10.8 X-HF Servo Actuator (AMF DWG 359-61202). The probe guide support also houses a high frequency actuator (see figure 6) for imparting high frequency ±1/4-inch X-axis motion to the probe test article. High-frequency translational motion is transmitted to the probe test article by the probe side FMS (see figure 4) which connects the dummy LEM docking ring to the transducer support. The X-HF servo actuator consists primarily of a tapered piston rod, flanged barrel, bearings, seals, and a rotary joint mounted on the flanged barrel. The servo actuator is installed in the center of the probe guide support with center line coincident with the ADTD X-axis. The threaded end of the piston rod is secured to the probe transducer support casting.

1.10.9 Probe Roll Servo Actuation (AMF DWG 359-61204 and 359-60201). Probe test article roll is achieved when the two hydraulic actuators (see figure 7) (AMF DWG 359-61206) acting in opposition against the probe roll drum, are energized. The Probe Roll Drive (AMF DWG 359-40205) actuates the roll drive system and provides 90 degrees of probe rotation, (on either side of the ADTD Y-Z plane) about the X-axis. The probe can be rotated ± 90 degrees in the Y-Z plane about the X-axis. The probe-roll drum is geared to the servo actuators. The rotary hydraulic joint of the probe X-HF actuator assembly, plus the set of back-to-back support bearings are installed on the actuator barrel. This allows the X-HF servo actuator to rotate with the probe-roll drum during probe roll operation.

1.10.10 LEM Docking Ring and Adapter Ring (AMF DWGS 359-40201 and 359-40240). The LEM docking ring is mounted on the probe FMS adapter ring. The adapter ring is connected to the probe transducer support by six load cell assemblies (AMF NO. 359-11008) see reference data section on load cells. To install the probe test article on the LEM docking ring the outward end of each probe leg brace is engaged in one of the three locking recesses located 120 degrees apart on the inside of the probe ring.

Photo

X-HF Servo Actuator

(To be supplied)

Figure 6

Photo

Probe Roll Servo Actuator

(To be supplied)

Figure 7

1.10.11 Drogue Side Assembly (AMF DWG 359-60301).

1.10.11.1 The major components of the drogue side assembly are as follows:

1.10.11.1.1 Drogue side vertical low frequency servo actuators (Z-LF)

1.10.11.1.2 Drogue side horizontal low frequency servo actuators (Y-LF)

1.10.11.1.3 Traverse assembly

1.10.11.1.4 Drogue side gimbal servo actuators (pitch and yaw)

1.10.11.1.5 Yoke gimbal restraint and pivot frame

1.10.11.1.6 Drogue mounting structure pivot table

1.10.11.1.7 Horizontal high frequency servo actuators (Y-HF) and horizontal small motion ring

1.10.11.1.8 Vertical high frequency actuators (Z-HF) and vertical small motion ring

1.10.11.1.9 Drogue test article mounting structure.

1.10.11.2 The drogue side assembly is mounted to the support structure and imparts Z-HF, Z-LF, Y-HF, Y-LF, Pitch, and Yaw motions to the drogue test article mounting structure. Two Z-LF actuators are mounted in parallel, with the actuator rods rigidly supported by the mounting structure. The barrels of the actuators are coupled together by means of a parallel pair of horizontal low frequency servo actuators. In order to accommodate differential thermal expansion between the actuators and the support structure, the horizontal actuator rods are connected to the vertical barrels through a self centering linkage consisting of opposing links engaging a sliding trunnion block. This geometry allows the Z loads to be equally shared by the linkage while allowing variations in horizontal actuator distances. Because the Y-LF actuators cannot be rigidly linked to the Z-LF actuators, it is necessary to couple the Z-LF actuator motions by means of the vertical actuator position equalizer (VAPE) drive assembly. This assembly consists of a rack and pinion set, made of 1040 carbon steel, coated with lubelok. A pinion gear is mounted on each Z-LF actuator barrel and their corresponding racks are attached rigidly to the mounting structure. The pinions for each Z-LF actuator are rigidly connected by the VAPE torque shaft, thus causing the Z-LF actuators to move together. The Y-LF actuators are translated in the Z-direction up to ± 16 inches by the Z-LF actuators. The two parallel Y-LF actuator barrels are rigidly connected by the traverse assembly. The traverse assembly is translated in the Y-direction up to ± 16 inches by the Y-LF actuators.

1.10.11.3 The traverse assembly supports the drogue pivot table by means of an eight-inch diameter ball and socket joint. The socket is lined with Teflon impregnated fabric to permit unlubricated operation. The pivot table is rotated ± 22 degrees with piston stop in ± 30 degrees with piston stops out (see Section III for additional data on stops) about the pitch and yaw axes by means of four drogue gimbal servo actuators mounted in quadrature on the pivot table and the traverse assembly. To prevent undesired roll motion the pivot table is engaged by the gimbal restraint yoke on the Y-axis by means of trunnion pins. The yoke in turn is engaged by the pivot frame through a trunnion pin on the Z-axis. The pivot frame is rigidly connected to the upper horizontal low frequency actuator barrel. This allows pitch and yaw freedom without undesirable roll motion.

1.10.11.4 Mounted within the drogue pivot table are four parallel Horizontal High Frequency Servo Actuators (Y-HF). The four actuator rods extend outwardly from the pivot table and engage the horizontal small motion ring which is thereby held concentrically with the pivot table imparting up to ± 1/4-inch high frequency motion along the ADTD Y-axis. Mounted on the horizontal small motion ring are four parallel Vertical High Frequency Servo Actuators (Z-HF). The four actuator rod ends engage the vertical small motion ring, imparting to the ring ± 1/4 inch high frequency motion along the ADTD Z-axis.

1.10.11.5 The drogue mounting structure is attached to the vertical small motion ring by means of the drogue side force measurement system (see data section) and receives the summation of the Y and Z low frequency and high frequency motions, as well as the pitch and yaw rotations. See table 1-2 for leading characteristics of the drogue side assembly.

1.10.12 Drogue Side Gimbal Servo Actuators (Yaw and Pitch) (AMF DWG 359-61303). The drogue side gimbal servo actuators (see figures 8 and 9) are attached at the rod end to the drogue mounting structure pivot table and at the blind end to the support members of the traverse assembly. Two gimbal actuators are required for pitch motion and two for yaw motion. The pitch actuators are controlled by the pitch servo valve which has an underlapped spool. This feature allows oil flow from one (pitch) actuator to the other to accommodate piston displacement during yaw motions. The yaw servo actuators are controlled by the yaw servo valve. Each gimbal servo actuator consists primarily of a barrel, piston rod, piston guide, rod end bearings, piston end cap, hydraulic connectors and seals.

1.10.13 Y-LF Actuator (AMF DWG 359-61312). The Y-LF actuators (see figure 10), mounted on the Z-LF actuator cylinders, support the drogue traverse mechanism. The servo actuators have a double-ended piston; each end attached to the vertically mounted moving cylinders and covered by a bellows assembly which contains any hydraulic leakage to prevent contamination of the test chamber. The Y-LF actuators provide up to ± 15-3/4 inches of drogue translation along the ADTD Y-axis. Each servo actuator consists primarily of a double-ended piston rod, seals, packings, plugs and connectors; also a barrel weldment containing the pads for mounting the pivot frame and brackets to attach the traverse assembly to the horizontal servo actuators.

Photo

Drogue Side Pitch Actuator

(To be supplied)

Figure 8

Photo

Drogue Side Yaw Actuator

(To be supplied)

Figure 9

Photo

Y-LF Actuator

(To be supplied)

Figure 10

1.10.14 Y-HF Actuator (AMF NO. 359-61305). Four high-frequency servo actuators (see figure 11) are mounted in parallel in the ADTD Y-Z plane within the drogue pivot table and are secured by cylinder trunnions in split ring-and-nut assemblies which permit the actuators to pivot in the Y-Z plane. This pivoting motion is provided to allow differential thermal expansion of the horizontal small-motion ring. The threaded, tapered, end of each actuator piston rod is secured to an alignment block, and the block is bolted and pinned in the horizontal small motion ring.

1.10.15 Z-LF Actuators (AMF DWG 359-61302). The Z-LF servo actuators (see figure 12) are mounted on the support structure and provide the drogue mounting structure with ± 16 inches of vertical translation along the Z-axis. Horizontal translation of ± 15-3/4 inches along the Y-axis is provided by the Y-LF servo actuators which are secured to the barrels of the vertical actuators and also support the traverse assembly. The Z-LF actuators are of the moving cylinder, double-ended actuator-type. The ends of the piston rod are attached to the support structure and covered by a bellows assembly which contains any hydraulic leakage to prevent contamination of a thermal vacuum test chamber. During vertical motion the pistons remain fixed and the actuator barrels move. Each vertical servo actuator consists primarily of a double-ended piston rod, barrel, seals, and mounting plates for the horizontal servo actuators.

1.10.16 Z-HF Actuator (AMF DWG 359-61304). Four Z-HF actuators (see figure 13) are mounted in parallel in the Y-Z plane on the horizontal small-motion ring and are attached at each end of the double ended piston rod to the vertical small-motion ring. Each of the Z-HF actuators is interconnected hydraulically and each actuator is connected to a servo valve. Acting in concert, the actuators impart ± 1/4-inch high frequency motion to the vertical small motion ring in the Z-direction, superimposing this motion on the transmitted Y and Z-LF, Yaw and Pitch, and Y-HF motions.

Photo

Drogue Y-HF Actuator

(To be supplied)

Figure 11

Photo

Drogue Z-LF Actuator

(To be supplied)

Figure 12

Photo

Drogue Z-HF Actuator

(To be supplied)

Figure 13

1.10.17 Traverse Assembly (AMF NO. 359-60302). The traverse assembly is a welded and riveted stainless steel structure consisting primarily of a hollow column, a transition cone and an 8-inch diameter gimbal ball. The traverse assembly is mounted between the horizontal actuators to form a part of the traverse mechanism, and supports the drogue pivot table. The hydraulic servo components for the gimbal actuators are contained within the column structure which is sealed as a high vacuum plenum.

1.10.18 Yoke Gimbal Restraint and Pivot Frame (AMF DWG 359-40306). The stainless steel gimbal-restraint yoke is attached at the yoke ends to trunnion pins on the drogue mounting structure pivot table and at its upper end to the pivot frame; the pivot frame is bolted to plates mounted on the moving cylinder of the upper-drogue horizontal actuator. The pivot frame is a tubular stainless steel welded assembly containing shims, bushings, bearings, and a taper pin which engages the upper end of the restraint yoke. Since the servo actuators allow ambigious roll positions due to the gimbal ball, the gimbal-yoke restraint is required to hold the horizontal centerline of the pivot table parallel to the ADTD S-Y plane during pitch and yaw motions.

1.10.19 Drogue Mounting Structure Pivot Table (AMF NO. 359-40303). The pivot table is socketed on an 8-inch diameter gimbal ball on the horizontal- and vertical-motion traverse assembly and is restrained by the yoke restraint from roll motions about the ADTD X-axis. The assembled unit transmits to the drogue test article low frequency vertical and horizontal motions and pitch and yaw motions. The pivot table is positioned in pitch and yaw by four hydraulic gimbal actuators; two operating in the plane of the X- and Y-axes and two operating in the plane of the X- and Z-axes to provide the pitch and yaw motions. The pivot table mounts the horizontal high-frequency hydraulic actuators and valves which provide an additional ± 1/4-inch (maximum) high-frequency motion to the drogue test article.

1.10.20 Horizontal Small Motion Ring (AMF DWG 359-60304). The horizontal small-motion ring is mounted concentrically about the pivot table and is attached to the tapered ends of the four Y-HF actuators mounted on the drogue pivot table. The four actuators, acting in concert, impart to the horizontal ring the ±1/4-inch high frequency motion transmitted to the drogue test article. The horizontal ring includes two vacuum sealed plenums which contain the hydraulic servo components to drive the four Z-HF actuators; which are mounted on the outboard face of the horizontal ring.

1.10.21 Vertical Small Motion Ring (AMF DWG 359-40305). The vertical small-motion ring is attached to the double-ended piston rods of the Z-HF actuators mounted on the horizontal small-motion ring. The vertical ring contains mounting pads to which are attached the six load cells that comprise the drogue side force measurement system which supports the drogue mounting structure and drogue test article. The vertical ring consists primarily of a reinforced aluminum ring casting, the FMS load cell mounting pads, eight threaded bushings and four setscrews used to secure the double-ended piston rods to the vertical small motion ring.

1.10.22 Drogue Mounting Structure (AMF DWG 359-40316). The drogue mounting structure which supports the drogue test article is a welded aluminum structure consisting primarily of a cylinder reinforced with gussets, plates and braces to ensure rigidity. The drogue mount transmits the loads generated by the colliding docking system test articles to the drogue side force measurement system. The dorgue mounting structure duplicates the LEM docking tunnel drogue mounting and tunnel lip details.

1.11 TRANSMISSION SYSTEM.

1.11.1 The transmission system is composed of signal conditioning equipment and two sets of cables which connect as follows:

1.11.1.1 One set of four cables, each approximately 4500 feet long which run from ADTD Cabinet No. 2 in the Computer Room in building 13 to ADTD Cabinet No. 7 in the Environmental Test Facility in building 32.

1.11.1.2 One set of four cables, each approximately 250 feet long which provide a temporary short communication link between the ADTD and the Computer in building 13.

1.11.1.3 At the computer end the cables are connected to the transmission line cabinet No. 2 assembly (see paragraph 1.14.4 for description). At the opposite ADTD end the cables connect to a transmission line panel in the control console (see paragraph 1.14.3.7.5 for description) to complete the circuit.

1.11.2 See AMF DWG 359-11012 for characteristics of the transmission line system cables and AMF DWGS 359-62520 and 359-62523 for the signal conditioning equipment.

1.12 VACUUM SYSTEMS (AMF NO. 359-11010 and 359-11011).

1.12.1 Contamination of the MSC space environment simulation chamber with hydraulic fluid is prevented by a single barrier sealing method on Teflon hoses and a double barrier sealing method on actuators. Areas containing dynamic hydraulic fluid seals are surrounded by a pressure environment of 12 ±2 torr. The 12 torr areas are enclosed by bellows or secondary dynamic seals and are in turn surrounded by a pressure environment of .01 torr. The .01 torr areas are sealed off from the chamber vacuum by a final shroud with static vacuum gaskets or O-rings. Hydraulic fluid areas having only static ends or gaskets are surrounded only by the .01 torr vacuum, which is in turn sealed by static vacuum gaskets or O-rings against the chamber vacuum.

Photo

Vacuum Pumps

(To be supplied)

Figure 14

1.12.2 Separate drainage lines are provided at the discharge end of each system to allow drainage of excess hydraulic oil into a catchment tank. See AMF DWG 359-61020 for vacuum systems assembly details. The vacuum pumps (see figure 14) are mounted on a mobile steel dolly. When the ADTD and its ancillary equipment is moved to MSC building 32, the same assembly (359-61020) is used except that the 12 torr catchment tank is installed in the sump area under Chamber B. In addition, a 15 gallon oil catch tank is connected to the 12 torr system. See AMF DWG 359-61006 for location of drainage chamber and catchment tank. Exhaust ports are provided on each pump for clamping of an exhaust hose to them to conduct exhaust gases out of the buildings. The vacuum in each system can be monitored on the controls provided on the vacuum assembly, see drawing 359-61020.

1.12.3 Each system is composed of a vacuum pump and electric motor along with the necessary controls, safety valves, pressure switches, bleed valves and gauges, all mounted on a single mobile steel dolly. See table in Data Section II-B for leading characteristics of the 12 ± 2 and .01± 1/2 torr systems. See manufacturers instruction manual for detailed operation, service and maintenance data in the data section.

1.13 HYDRAULIC INSTALLATION (AMF DWG 359-61006 and 359-61016).

1.13.1 The hydraulic installation includes all the hydraulic transmission lines and environmental chamber penetration fittings, hydraulic power pack, accumulator racks, and the associated servo actuators which are in the ADTD general assembly. The hydraulic system uses hydraulic fluid in accordance with military specification MIL-H-5606A. Connections for the hydraulic transmission lines, environmental chamber penetration fittings, power pack, and accumulator rack is shown on AMF DWG 359-61016 for building 13 and on AMF DWG 359-61006 for building 32. The normal operating hydraulic fluid pressure is 3000 psig. Actuators, valves and other fluid system components are designed to a proof pressure of 4500 psig and will withstand a burst pressure of 7500 psig. Fluid transmission lines and hoses will withstand a proof pressure of 6000 psig and a burst pressure of 12000 psig.

1.13.2 All hydraulic actuators and dynamic sealed connections are provided with a double sealing protection barrier against contamination of the space environment simulation chamber with hydraulic fluid. See paragraph 1.12, Vacuum Systems for additional information on this subject. The double barrier system is used on the probe actuator assembly, probe traverse servo actuator and drogue actuator assembly. A single .01 torr barrier is used on the pressure, return and 12 torr drain manifolds and all hydraulic and drain lines. The lines are made of Teflon.

1.13.3 The servo valves and actuators form a part of the hydraulic installation. Upon a servo position command signal from the NASA Manned Spacecraft Center analog computer, one or more of the servo valves are energized in the probe and drogue actuator assemblies, and the probe traverse servo actuator. The servo valve in turn hydraulically actuates the respective servo actuator or servo torque motor. See AMF DWGS 359-61203 and 359-61204 for the probe actuator assembly; AMF DWGS 359-61201, 359-61202 and 359-61203 for the probe traverse servo actuator; and AMF DWGS 359-61307 and 359-61308 for drogue actuator assemblies. When the actuating mechanism is energized, a precision potentiometer which is mechanically connected to the actuator feeds back a voltage to the servo amplifier to determine position errors.

1.13.4 <u>Hydraulic Power Pack</u> (AMF NO. 359-11401). The hydraulic power pack (see figure 15) is a unitized assembly which delivers hydraulic fluid at the rate of 35 gallons per minute at a nominal 3000 psi to the hydraulic installation. The hydraulic power pack is a self-contained, mobile, electric driven, water cooled unit. The system is comprised of two high pressure piston pumps (one unit for standby duty), a supercharging gear pump, intermediate and final filtering systems, storage reservoir, and an electric motor and starting system. Necessary valving, plumbing, instrumentation and controls complete the power pack. An electrical terminal strip with contacts for motor control, pump unloader, pressure and temperature indicators are provided for remote control purposes. The high pressure pump is of the pressure compensated type which automatically adjusts its

Photo

Hydraulic Power Pack

(To be supplied)

Figure 15

Photo

Accumulator Racks

(To be supplied)

Figure 16

output flow in response to a changing load to maintain a pre-set system pressure. See data section for leading characteristics of the hydraulic power pack. See manufacturers instruction manual for detailed information on operation and routine service in data section.

1.13.5 Accumulator Rack Installation (AMF DWG 359-61009). The accumulator rack (see figure 16) consists of two free standing racks each containing four accumulators, shutoff valves for each accumulator, manifolds for attaching piping, and miscellaneous hardware to secure the accumulators. The valving allows any number of accumulators to be placed on the line. Normal operation utilizes 4 units with remainder as spares connected to the supply line but valved off.

1.13.6 Hydraulic Penetration Plates for Chamber B Penetrations, VS 101 and VS 102 (AMF DWG 359-61010 and 359-61011).

1.13.6.1 The two plates (see figure 17) are used in Chamber B of building 32 to provide an access for hydraulic cables from the exterior of the chamber to the interior of the chamber maintaining the environmental integrity of the test chamber. The plates consist of round stainless steel plates with quick disconnect hydraulic couplings covered on the exterior side with a shroud. Hydraulic cables are attached to either side of the couplings.

1.13.7 Vacuum Penetration Plate for Chamber B Penetration, D 101 (AMF DWG 359-61012).

1.13.7.1 This plate (see figure 18) is used in chamber B of building 32 to provide an access for fluid drain and secondary vacuum from the exterior of the chamber to the interior of the chamber maintaining the environmental integrity of the test chamber. The plate consists of a round stainless steel retainer plate with an adapter at the exterior side to connect the Tygon vacuum lines and adapters for connecting vacuum and hydraulic drain line hoses to the interior side.

Photo

Hydraulic Penetration Plates (VS 101 and VS 102)

(To be supplied)

Figure 17

Photo

Vacuum Penetration Plate (D101)

(To be supplied)

Figure 18

1.14 ELECTRICAL INSTALLATION (AMF DWG 359-62001).

1.14.1 The major electrical equipment composing the electrical installation are as follows:

1.14.1.1 Control console assembly

1.14.1.2 Transmission line cabinet NO. 2 assembly

1.14.1.3 Probe and drogue FMS electrical installation

1.14.1.4 Two electronic feed-thru penetration plates (for MSC Chamber B, VS103 and 4 or 7)

1.14.1.5 Connecting cable assemblies, connectors and wire

1.14.1.6 MSC furnished analog computer.

1.14.2 The MSC computer is located in building 13 at MSC and is used to solve the equation that characterizes the dynamic aspects of the docking vehicles. These solutions, (or position commands) are transmitted to the ADTD via the long or short ADTD transmission line system cables (see paragraph 1-11).

1.14.3 Control Console Assembly (AMF DWG 359-62002).

1.14.3.1 The ADTD control console (see figure 19) is composed of seven enclosure frames and an attached writing desk. The control console contains three Honeywell heater thermocouple recorder units, servo control panels, amplifiers, power supplies to operate and monitor the servo and FMS systems, monitor and status panels and associated test equipment and jack panels. In addition the console contains a VTVM, a function generator, oscilloscope and oscillograph. All docking system closed loop testing will be started and stopped at the console. The following paragraphs provide a description of the function of the various panels in the control console.

Photo

Control Console

(To be supplied)

Figure 19

1.14.3.2 Enclosure Frame NO. 1 (AMF NO. 359-62011). This enclosure frame contains three Minneapolis 16 channel temperature recorders. Each recorder provides a continuous record in chart form of the actual temperatures at the area of the probe 42 inch low frequency potentiometer, the drogue 30 inch low frequency potentiometer, the drogue pitch and yaw 30 degree potentiometers, the drogue vertical and horizontal ± 16 inch potentiometers, and one each in both of the pressure manifold accumulators.

1.14.3.3 Enclosure Frane NO. 3 (AMF NO. 359-62005). This enclosure frame contains seven buckets of circuit cards, as follows:

1.14.3.3.1 Bucket A1 - Drogue pitch ± 30 degrees.

This bucket contains the following cards:

- A3 - Network Card
- A4 - DC Amplifier
- A5 - Valve Driver
- A8 - Buffer Amplifier
- A9 - Error Abort Network and Amplifier
- A10 - Velocity Abort Differentiator
- A12 - Threshold Detector

1.14.3.3.2 Bucket A2 - Drogue yaw ± 30 degrees.

Contains the same cards as Bucket A1

1.14.3.3.3 Bucket A3 - Drogue horizontal ± 1/4-inch.

This bucket contains the following cards:

- A3 - Network Card
- A4 - DC Amplifier
- A5 - Valve Driver
- A12 - Threshold Detector

1.14.3.3.4 Bucket A4 - Drogue vertical ± 1/4-inch.

Contains the same cards as Bucket A3

1.14.3.3.5 Bucket A5 - Drogue horizontal ± 16-inch.
Contains the same cards as Bucket A1

1.14.3.3.6 Bucket A6 - Drogue vertical ± 15-3/4-inch.
Contains the same cards as Bucket A1

1.14.3.3.7 Bucket A7 - Abort logic circuitry.
This bucket contains the following cards:

A1 - Exercise Oscillator
A2 - Threshold Detector for Power Abort
A3 - Threshold Detector for Force Abort
A4 - Threshold Detector for North American Abort
A5 - Threshold Detector for Computer Abort
A7 - 14 Input OR Gate, Abort Logic
A8 - 14 Input OR Gate, Abort Logic
A9 - 10 Input OR Gate, Abort Logic
A10 - 10 Input OR Gate, Abort Logic
A11 - 10 Input Dual OR Gate, Abort Logic
A12 - Power Supply Summing Network

1.14.3.3.8 All buckets are wired on 4-1/2-inch by 6-inch plug-in cards manufactured by AMF. The cards are inserted into the panel buckets and each bucket contains 12 cards. See AMF DWG 359-62005 for a listing of specific type of cards used. Each card has a front plate which supports test points, switches, indicator lights and card removal handle. The plug-in end of each card has a pin type connector which is inserted into a taper pin insertion type connector on the console.

1.14.3.4 Enclosure Frame NO. 4 (AMF NO. 359-62006). This enclosure frame holds a part of the writing desk. At the top of the frame are six Lambda Electric Corporation, Model NO. LH124FM, regulated power supplies with built-in current overload protection. The output of the power supplies is listed below:

1.14.3.4.1 Top row

1. +28 VDC at .4 amperes
2. -28 VDC at .4 amperes

1.14.3.4.2 Bottom row

1. +15 VDC at .1 amperes
2. -15 VDC at .1 amperes
3. +12 VDC at .7 amperes
4. -12 VDC at .7 amperes

1.14.3.4.3 The six Lambda Electric power supplies supply power as follows:

1. ±28 VDC Power Supplies are used for powering:

   Buffer Cards A8

   Valve Driver Cards A5

   Manual Position Relays on A3

   System Test Panel Lamps

   14 Input OR Gate

   10 Input OR Gate

   10 Input Dual OR Gate

2. ±15 VDC Power Supplies are used for powering:

   DC Amplifier Cards A4

   Error Abort Cards A9

   Velocity Abort Cards A10

   Force Integral Panel 8A7

3. ± 12 VDC Power Supplies are used for powering:

   Exercise Oscillator Card

   Manual Position Potentiometers

   Displacement Xducers

1.14.3.4.4 The DC voltmeter panel (AMF NO. 359-62509) contains a vacuum tube voltmeter and a patching panel for probe and drogue position input and feedback. The panel is used to measure precision commands and feedback signals.

1.14.3.4.5 The servo test panel (AMF NO. 359-62510) enables the operator to substitute a dummy load in place of a servo valve during test checkout for each servo channel electronics individually by placing the appropriate toggle switch to the DUMMY position. Input from the system test panel (AMF NO. 359-62502) is connected when the appropriate switch is placed in the TEST position. This allows the sine wave outputs from the .1 and .5 cycles per second oscillator or the function generator output to be connected to each servo channel input. In the NORMAL position, regular computer input is connected. Provisions are also made to switch a spare transducer into the general assembly, in the event of an operating transducer failure.

1.14.3.4.6 The three buckets contain circuit cards for three individual servo channels as follows:

1.14.3.4.6.1 Bucket A4 - Probe 42-inch

This bucket contains the following cards:

- A3 - Network Card
- A4 - DC Amplifier
- A5 - Valve Driver
- A8 - Buffer Amplifier
- A9 - Error Abort Network and Amplifier
- A10 - Velocity Abort Differentiator
- A12 - Threshold Detector

1.14.3.4.6.2 Bucket A5 - Probe 90-inch

Contains the same cards as Bucket A4

1.14.3.4.6.3 Bucket A6 - Probe ± 1/4 inch

This bucket contains the following cards

- A3 - Network Card
- A4 - DC Amplifier
- A5 - Valve Driver
- A12 - Threshold Detector

1.14.3.5 Enclosure Frame NO. 5 (AMF NO. 359-62007). This enclosure frame contains the second half of the writing desk. The top of the enclosure frame is the oscilloscope panel which contains the Tektronix NO. RM561A, oscilloscope assembly, Tektronix NO. 2B67 time base unit and Tektronix NO. 3A72 amplifier. It is used during test to measure amplifier gains, wave shapes and amplitudes.

1.14.3.5.1 The system Monitor Panel (AMF NO. 359-62511) is used to display the actual displacement of the probe and drogue components, and hydraulic system pressure. The operator may override the system test panel (AMF NO. 359-62502) or computer input signal by pressing the manual POSITION switch to ON and adjusting the manual POSITION control.

1.14.3.5.2 The function generator (EXACT ELECTRONICS, INC., NO. 250) is used to supply variable frequency and amplitude signals for adjustment of abort circuits, and checking frequency response and gain of each servo channel.

1.14.3.5.3 The elapsed time meter panel (located under the writing desk) provides indication of running time for the 400 cycle servo, 60 cycle instrumentation and 60 cycle force measurement power supplies (see AMF NO. 359-62521).

1.14.3.5.4 The feedback pressure transducer panel (AMF NO. 359-62525) contains 5 signal conditioner units and amplifiers, which demodulate and amplify signals from pressure transducers at the drive cylinders. This demodulated signal is used as feedback in the servo channel electronics.

1.14.3.6 Enclosure Frame NO. 6 (AMF NO. 359-62008). This enclosure frame contains the system status and system test panels and the North American Control Panel DS13E65-T4.

1.14.3.6.1 The system status panel (AMF NO. 359-62501) carries visual displays which reflect the status of the ADTD systems and subsystems; hydraulic power pack, vacuum systems and abort conditions and controls as follows:

1.14.3.6.1.1 Hyd. System - start/stop

1.14.3.6.1.2 Hyd. P.S. temp

1.14.3.6.1.3 Hyd. Heater - off/on

1.14.3.6.1.4 Secondary Vacuum System (high and low) start/stop

1.14.3.6.1.5 Hybrid Computer Remote Control

1.14.3.6.1.6 ADTD - ready/not ready switch

1.14.3.6.1.7 Ref. Condition Indicator switch

1.14.3.6.1.8 Manual (local and remote) abort

1.14.3.6.1.9 Lamp test button (for System Status and System Test Panels)

1.14.3.6.2 The system test panel (AMF NO. 359-62502) is used to test the servos for frequency response. When the panel is placed in the FREQ. RESPONSE mode, the output of the function generator from enclosure frame 5 is connected. The output amplitude of the function generator output may be varied by turning the appropriate LEVEL SET control on the system test panel. .1 or .5 cycle sine waves are provided when the appropriate switch is placed in the EXERCISE position. The input can be varied as required by turning the appropriate panel control.

1.14.3.7 Enclosure Frame NO. 7 (AMF NO. 359-62009). This enclosure frame contains the circuit breaker panel, visicorder, transducer calibration panel, and two jack panels.

1.14.3.7.1 The circuit breaker panel (AMF NO. 359-62508) contains the circuit breakers and indicator lights for the drogue valves, probe valves and 28 VDC supply. It also has circuit breakers for the servo, instrumentation and force measurement system 120 VAC supply.

1.14.3.7.2 The Honeywell Visicorder, Model 1508, supplies continuous strip chart recording of 10 channels simultaneously for frequency response and phase shift measurement. It will record the servo input, output and error on any channel, and also any probe and drogue force abort measurements.

1.14.3.7.3 The transducer calibration panel (AMF NO. 359-62514) is used to calibrate the probe and drogue potentiometer feedback output. There are two screwdriver adjustment type potentiometers for each feedback and monitor circuit. Test points for panel potentiometer wiper contacts and ground potential are provided.

1.14.3.7.4 The two jack panels, ADC Products Company, NO. PJ-390, contain 52 PJ339 jacks on each panel. The jacks are connected to significant test points from the various control console test equipments. The panel jacks can be patched to connect the different functions as required for testing. (See jack panel illustration in Data Section IB.)

1.14.3.7.5 Enclosure Frame NO. 8 (AMF NO. 62010). This enclosure frame contains ten Honeywell, Model 104-1 DC Amplifiers which are used to amplify the signal in the Visicorder in enclosure frame 7; twelve differential DC Amplifiers, Cubic Corporation, Model 1300, and twelve signal conditioning modules, Endevco Corporation, Model 4402, used to feed the force transducer signal through the transmission line equipment panel (AMF NO. 359-62523) to the MSC computer.

1.14.4 Transmission Line Cabinet NO. 2 Assembly (AMF DWG 359-62520).

1.14.4.1 The transmission line cabinet NO. 2 (see figure 20) is located in building 13 in close proximity to the MSC analog computer. It is connected to the computer by four 50 foot cables labeled A, B, C, D. The cabinet is at the opposite end of the electrical transmission lines that run from the control console assembly. The

Photo

Transmission Line Cabinet No. 2

(To be supplied)

Figure 20

transmission line cabinet contains transmission line terminal equipment and differential DC amplifiers which are similar in nature to those contained in enclosure frame 8 of the control console assembly.

1.14.4.2 The transmission line terminal equipment (AMF NO. 359-62522) contains choppers, transformers and amplifiers for isolating and balancing transmission lines for low noise pickup.

1.14.4.3 The twelve Cubic Corporation, Model 1300, differential DC Amplifiers are the same as those used in the control console, enclosure frame 8, and are used to balance the output and provide low noise pickup from the computer. These feed into the transmission lines connecting to the control console. (Note that three of the twelve Cubic amplifiers in cabinet No. 2 are not in use.)

1.14.5 Probe Side and Drogue Side Electrical Installation (AMF DWG 359-62003).

1.14.5.1 The probe and drogue electrical installation contains the heaters, thermocouples, connectors, plug, and wiring for the servo valve solenoids, transducers and other electrical components of the general assembly. See AMF DWG 359-62003 for connection details.

1.14.6 Electronic Feed-Thru Penetration Plates for Chamber B Penetrations VS 103 and 107 . (AMF DWGS 359-62513-1 and -2).

1.14.6.1 The two plates (see figure 21) are used in chamber B of building 32 to provide an access for electrical cables from the exterior of the chamber to the interior of the chamber maintaining the environmental integrity of the test chamber. The plates consist of round stainless steel plates with feed-thru connectors. Cables are attached to either side of the connectors.

Photo

Electronic Penetration Plates

(To be supplied)

Figure 21

SECTION IB

DATA

LEADING CHARACTERISTICS OF PROBE SIDE ASSEMBLY

Item	Data
Guide support	Driven 42-inches translation along the X-axis by the probe low frequency actuator
Probe roll drive	Rotates ±90 degrees in the Y-Z plane about the X-axis
Actuation method	
Axial translation	Linear ram
Roll motion	Hydraulic servo motors and gear reduction
Axial acceleration (maximum)	1.75 feet per second
Roll speed	2 degrees per second
Actuators	
Probe traverse servo (AMF NO. 359-61201)	Stroke - 42-inches
High frequency probe servo (AMF NO. 359-61202)	Stroke - 0.537 ±.007-inches
Probe roll motor (AMF NO. 359-61206)	Rotation continuous in either direction, two geared drives with pinions in opposition, total reduction ratio approximately 2900:1
Operating pressure of Probe Side Assembly Actuators	3000 PSIG
Proof pressure of Probe Side Assembly Actuators	4500 PSIG
Burst pressure of Probe Side Assembly Actuators	7500 PSIG

LEADING CHARACTERISTICS OF PROBE SIDE ASSEMBLY

Item	Data
Servo Valves	See leading characteristics sheet in this section
Potentiometers	Manufactured by Computer Instrument Corp., Hempstead, New York Part Nos. 205989-3 and 205989-4

LEADING CHARACTERISTICS OF DROGUE SIDE ASSEMBLY

Item	Data
Drogue pivot table	
Orientation	Reference position is on the centerline of probe
Motion	Pitch ±22 degrees Yaw ±22 degrees Vertical translation ±16 inches Horizontal translation ±15-3/4-inches
Actuators	
Drogue, horizontal, Y-HF (AMF NO. 359-61305)	Stroke - 0.540 ±.007-inch
Drogue, vertical, Z-HF (AMF NO. 359-61304)	Stroke - 0.537 ±.007-inch
Drogue, horizontal, Y-LF (AMF NO. 359-61301)	Stroke - ±15-3/4-inches
Drogue, vertical, Z-LF (AMF NO. 359-61302)	Storke - ±16-inches
Drogue, gimbal (AMF NO. 359-61303)	Stroke - 0 to 40.125-inches
Operating pressure of Drogue Side Assembly Actuators	3000 PSIG
Proof pressure of Drogue Side Assembly Actuators	4500 PSIG
Burst pressure of Drogue Side Assembly Actuators	7500 PSIG
Servo Valves	See leading characteristics sheet in this section
Potentiometers	Manufactured by Computer Instrument Corp., Hempstead, New York, Part Nos. 205989-2 and 205989-5

LEADING CHARACTERISTICS OF SERVO VALVES

HF, AMF NO. 359-11001

Rated Flow	15.4 cis ± 10% at 1000 psi valve drop*
Rated Current	30 ma (parallel)
Supply Pressure	3000 psi
Hysteresis	less than 2.5% of rated current
Threshold	less than 0.5% of rated current
Pressure Gain	greater than 10,000 psi at 10% of rated current
Null Leakage	less than 2.0 cis
Coil Resistance	130 ohms ± 10% per coil at +70°F
Coil Inductance	less than 0.7 henries per coil
Temperature Range	minus 40°F to +275°F (fluid and ambient)
Proof Pressure	4500 psi
Hydraulic Fluid	MIL-H-5606
Recommended Filtration	10 microns
Weight	12 ounces nominal
Installation Details	per Moog Model 31-010A Data Sheet
Acceleration Sensitivity	Torque motor to be mass balanced for minimum acceleration sensitivity
Frequency Response	90° phase lag at greater than 300 cps; at peak input amplitude equal to 25% of rated current; maximum amplitude +3 db. - phase lag at 100 cps, maximum 50°, 35° design objective
Burst Pressure	7500 psi minimum
Manufacturer	Similar to Moog Model 31-304

Roll and Yaw, AMF NO. 359-11002

Rated Flow	3.85 cis ± 10% at 1000 psi valve drop
Rated Current	30 ma (parallel)
Supply Pressure	3000 psi

LEADING CHARACTERISTICS OF SERVO VALVES

Hysteresis	less than 2.5% of rated current
Threshold	less than 0.5% of rated current
Pressure Gain	greater than 7500 psi at 10% of rated current
Null Leakage	less than 1.0 cis
Coil Resistance	130 ohms ± 10% per coil at +70°F
Coil Inductance	less than 0.7 henries per coil
Temperature Range	minus 40°F to +275°F (fluid and ambient)
Proof Pressure	4500 psi
Hydraulic Fluid	MIL-H-5606
Recommended Filtration	10 microns
Weight	12 ounces nominal
Installation Details	per Moog Model 31-010A Data Sheet
Frequency Response	90° phase lag at greater than 100 cps; at peak input amplitude equal to 25% of rated current; maximum amplitude + 3 db. - phase lag at 12 cps less than 12°
Burst Pressure	7500 psi minimum
Manufacturer	Similar to Moog Model 31-305

<u>Pitch, AMF NO. 359-11003</u>

Rated Flow	3.85 cis ± 10% at 1000 psi valve drop
Rated Current	30 ma (parallel)
Supply Pressure	3000 psi
Hysteresis	less than 2.5% of rated current
Threshold	less than 0.5% of rated current
Valve Underlap	All spool lands to be underlapped 20% of maximum stroke

LEADING CHARACTERISTICS OF SERVO VALVES

Null Leakage	to be determined after valve null cut is tested
Coil Resistance	130 ohms ± 10% per coil at +70°F
Coil Inductance	less than 0.7 henries per coil
Temperature Range	minus 40°F to +275°F (fluid and ambient)
Proof Pressure	4500 psi
Hydraulic Fluid	MIL-H-5606
Recommended Filtration	10 microns
Weight	12 ounces nominal
Installation Details	per Moog Model 31-010A Data Sheet
Frequency Response	90° phase lag at greater than 100 cps; at peak input amplitude equal to 25% of rated current; maximum amplitude + 3 db; phase lag at 12 cps maximum 12°, 6° design objective
Burst Pressure	7500 psi minimum
Manufacturer	Similar to Moog Model 31-306

X, Y, and Z Axis, AMF NO. 359-11004

Rated Flow	77 cis ± 10% at 1000 psi valve drop*
Rated Current	30 ma (parallel)
Supply Pressure	3000 psi
Hysteresis	less than 2.5% of rated current
Threshold	less than 0.5% of rated current
Pressure Gain	greater than 10,000 psi at 10% of rated current
Null Leakage	less than 4.0 cis
Coil Resistance	130 ohms ± 10% per coil at +70°F

LEADING CHARACTERISTICS OF SERVO VALVES

Coil Inductance	less than 0.7 henries per coil
Temperature Range	minus 40°F to +275°F (fluid and ambient)
Proof Pressure	4500 psi
Hydraulic Fluid	MIL-H-5606
Recommended Filtration	10 microns
Weight	36 ounces nominal
Installation Details	per Moog Model 35-010A Data Sheet
Frequency Response	90° phase lag at greater than 100 cps; at peak input amplitude equal to 25% of rated current; maximum amplitude + 3 db. phase lag at 12 cps less than 12°
Burst Pressure	7500 psi minimum
Manufacturer	Similar to Moog Model 35-112

LEADING CHARACTERISTICS OF SHOCK ISOLATION UNITS

For leading characteristics of Shock Isolation Units see AMF DWG 359-30101

LEADING CHARACTERISTICS OF BELLOWS

Item	Data
Types	
AMF NO. 359-31203	Used on Probe AF Actuator
Spring Rate	353 pounds/inch
AMF NO. 359-31207	Used on Drogue Actuator Assembly
Spring Rate	1.0 pounds/inch
AMF NO. 359-31303	Used on Drogue Side Gimbal Servo Actuator (Yaw and Pitch)
Spring Rate	2.3 pounds/inch
AMF NO. 359-31304	Used on Drogue Vertical HF Actuator
Spring Rate	93 pounds/inch
AMF NO. 359-31314	Used on Drogue Side Assembly
Spring Rate	1.2 pounds/inch
AMF NO. 359-31305	Drogue Gimbal Assembly
Spring Rate	70 pounds/inch
AMF NO. 359-31316	Drogue Side Assembly
Spring Rate	1.2 pounds/inch
AMF NO. 359-31315	Drogue Side Assembly
Spring Rate	1.2 pounds/inch
Technical Characteristics	See appropriate drawings for physical characteristics of bellows

Formulae for Predicting Safe Bellows Internal Pressure

$$\text{Safe Internal Pressure in lbs per sq inch} = \frac{2\pi K}{\text{Lengths}}$$

K = Spring rate

LEADING CHARACTERISTICS OF THE SECONDARY VACUUM SYSTEMS

Item	Data
12 ±2 torr system	Pumping rate of 5 cfm free air 2 x 10^{-2} torr
Volume	6 cubic feet
Oil leakage rate	200 cc per minute of MIL-H-5606 hydraulic fluid
01 ± .005 torr system	Pumping rate of 39 cfm free air 2 x 10^{-3} torr
Volume	60 cubic feet
Oil leakage rate	20 cc per minute of MIL-H-5606 hydraulic fluid
Back-flow shut-off	T/C guage located at Vacuum Penetration Plate senses excessive vacuum (indicating a secondary vacuum system leak in the chamber) and controls solenoid valve to prevent vacuum system backflow
Both systems	
Time, pumpdown	To 12 or .01 torr from 1 atmosphere in 30 minutes
Electrical motor	220 volts, 3 phase, 60 cycles, fully enclosed, across the line starting
Manufacturer	Clark/Dresser Vacuum Division Clark Brothers, Olean, New York

LEADING CHARACTERISTICS OF HYDRAULIC POWER PACK

Item	Data
Construction	4 wheel trailer, with front steering tow bar, 600 x 9 pneumatic tires, mechanical parking brake, and storage facilities for hoses and electrical cable. Can be towed up to 20 MPH speeds. Welded steel framework with cabinet outer shell.
Fluid	Hydraulic fluid per specification MIL-H-5606A or MIL-O-6083
Continuous operation (at 100°F oil temperature)	0-30 GPM maximum (0-60 percent stroke) at 3000 psi 0-50 GPM maximum (0-100 percent stroke) at 1750 psi Note: See manufacturers instruction manual for additional performance data under other operating conditions.
Intermittant operation (repeating cycle)	50 GPM at 3000 psi - 3 minutes maximum duration 15 GPM at 3000 psi - 12 minutes duration
Towing	Can be towed up to 20 MPH on paved roads. Maximum wheel cramping angle 40 degrees. Minimum turning radius approximately 13 feet.
Operating temperatures	-40°F to +125°F
Electric power	440 VAC, 60 cycles, 3 phase, 155 amperes maximum during intermittant overlaod
Water temperature	30 GPM at 80°F at 20 psi, or 35 GPM at 85°F at 25 to 30 psi

LEADING CHARACTERISTICS OF HYDRAULIC POWER PACK

Item	Data
Oil Heater	Automatically controlled immersion type rated for 25 KW minimum
Control System	Fused 120 VAC, single phase
Displays	Power ON lamp Pump ON lamp Low Pressure Alarm lamp Hi Temperature Alarm lamp Oil Heater On lamp
Gauges	Pressure indication - 0 to 160 PSIG - 0 to 1000 PSIG - 0 to 5000 PSIG Temperature indication - 40°F to 240°F (Red lined beyond 125°F)
Manufacturer	Kahn and Company, Inc., Wethersfield, Connecticut Model No. 181-082

LEADING CHARACTERISTICS OF FMS TRANSDUCERS

Item	Data
Dimensions (overall)	10.50-inches by 3.00-inches diam.
Operating Environment	
Humidity	0 to 100 percent humidity
Temperature	Operating - Normal from -250°F to + +250°F Non-operating - From -300°F to +265°F
Pressure	Standard atmospheric to 10^{-6} torr
Electrical	
Range	3000 pounds tension and compression
Overload	4500 pounds tension and compression
Uni-directional Output	1.75 MV/V ± .002 MV/V
End Point Linearity	.04 to .08%
Hysteresis	.01 to .03%
Deflection	Less than .005-inches for 3000 pounds tension or compression load
Vacuum Operation	Hermetically sealed
Input and Output Resistance	350 ohms ±1% at 70°F
Repeatability	Within .00175 MV/V
Mechanical	
Case	Type 304 Stainless Steel
Manufacturer	Ormond Transducers, Inc. Model No. SS24-3K-6094A

TABLE OF WEIGHTS

Item	Weight (Pounds)
Seismic Mass	28,000
ADTD Structure	13,100
Z-LF Actuators	3,900
Y-LF Actuators	3,100
Traverse and Hydraulic Assembly	500
Drogue Table	400
Horizontal Ring	200
Vertical Ring	150
Drogue Nut	50
Yoke	75
Load Cells	100
Probe Ring	55
Probe Assembly	1,720
X-LF Actuators	1,500
Drogue Gimbal	45
Y-HF Actuator	20

LIST OF VENDOR CONTACTS

Minneapolis Honeywell
3345 West Hunting Park Avenue
Philadelphia, Pennsylvania
215-226-2400 - F.J. Doherty

Lambda Electronics Corporation
515 Broad Hollow Road
Melville, Long Island, New York
516-694-4200 - Mr. Simon

Textronix
1045 Taylor Avenue
Towson, Maryland
301-825-9000 - Mrs. Darmer

Exact Electronics
Hillsboro, Oregon
201-796-5070 - W.R. Stovin

Cubic Corporation
9233 Balboa Avenue
San Diego, California
714-277-6780 - J. Simpson

Endevco Corporation
810 S. Arroyo Parkway
Pasadena, California
MU 1-2401 - E.H. Rosenthal

Metal Bellows
20977 Knapp Street
Chatsworth, California
341-4900 - Paul Campbell

Electronic Module Corporation
1949 Green Spring Drive
Timonium, Maryland
301-252-2900 - Joe Ritter

Quick Disconnect Couplings
Sunnyhill Research and Mfg. Co.
Imperal, Pennsylvania
412-899-2291

Penn Flurocarbon Company
Holley Street & Madison Avenue
Clifton Heights, Pennsylvania
215-MA-2-2300 - W. McCaw

Kahn & Co.
P. O. Box 516
Hartford, Connecticut
203-529-8643 - H. Miller

Transducers, Inc.
11971 E. Rivera Road
Santa Fe Springs, California
213-693-2711 - W. Reynolds

Moog Servo Controls
Pionner Airport
E. Aurora, New York
716-652-2000 - D. Gorsline

Hydrapower
Main Street
New Rochelle, New York
914-NE-2-2200 - J. Fanning

Lourdes Industries
Gazza Boulevard
Farmingdale, New York
516-CH-9-6800 - F. Smith

C. I. C. - Computer Instrument Co.
92 Madison Avenue
Hempstead, New York
IVanhoe 3-8200 - J. Kristofferson

VIB Mountings (Vibration)
Butler, New Jersey
201-838-1780 - Mr. Waring

Dresser Industries
150 "A" Street
Needham Heights, Massachusetts
716-372-2101 - Mr. Rolley

LIST OF TEFLON TUBING

Vacuum Lines

From	To	Teflon ID	Length in Feet
Probe Low Frequency	Vacuum Manifold	3/4 inch (Outer)	16
Probe Low Frequency	Vacuum Manifold	1/4 inch (Inner)	19
Probe LF Bellows	Vacuum Manifold	* 1 inch (Outer)	10
Probe LF Bellows	Vacuum Manifold	3/8 inch (Inner)	11
Probe HF	Vacuum Manifold	* 1 inch (Outer)	10
Probe HF	Vacuum Manifold	3/8 inch (Inner)	11
Vertical HF + Y	Vacuum Manifold	3/4 inch (Outer)	14
Vertical HF + Y	Vacuum Manifold	1/4 inch (Inner)	15
Vertical HF - Y	Vacuum Manifold	3/4 inch (Outer)	14
Vertical HF - Y	Vacuum Manifold	1/4 inch (Outer)	15
Horizontal HF + Y	Vacuum Manifold	3/4 inch (Outer)	14
Horizontal HF + Y	Vacuum Manifold	1/4 inch (Inner)	15
Horizontal HF - Y	Vacuum Manifold	3/4 inch (Outer)	14
Horizontal HF - Y	Vacuum Manifold	1/4 inch (Inner)	15
Drogue LF	Vacuum Manifold	* 1 inch (Outer)	16
Drogue LF	Vacuum Manifold	3/8 inch (Inner)	17
Horizontal LF Bellows	Vacuum Manifold	* 1 inch	18
Plus Gimbal	Vacuum Manifold		
Pitch Cyl + Z	359-61306	* 1 inch (Outer)	1-1-4-1/2
Pitch Cyl + Z	359-61306	3/8 inch (Inner)	1-1-4-1/2
Pitch Cyl - Z	359-61306	* 1 inch (Outer)	1-1-3, 4 inches
Pitch Cyl - Z	359-61306	3/8 inch (Inner)	1-1-3, 4 inches
Yaw Cyl + Y	359-61306	* 1 inch (Outer)	1-1-2-1/2
Yaw Cyl + Y	359-61306	3/8 inch (Inner)	1-1-2-1/2

Vacuum Lines

From	To	Teflon ID	Length in Feet
Yaw Cyl - Y	359-61306	* 1 inch (Outer)	1-1-1-1/4
Yaw Cyl - Y	359-61306	3/8 inch (Inner)	1-1-1-1/4
Junction - Y	359-61306	* 1 inch (Outer)	3, 10 inches
Junction - Y	359-61306	3/8 inch (Inner)	3, 10 inches
Junction + Y	359-61306	* 1 inch (Outer)	1-1/2
Junction + Y	359-61306	3/8 inch (Inner)	1-1/2
Junction - Y + Y	359-61312	* 1 inch (Outer)	1
Junction - Y + Y	359-61312	3/8 inch (Inner)	1
VLF Bellows UP - Y	359-61312	* 1 inch (Outer)	4-1/2
VLF Bellows UP - Y	359-61312	3/8 inch (Inner)	4-1/2
VLF Bellows UP + Y	359-61312	* 1 inch (Outer)	4-1/2
VLF Bellows UP + Y	359-61312	3/8 inch (Inner)	4-1/2
VLF Bellows Down - Y	359-61312	* 1 inch (Outer)	1
VLF Bellows Down - Y	359-61312	3/8 inch (Inner)	1
VLF Bellows Down + Y	359-61312	* 1 inch (Outer)	1
VLF Bellows Down + Y	359-61312	3/8 inch (Inner)	1
VLF Junction - Y	359-61312	* 1 inch (Outer)	4-1/2
VLF Junction - Y	359-61312	3/8 inch (Inner)	4-1/2
VLF Junction + Y	359-61312	* 1 inch (Outer)	4-1/2
VLF Junction + Y	359-61312	3/8 inch (Inner)	4-1/2
HLF Bellows IN - Y	359-61312	* 1 inch (Outer)	1-1/2 - 1-1/2
HLF Bellows IN - Y	359-61312	3/8 inch (Inner)	1-1/2 - 1-1/2
HLF Bellows IN + Y	359-61312	* 1 inch (Outer)	1-1/2 - 1-1/2
HLF Bellows IN + Y	359-61312	3/8 inch (Inner)	1-1/2 - 1-1/2
HLF Junction VLF - Y	359-61312	* 1 inch (Outer)	1
HLF Junction VLF - Y	359-61312	3/8 inch (Inner)	1
HLF Junction VLF + Y	359-61312	* 1 inch (Outer)	1
HLF Junction VLF + Y	359-61312	3/8 inch (Inner)	1

Vacuum Lines

From	To	Teflon ID	Length in Feet
Junction 359-61306	359-61312	* 1 inch (Outer)	1
Junction 359-61306	359-61312	3/8 inch (Inner)	1
Junction to VAC	359-61312	* 1 inch (Outer)	1 - 1
Junction to VAC	359-61312	3/8 inch (Inner)	1 - 1
HLF Bellows Out - Y	359-61312	* 1 inch	5
HLF Bellows Out + Y	359-61312	* 1 inch	5
Junction - Y and + Y	359-61312	* 1 inch	7 - 4

Hydraulic Lines

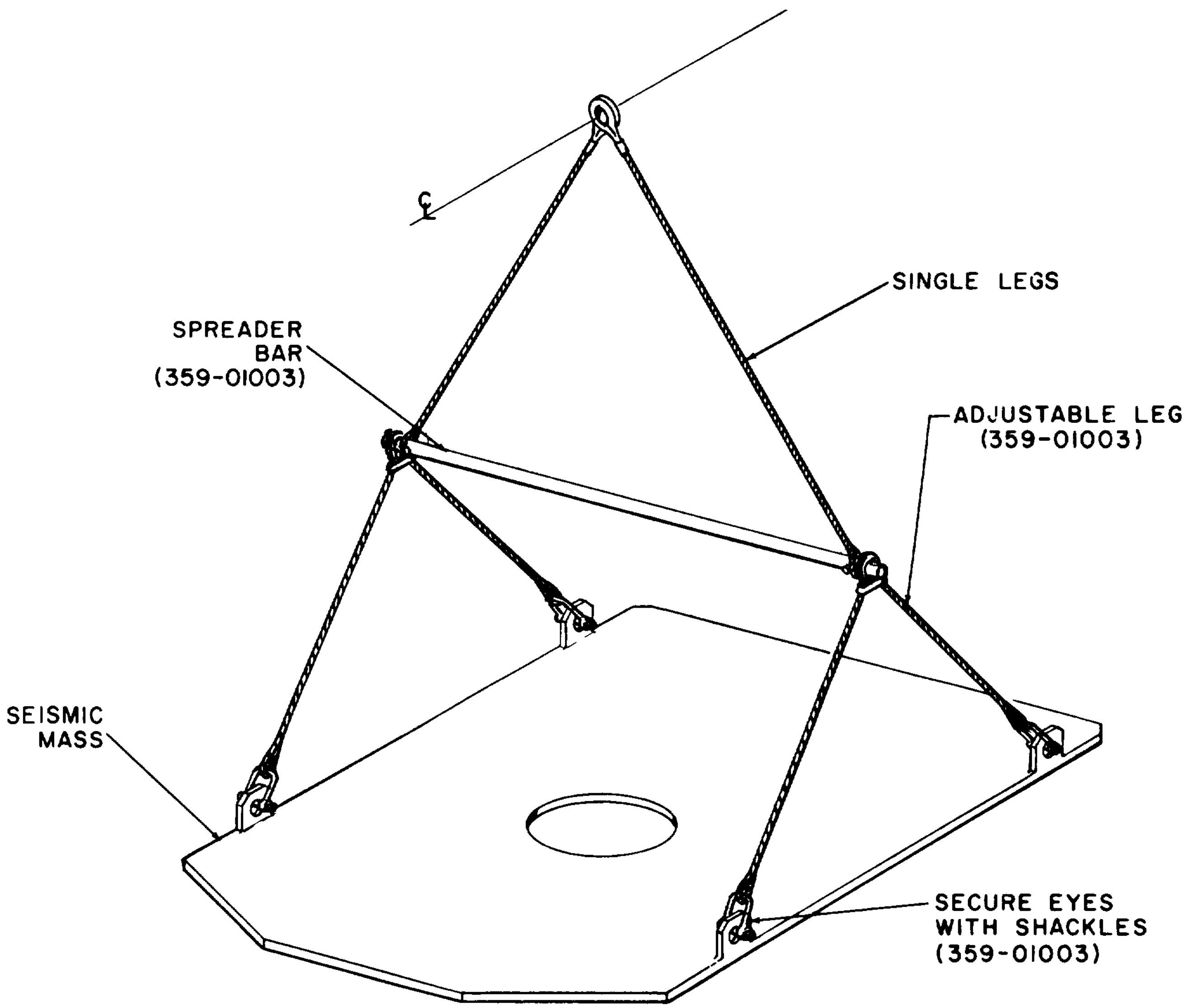
PLF - Y Return	Hydraulic Manifold	2-1/2 inch	7
PLF - Y Pressure	Hydraulic Manifold	2-1/2 inch	7
PLF + Y Return	Hydraulic Manifold	2-1/2 inch	10
PLF + Y Pressure	Hydraulic Manifold	2-1/2 inch	10
Roll Return	Hydraulic Manifold	1-1/2 inch	9 - 5
Roll Pressure	Hydraulic Manifold	1-1/2 inch	9 - 5
PHF Return	Hydraulic Manifold	2-1/4 inch	9 - 5
PHF Pressure	Hydraulic Manifold	2-1/4 inch	9 - 5
HHF Return	Hydraulic Manifold	2-1/2 inch	16
HHF Pressure	Hydraulic Manifold	2-1/2 inch	16
VHF Return	Hydraulic Manifold	2 inch	16
VHF Return	Hydraulic Manifold	1-1/2 inch	2
VHF Pressure	Hydraulic Manifold	2 inch	13
VHF Pressure	Hydraulic Manifold	1-1/2 inch	6
Pentration Return	Hydraulic Manifold	6 inch	72
Pentration Pressure	Hydraulic Manifold	6 inch	50
Pitch Return	Hydraulic Manifold	1-1/2 inch	24
Pitch Pressure	Hydraulic Manifold	1-1/2 inch	26

Hydraulic Lines

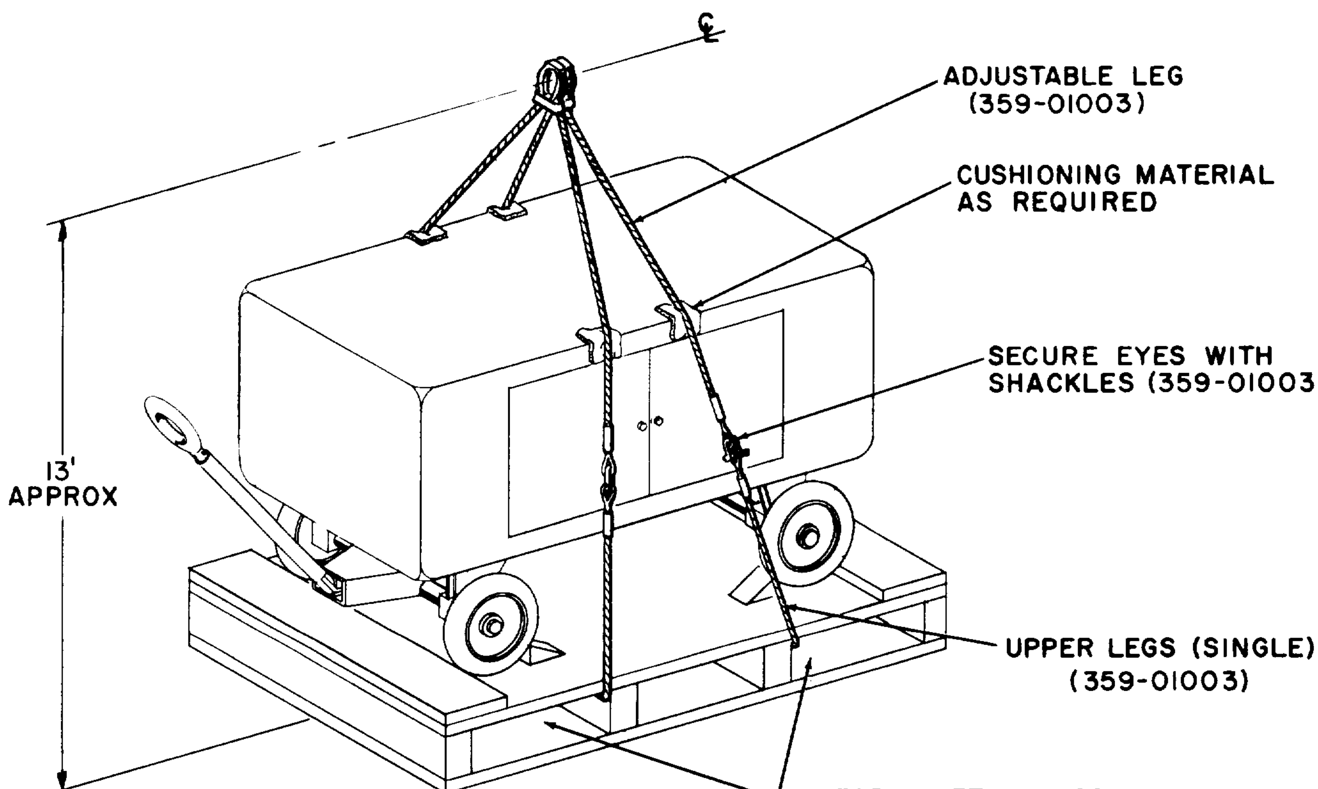
From	To	Teflon ID	Length in Feet
VHF Return	Hydraulic Manifold	2 inch	8 - 12
VHF Return	Hydraulic Manifold	1-1/2 inch	2
Yaw Return	Hydraulic Manifold	1-1/2 inch	24
Yaw Pressure	Hydraulic Manifold	1-1/2 inch	26
HLF - Y Return	Hydraulic Manifold	2-1/2 inch	22
HLF + Y Pressure	Hydraulic Manifold	2-1/2 inch	22
HLF + Y Return	Hydraulic Manifold	2-1/2 inch	18
HLF - Y Pressure	Hydraulic Manifold	2-1/2 inch	18
VLF - Y Return	Hydraulic Manifold	2-1/2 inch	24
VLF + Y Pressure	Hydraulic Manifold	2-1/2 inch	24
VLF + Y Return	Hydraulic Manifold	2-1/2 inch	22
VLF - Y Pressure	Hydraulic Manifold	2-1/2 inch	22
Vacuum Manifold Return	Hydraulic Manifold	* 1 inch	12
Vacuum Manifold Pressure	Hydraulic Manifold	* 1 inch	12
HLF - Y UP	Down	1-1/2 inch	1-1/2 - 3, 7 inches - 1-1/2
HLF + Y UP	Down	1-1/2 inch	1-1/2 - 3, 7 inches - 1-1/2
VLF - Y + Y	C1	1-1/2 inch	3 - 13 - 3
VLF - Y + Y	C2	1-1/2 inch	2-1/2 - 2-1/2 - 13
Drogue - Y	Hydraulic Manifold	* 1 inch	1 - 1
Drogue + Y	Hydraulic Manifold	3/8 inch	1 - 1
Drogue + Y	Hydraulic Manifold	* 1 inch	1 - 1
Drogue + Y	Hydraulic Manifold	3/8 inch	1 - 1

* 7/8 inch ID may be used and expanded to suit.

LIFTING SEISMIC MASS



LIFTING HYDRAULIC POWER SUPPLY

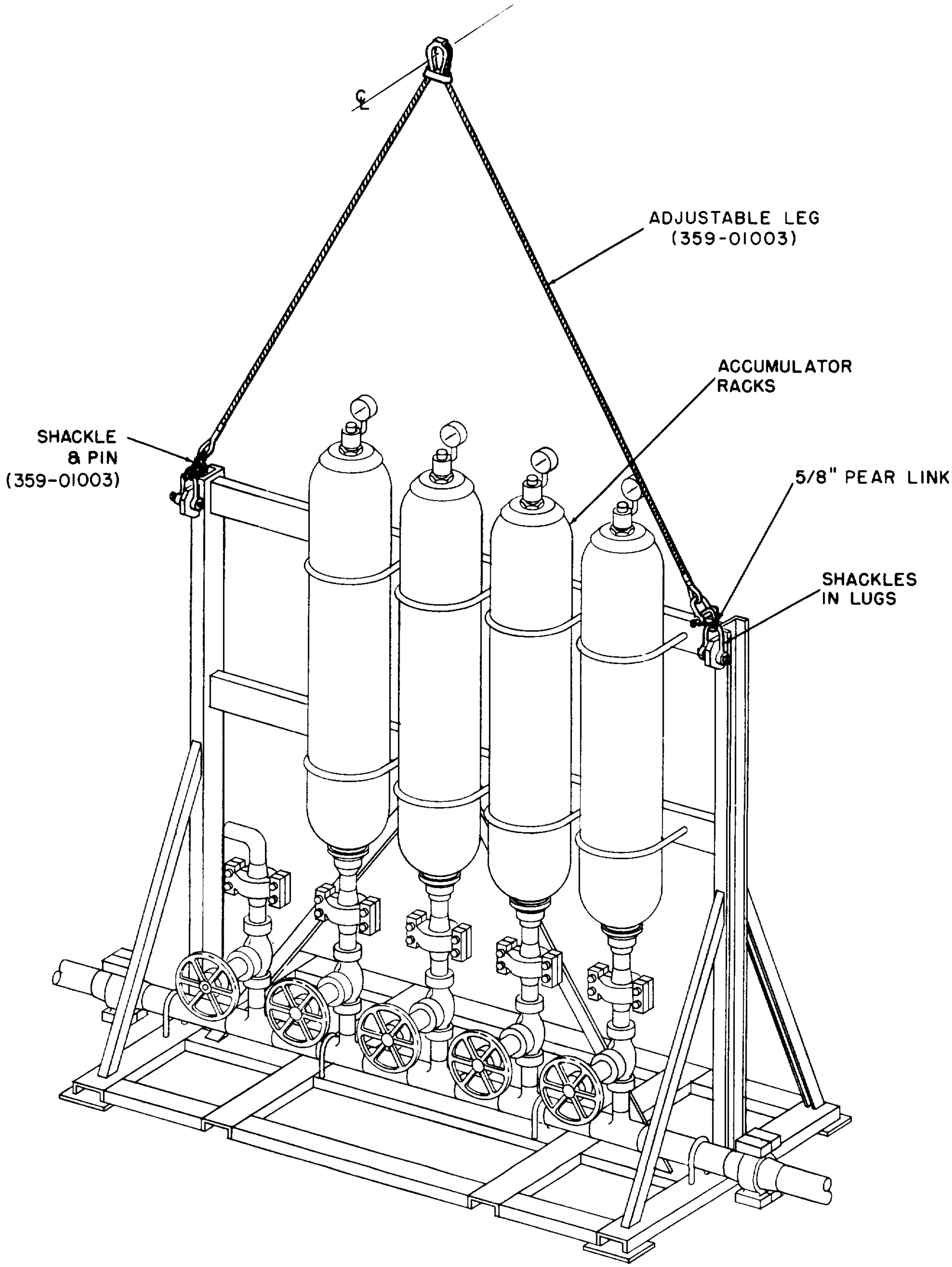


(A) USE SLINGS ONLY WHEN HYDRAULIC POWER SUPPLY IS ON SHIPPING SKID. PREFERRED METHOD OF HANDLING IS 2-TON FORK-LIFT TRUCK, WHENEVER POSSIBLE.

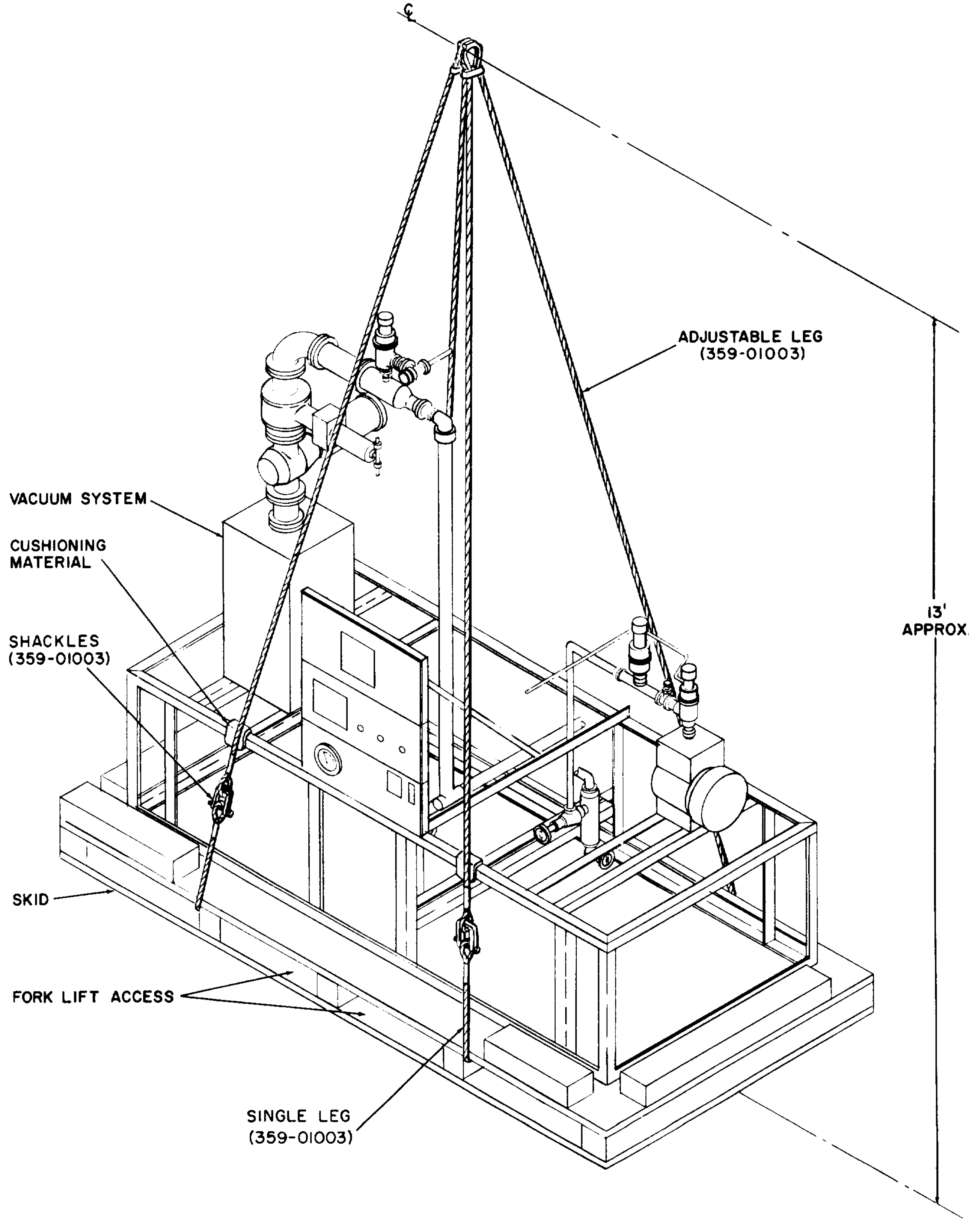
(B) WHEN OFF SKID, TOW HYDRAULIC POWER SUPPLY WITH FORK-LIFT TRUCK BY ATTACHMENT TO CART STEERING DRAW-BAR.

NOTE: HANDBRAKES PROVIDED AT REAR WHEELS MUST BE RELEASED PRIOR TO TOWING AND RESET AFTER POSITIONING.

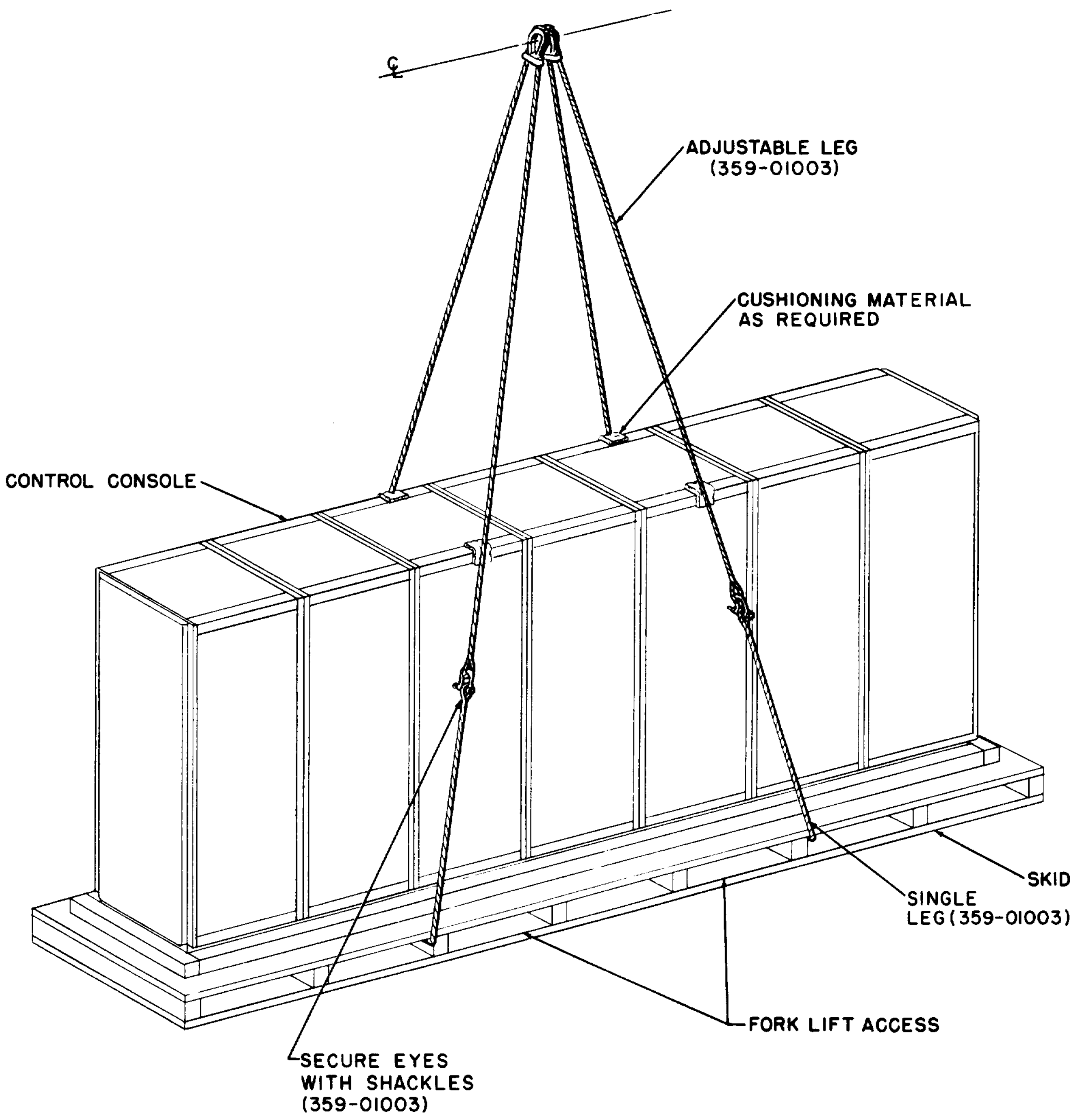
LIFTING ACCUMULATOR RACKS



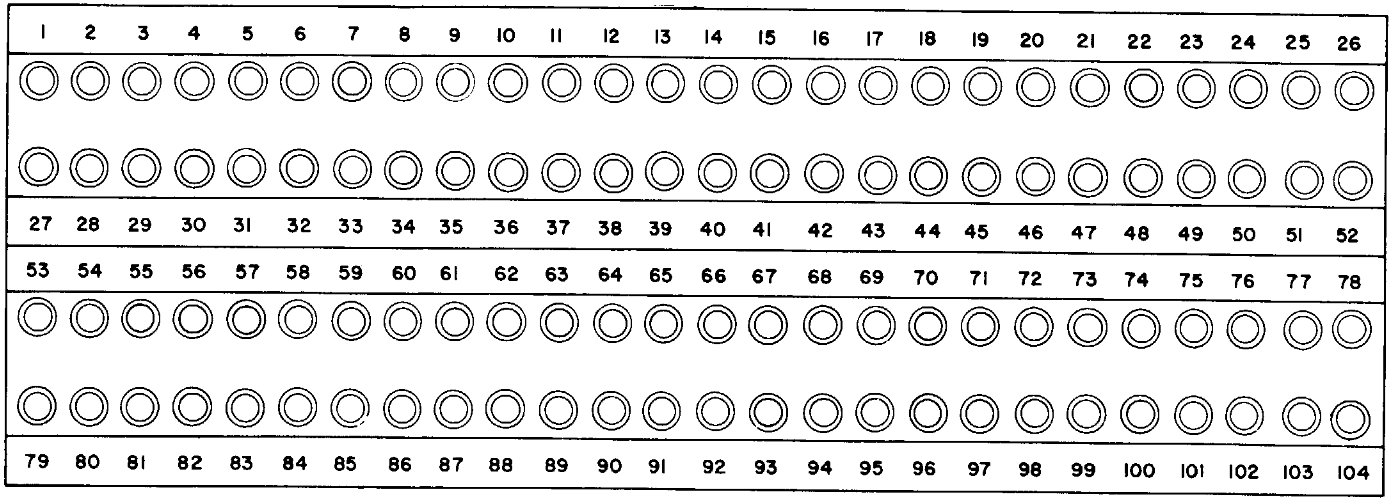
LIFTING VACUUM SYSTEM



LIFTING CONTROL CONSOLE



JACK PANEL IDENTIFICATION



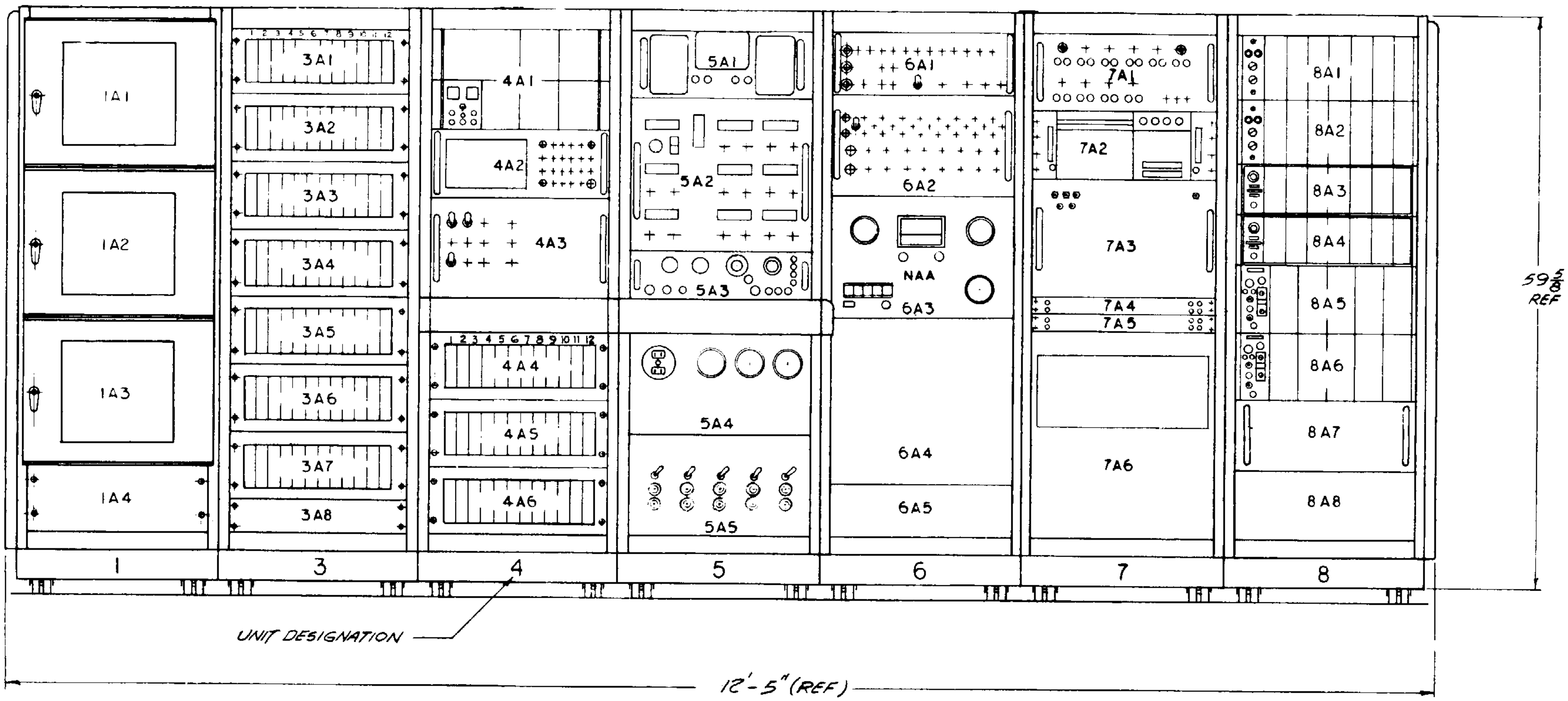
Test Point Number	Test Point Connection ROW 1
1.	Servo Input Probe 42"
2.	Servo Input Probe ±1/4"
3.	Servo Input Probe Roll 90°
4.	Servo Input Drogue Horizontal ±16"
5.	Servo Input Drogue Vertical ±16"
6.	Servo Input Drogue Horizontal ±1/4"
7.	Servo Input Drogue Vertical ±1/4"
8.	Servo Input Drogue Pitch 30°
9.	Servo Input Drogue Yaw 30°
10.	Spare
11.	Spare
12.	Spare
13.	Spare
14.	Spare
15.	Spare
16.	Spare
17.	Spare
18.	Spare
19.	Spare
20.	Spare
21.	Spare
22.	Spare
23.	Spare
24.	Spare
25.	Spare
26.	Spare

Test Point Number	Test Point Connection ROW 2
27.	Position Feedback Probe 42"
28.	Position Feedback Probe ±1/4"
29.	Position Feedback Probe 90°
30.	Position Feedback Drogue Horizontal ±16"
31.	Position Feedback Drogue Vertical ±16"
32.	Position Feedback Drogue Horizontal ±1/4"
33.	Position Feedback Drogue Vertical ±1/4"
34.	Position Feedback Drogue Pitch 30°
35.	Position Feedback Drogue Yaw 30°
36.	Spare
37.	Spare
38.	Spare
39.	Spare
40.	Spare
41.	Spare
42.	Spare
43.	Spare
44.	Spare
45.	Spare
46.	Excitation Voltage Probe Signal Condition Unit 8A5
47.	P1 Cubic Differential DC Amplifiers Output 8A3
48.	P2 Cubic Differential DC Amplifiers Output 8A3
49.	P3 Cubic Differential DC Amplifiers Output 8A3
50.	P4 Cubic Differential DC Amplifiers Output 8A3
51.	P5 Cubic Differential DC Amplifiers Output 8A3
52.	P6 Cubic Differential DC Amplifiers Output 8A3

Test Point Number	Test Point Connection ROW 3
53.	Spare
54.	Spare
55.	Spare
56.	Spare
57.	Spare
58.	Spare
59.	Spare
60.	Spare
61.	Spare
62.	Spare
63.	Spare
64.	Spare
65.	Spare
66.	Spare
67.	Spare
68.	Spare
69.	Spare
70.	Spare
71.	Spare
72.	Excitation Voltage Drogue Signal Condition Unit 8A6
73.	D1 Cubic Differential DC Amplifiers Output 8A4
74.	D2 Cubic Differential DC Amplifiers Output 8A4
75.	D3 Cubic Differential DC Amplifiers Output 8A4
76.	D4 Cubic Differential DC Amplifiers Output 8A4
77.	D5 Cubic Differential DC Amplifiers Output 8A4
78.	D6 Cubic Differential DC Amplifiers Output 8A4

Test Point Number	Test Point Connection ROW 4
79.	Channel #1. Accudata DC Amplifier 8A1 to Visicorder
80.	Channel #2. Accudata DC Amplifier 8A1 to Visicorder
81.	Channel #3. Accudata DC Amplifier 8A1 to Visicorder
82.	Channel #4. Accudata DC Amplifier 8A1 to Visicorder
83.	Channel #5. Accudata DC Amplifier 8A1 to Visicorder
84.	Channel #6. Accudata DC Amplifier 8A1 to Visicorder
85.	Channel #7. Accudata DC Amplifier 8A1 to Visicorder
86.	Channel #8. Accudata DC Amplifier 8A1 to Visicorder
87.	Channel #9. Accudata DC Amplifier 8A2 to Visicorder
88.	Channel #10. Accudata DC Amplifier 8A2 to Visicorder
89.	Spare
90.	Spare
91.	Spare
92.	Spare
93.	Spare
94.	Spare
95.	Spare
96.	Spare
97.	Spare
98.	Spare
99.	Spare
100.	Spare
101.	Spare
102.	Spare
103.	Spare
104.	Spare

CONTROL CONSOLE IDENTIFICATION



UNIT NO.	DESCRIPTION	UNIT NO.	DESCRIPTION
1A1	RECORDER	5A4	RECEPTACLE PANEL
1A2	RECORDER	5A5	FEEDBACK PRESS. TRANSDUCERS
1A3	RECORDER		
1A4	BLANK	6A1	SYSTEM STATUS PANEL
		6A2	SYSTEM TEST PANEL
3A1	PITCH ±30°	6A3	CONTROL PANEL
3A2	YAW ±30°	6A4	BLANK
3A3	Y HORIZ. ±1/4"	6A5	BLANK
3A4	Z VERT. ±1/4"		
3A5	Z VERT. ±16"	7A1	CIRCUIT BREAKER PANEL
3A6	Y HORIZ. ±16"	7A2	VISICORDER
3A7	ABORT	7A3	XDUCER CALIBRATION
3A8	BLANK	7A4	PANEL WITH PJ339 JACKS
		7A5	PANEL WITH PJ339 JACKS
4A1	POWER SUPPLY	7A6	BLANK
4A2	DC VOLTMETER PANEL		
4A3	SERVO TEST PANEL (359-62510-1)	8A1	DC AMPLIFIER
4A4	X HORZ. 42 IN.	8A2	PANEL, FILLER
4A5	X ROLL ±90°	8A3	DIFFERENTIAL DC AMPLIFIER
4A6	X HORZ. 1/4 IN.	8A4	PANEL, FILLER
		8A5	SIGNAL CONDITIONING MODULE
5A1	OSCILLOSCOPE	8A6	SIGNAL CONDITIONING MODULE
5A2	SYSTEM MONITOR PANEL	8A7	FORCE ABORT
5A3	FUNCTION GENERATOR	8A8	TRANSMISSION LINE TERMINAL EQUIPMENT

LIST OF AVAILABLE SPARES

The spare parts in this list are available for use. They include (but are not limited to) the following categories of spares:

1. One complete set of seals for each type of actuator.
2. One complete set of seals for each subsystem (shrouds, bellows, cover plates etc.
3. One of each type potentiometer.
4. One set of crush washers for each use.
5. One of each type(minimum)of hydraulic valves.

Item Name	Part Number	Assembly Used On	Quantity Available
Valve Driver	359-62045	359-62002	1
Buffer Card	359-62041	359-62002	1
Threshold Detector	359-62046	359-62002	1
Power Supplies	Lambda LH-124FM-0332	359-62002	1
Pilot Light Bulbs	327	359-62002	12
Circuit Breaker	Heinemann JA 2-A3	359-62002	2
Amplifiers	Pace CD10	359-62002	1
Relays	KHYPU6D, 26.5 VDC	359-62002	2
Fuses	3AG Slo-Blow, 3 amp.	359-62002	2 boxes
Diodes	IN 4004	359-62002	6
Desk Top (work/writing shelf)		359-62002	1
Insertion & Removal Tool	Deutsch M15513-20	359-62002	3
Insertion & Removal Tool	Deutsch M15513-16	359-62002	3
Insertion & Removal Tool	Deutsch M15513-12	359-62002	2
Insertion & Removal Tool	Deutsch M15515-20	359-62002	1
Insertion & Removal Tool	Deutsch M15515-16	359-62002	2
Insertion & Removal Tool	Deutsch M15515-12	359-62002	2
Circuit Breaker	Heineman JA1-A3	359-62002	1
Circuit Breaker	Heineman JA2-A3	359-62002	1
Push Button	GE CR104A	359-62002	1
28 V Pilot Lamps & Holders		359-62002	18
Tip Plugs		359-62002	20
Tip Jacks		359-62002	82
Banana Plugs		359-62002	12 (r) 12 (blk) 12 (grn)
Teflon Tubing	Nos. 18 & 22	359-62002	1 spool ea
Buss Wire	Nos. 20, 22, & 24	359-62002	1 roll ea
1/2" Strain Relief Connections	.125 to .250 Diam.	359-62002	17
1/2" Strain Relief Connections	.375 to .500 Diam.	359-62002	20
1/2" Strain Relief Connections	.437 to .562 Diam.	359-62002	9
Card Angle Handles	1230-2 (.1 at 100V)	359-62002	4
Capacitors	Godall Condensor New Jersey (.1 at 100 V)	359-62002	15
Blank Cards (with conn. contacts)		359-62002	4

Item Name	Part Number	Assembly Used On	Quantity Available
Printed CKT Boards	312-41005-7	359-62002	6
Printed CKT Boards	312-41017-7	359-62002	3
Transformer	James Electronics Inc. Chicago, Illinois 8104	359-62002	1
Choppers	Cambridge Scientific Maryland 455D	359-62002	2
Transformers	1719 (400 CY, 6.3 V)	359-62002	2
Component Clips	7109-1CT	359-62002	15
Component Clips	20160-4	359-62002	23
Component Clips	6009-8CT	359-62002	16
Toggle Switch	2TP12-7 (Micro Switch)	359-62002	5
Relays	Allied Control Co. New York MU2C600D33	359-62002	3
P.S. Cable Clamps	8	359-62002	5
Transistor Sockets		359-62002	25
Heat Sinks		359-62002	18
Switch	TS-6	359-62002	5
Switch	PM-6	359-62002	1
Knobs	(1/8" shaft)	359-62002	9
Knobs	DS90-3-2G (1/4" shaft)	359-62002	6
Knobs	412DB2K1 (1/4" shaft)	359-62002	3
Knobs	409R1K1 (1/8" shaft)	359-62002	3
10K at 2W Dual Pot	RV4	359-62002	2
1K & 10K 2W Dual Pot	RV4	359-62002	1
2K at 2W Pot	RV4	359-62002	6
1000 Ω at 2W Pot	RV4	359-62002	2
1K at 2W Pot	RV4	359-62002	9
1 Meg. at 2W Pot	RV4	359-62002	2
2.5K at 2W Pot	RV4	359-62002	12
10K at 2W Pot	RV4	359-62002	2
5000 Ω at 3/4W	RV6	359-62002	20
5.0 Meg. at 3/4W Pot		359-62002	9
50K at 3/4W Pot		359-62002	29
10K at 3/4W Pot		359-62002	13
100 Ω at 3/4W Pot		359-62002	2
1K at 3/4W Pot		359-62002	5
50K at 3/4W Pot		359-62002	1

Item Name	Part Number	Assembly Used On	Quantity Available
Connectors (Amphenol)	143-022-01	359-62002	49
Diode	HS-4	359-62002	24
Diode	IN126	359-62002	109
Diode	IN137A	359-62002	4
Diode	IN225A	359-62002	7
Diode	IN457	359-62002	30
Diode	IN463	359-62002	45
Diode	IN626	359-62002	5
Diode	IN645	359-62002	3
Diode	IN712	359-62002	50
Diode	IN713	359-62002	1
Diode	IN962	359-62002	7
Diode	IN1510A	359-62002	5
Diode	IN1511A	359-62002	5
Diode	IN3026	359-62002	10
Diode	IN3516	359-62002	52
Diode	IN3518	359-62002	7
Diode	IN3520	359-62002	3
Diode	DR385	359-62002	16
Diode	1/4Z1105	350-62002	2
Transistors	2N916	359-62002	7
Transistors	2N930	359-62002	3
Transistors	2N1132A	350-62002	19
Transistors	2N1132B	359-62002	8
Transistors	2N1613	359-62002	33
Transistors	2N2223	359-62002	2
Transistors	2N2323	359-62002	3
Transistors	2N2564	359-62002	10
Transistors	2N2604	359-62002	6
Extraction Tools (AMP Tab Terms)		359-62002	4
Burr Brown Ampl's	1506	359-62002	10
Burr Brown Ampl's	1508	359-62002	6
Pilot Lamp for Lambda Power Supply		359-62002	1
Packing Pref	MS28778-4	359-60004-1	66
O Ring	2-260-B318-7	359-60004-1	1
O Ring	2-377-B318-7	359-60004-1	2
O Ring	2-161-B318-7	359-60004-1	1
O Ring	2-166-B318-7	359-60004-1	1
O Ring	2-171-B318-7	359-60004-1	5
O Ring	2-25-B318-7	359-60004-1	15
Potentiometer	205989-2	359-60004-1	1

Item Name	Part Number	Assembly Used On	Quantity Available
Potentiometer	205989-1	359-60004-1	1
Seal	NAS159808Y	359-60201-1	12
Potentiometer	205989-3	359-60201-1	1
Potentiometer	205989-4	359-60201-1	1
O Ring	2-278-B318-7	359-60201-1	2
O Ring	2-274-B318-7	359-60201-1	5
O Ring	2-169-B318-7	359-60201-1	1
O Ring	2-143-B318-7	359-60201-1	4
O Ring	2-140-B318-7	359-60201-1	2
Seal	359-40227-7	359-60201-1	2
O Ring	2-266-B318-7	359-60202-1	1
O Ring	2-275-B318-7	359-60202-1	1
Glyd Ring	S-40080-2 (Matl: T.F.E. W.S.S. Spec ZZ53)	359-60202-1	1
Glyd Ring	S-40080-1 (Matl: R.F.E. W.S.S. Spec ZZ53)	359-60202-1	1
O Ring	MS28775-240	359-60202-1	3
Back Up Ring	8-240-N300-9	359-60202-1	1
O Ring	MS28775-233	359-60202-1	1
Back Up Ring	8-233-N300-9	359-60202-1	1
Glyd Ring	S12546-143 (Matl: Bronze Reinf. TFE-16966)	359-60202-1	4
O Ring	MS28775-144	359-60202-1	10
Glyd Ring	S12547-240 (Matl: Bronze Reinf. TFE-16966)	359-60202-1	2
Glyd Ring	S12546-435 (Matl: Bronze Reinf. TFE-16966)	359-60202-1	4
O Ring	NS28775-435	359-60202-1	4
O Ring	2-273-N304-7	359-60202-1	4
Back Up Ring	8-273-N300-9	359-60202-1	4

Item Name	Part Number	Assembly Used On	Quantity Available
Servo Valve	359-11002	359-61206-7	2
O Ring	MS28775-010	359-61206-7	56
Potentiometer	205989-5	359-60301-1	1
O Ring	359-40340-7	359-60303-1	1
Ring Seal	359-41350-7	359-60303-1	4
O Ring	NS28775-013	359-60303-1	8
O Ring	2-37-B318-7	359-60303-1	4
O Ring	2-120-B318-7	359-60303-1	8
O Ring	2-135-B318-7	359-60303-1	8
O Ring	2-137-B318-7	359-60303-1	8
O Ring	2-156-B318-7	359-60303-1	4
O Ring	MS28775-015	359-60303-1	20
Gasket	359-40323-7	359-60303-1	2
O Ring	MS28775-229	359-61304-1	2
Back Up Ring	8-229-N300-9	359-61304-1	2
O Ring	2-231-B318-7	359-61304-1	2
Glyd Ring	512546-224 (Matl: Bronze Reinforced T. F. E. -16966)	359-61304-1	4
O Ring	MS28775-225	359-61304-1	4
Glyd Ring	512547-143 (Matl: Bronze Reinforced T. F. E. -16966)	359-61304-1	2
O Ring	MS28775-142	359-61304-1	2
Glyd Ring	512547-232	359-61305-1	2
O Ring	MS28775-231	359-61305-1	2
Glyd Ring	512546-137 (Matl: Bronze Reinf. T. F. E. -16966)	359-61305-1	4
O Ring	MS28775-138	359-61305-1	4
O Ring	MS28775-232	359-61305-1	2
Back Up Ring	8-232-N300-9	359-61305-1	2
Back Up Ring	MS28774-010	359-61307-1	8
Back Up Ring	MS28774-113	359-61307-1	24
O Ring	MS28775-012	359-61307-1	20
O Ring	MS28775-111	359-61307-1	8
O Ring	MS28775-113	359-61307-1	24
Packing PREF	MS28778-2	359-61307-1	28
Packing PREF	MS28778-8	359-61307-1	43
Crush Washer	MC185-C2B	359-61307-1	28
O Ring	2-19-B318-7	359-61307-1	4
O Ring	2-29-B318-7	359-61307-1	4

Item Name	Part Number	Assembly Used On	Quantity Available
O Ring	2-35-B318-7	359-61307-1	6
Back Up Ring	MS28777-8	359-61308-1	8
O Ring	MS28775-011	359-61308-1	16
O Ring	MS28775-241	359-61308-1	4
O Ring	NAS1598C44	359-61308-1	28
Crush Washer	MC185C8B	359-61308-1	34
O Ring	2-152-B318-7	359-61308-1	8
O Ring	2-31-B318-7	359-61308-1	2
Glyd Ring	512546-010	359-61308-1	16
Glyd Ring	512546-014	359-61308-1	16
Glyd Ring	512546-240	359-61308-1	4
Potentiometer	Ser. No. 598-6G (Similar Model 119)	359-61313-1	1
O Ring	MS28775-129	359-61303-1	3
Back Up Ring	MS28774-129	359-61303-1	3
O Ring	MS28775-234	359-61303-1	6
Back Up Ring	MS28774-234	359-61303-1	6
O Ring	2-234-B318-7	359-61303-1	6
O Ring	MS28775-215	359-61303-1	6
O Ring	2-26-B318-7	359-61303-1	12
Glyd Ring	512547-145	359-61303-1	6
Glyd Ring	512546-214	359-61303-1	6
O Ring	MS28775-017	359-61312-1	8
Packing PREF	MS28778-6	359-61312-1	27
O Ring	2-175-B318-7	359-61312-1	2
O Ring	2-242-B318-7	359-61312-1	2
O Ring	2-273-B318-7	359-61312-1	4
O Ring	2-27-B318-7	359-61312-1	8
O Ring	2-174-B318-7	359-61312-1	4
Back Up Ring	MS28777-4	359-61312-1	12
Glyd Ring	540056 (Matl: Reinf. Bronze-ette 16966)	359-61302-1	1
O Ring	MS28775-447	359-61302-1	1
Glyd Ring	S-12546-447	359-61302-1	1
O Ring	MS28775-448	359-61302-1	1
O Ring	2-377-N304-7	359-61302-1	1
Back Up Ring	8-377-N300-9	359-61302-1	1
Servo Valve	359-11004	359-61309-1	3
Gasket	359-41359-7	359-61309-1	2
O Ring	MS28775-014	359-61309-1	24
O Ring	MS28775-119	359-61309-1	4

Item Name	Part Number	Assembly Used On	Quantity Available
O Ring	MS28775 122	359-61309-1	4
O Ring	MS28775-123	359-61309-1	4
Back Up Ring	MS28774-119	359-61309-1	4
Back Up Ring	MS28774-123	359-61309-1	4
O Ring	2-123-B318-7	359-61309-1	4
O Ring	2-139-B318-7	359-61309-1	4
Crush Washer	MC185C4B	359-61309-2	52
O Ring	2-272-N304-7	359-61301-1	4
O Ring	MS28775-446	359-61301-1	16
O Ring	MS28775-445	359-61301-1	4
Back Up Ring	8-272-N300-9	359-61301-1	4
Glyd Ring	540055 (Matl: Bronze Reinf. T.F.E. 16866)	359-61301-1	4
Glyd Ring	512546-445 (Matl: Bronze Reinf. T.F.E. 16966)	359-61301-1	16
Back Up Ring	MS28777-16	359-61310-1	8
Packing PREF	MS28778-16	359-61310-1	52
Glyd Ring	512546-333 (Matl: Bronze Reinf. T.F.E. 16966)	359-61201-1	4
O Ring	MS28775-334	359-61201-1	4
Glyd Ring	512547-243 (Matl: Bronze Reinf. T.F.E. 16966)	359-61201-1	2
O Ring	MS28775-242	359-61201-1	2
O Ring	MS28775-243	359-61201-1	1
Back Up Ring	MS28774-243	359-61201-1	1
Glyd Ring	512546-328	359-61201-1	2
O Ring	MS28775-329	359-61201-1	2
O Ring	2-243-B318-7	359-61201-1	2
Crush Washer	MC185C16B	359-61203-1	32
O Ring	2-269-B318-7	359-61203-1	1
Servo Valve	359-11001	359-61204-1	5
Packing Pref	MS28778-12	359-61204-1	9
Servo Valve	359-11003	359-61306-1	1
Shut Off Valve	359-11009-5	359-61306-1	1
Crush Washer	MC18566B	359-61306-1	23
Back Up Ring	MS28777-6	359-61306-1	5
O Ring	MS28775-127	359-61306-1	4

Item Name	Part Number	Assembly Used On	Quantity Available
Seal	NAS1598C34	359-61306-1	21
Seal	NAS1598C64	359-61306-1	25
Crush Washer	MC185C4A (NASA)	359-61008-1	14
Crush Washer	MC185C12B	359-61008-1	4
Crush Washer	MC185C24B	359-61008-1	14
Crush Washer	MC185C32B (NASA)	359-61008-1	20
Packing Pref	MS28778-32	359-61010-1	6
O Ring	2-271-B318-7	359-61010-1	2
O Ring	2-277-B318-7	359-61010-1	2
O Ring	2-456-B318-7	359-61010-1	1
Packing Pref	MS28778-24	359-61011-1	6
O Ring	2-246-B318-7	359-61011-1	1
Seal	NAS1598C4N	359-61012-1	4
O Ring	2-115-B318-7	359-61012-1	18
O Ring	2-119-B318-7	359-61012-1	1
O Ring	2-154-B318-7	359-61012-1	1
Valve	359-11009-1	359-61013-1	2
Valve	359-11009-2	359-61013-1	1
Valve	359-11009-3	359-61013-1	1
Valve	359-11009-4	359-61013-1	1
Valve	359-11009-6	359-61013-1	1
O Ring	MS28778-20	359-61013-1	2
Lockwire	MS20995C32	-	-
Lockwire	MS20995NC32	-	-
Grease	D33	-	-
Sealant	359-10004	359-60201-1	-
Locktite		359-61312-1	-
Adhesive	EC1099	-	-
Cement	Tygobond 50	359-61312-1	-
Oil	5606		
Paint	Submarine White Semi-Gloss		

Controls and Indicators - System Status Panel, AMF NO. 359-62501-1 (Sheet 1 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
HYD SYSTEM READY press-to-test indicator lamp	L12	Green	Lights when hydraulic system is ready to be started.
HYD SYSTEM START pushbutton	S10	None	Starts hydraulic system when switch is depressed.
HYD SYSTEM STOP pushbutton	S11	None	Stops hydraulic system operation.
OIL OVER TEMP press-to-test indicator lamp	L13	Red	Lights when temperature of hydraulic system oil is over allowable limits.
HYDRAULIC HEATERS selector switch	S9	OFF-ON	Connects and disconnects hydraulic system oil heaters.
OIL UNDER PRESS press-to-test indicator lamp	L14	Red	Lights when hydraulic pressure is under 2400 psig.
HIGH VAC SYSTEM READY press-to-test indicator lamp	L15	Green	Lights when high-vacuum system is ready to be started.
HIGH VAC SYSTEM START pushbutton	S12	None	Starts high-vacuum system when switch is depressed.

Controls and Indicators - System Status Panel, AMF NO. 359-62501-1 (Sheet 2 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
HIGH VAC SYSTEM STOP pushbutton	S13	None	Stops high-vacuum system when switch is depressed.
LOW VAC SYSTEM READY press-to-test indicator lamp	L16	Green	Lights when low-vacuum system is ready to be started.
LOW VAC SYSTEM START pushbutton	S14	None	Starts low-vacuum system when switch is depressed.
LOW VAC SYSTEM READY	S15	None	Stops low-vacuum system when switch is depressed.
COMPUTER READY indicator lamp	L2	Green	Lights when the test device servos are ready to be operated.
CHAMBER READY indicator lamp	L9	Green	Lights when the test chamber is ready for use.
SERVOS READY indicator lamp	L3	Green	Lights when the electronic input amplifiers to the servos are operating.
TEST indicator lamp	L4	Green	Lights when a test is being performed.
ABORT POS indicator lamp	L6	Red	Lights when test device probe and drogue are incorrectly positioned.

Controls and Indicators - System Status Panel, AMF NO. 359-62501-1 (Sheet 3 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
ABORT VEL indicator lamp	L1	Red	Lights when velocity of test device elements have exceeded the speed limitations.
ABORT POWER indicator lamp	L10	Red	Lights when test device power is overhead.
ABORT FORCE indicator lamp	L11	Red	Lights when the force of the probe and drogue have exceeded operating limitations.
ADTD toggle switch	S3	READY NOT READY	In READY position a circuit is completed to advise test conductor that test device is ready for operation.
REFERENCE POSITION toggle switch	None	None	Spare toggle switch.
EMERGENCY toggle switch	S6	NORMAL ABORT	Aborts system when placed in ABORT position.
LAMP TEST pushbutton	S7	None	When depressed will test indicator lamps on panel.
28VDC HTR SUPP indicator lamp	L5	None	Lights when 28VDC heater power supplies are operating.

Controls and Indicators - System Status Panel, AMF NO. 359-62501-1 (Sheet 4 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
HYBRID COMPUTER REMOTE CONTROL Pushbutton Indicator Lamps			
GO	S20	Green	When depressed will start computer.
RESTART	S19	Blue	When depressed will restart computer.
(None)	S18	White	Spare pushbutton.
NEXT TEST	S17	White	When depressed will start next test from computer.
STOP	S16	Red	When depressed will stop computer test.

Controls and Indicators - System Test Panel, AMF NO. 359-62502-1 (Sheet 1 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
TEST CHANNEL			
FREQ RESPONSE indicator lamps for PROBE			
42 IN.	L1	White	Lights when function generator output is connected.
±1/4 IN.	L3		
$\pm 90^{\circ}$	L5		
Drogue			
±16-IN. VERTICAL	L7		
±1/4-IN. VERTICAL	L9		
$\pm 30^{\circ}$ PITCH	L11		
±16-IN. HORIZONTAL	L13		
±1/4-IN. HORIZONTAL	L15		
$\pm 30^{\circ}$ YAW	L17		
EXERCISE indicator lamps for PROBE			
42 IN.	L2	Blue	Lights when test device servo is actuated.
±1/4 IN.	L4		
$\pm 90^{\circ}$	L6		
DROGUE			
±16-IN. VERTICAL	L8		

Controls and Indicators - System Test Panel, AMF NO. 359-62502-1 (Sheet 2 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
±1/4-IN. VERTICAL	L10		
$\pm 30^{\circ}$ PITCH	L12		
±16-IN. HORIZONTAL	L14		
±1/4-IN. HORIZONTAL	L16		
$\pm 30^{\circ}$ YAW	L18		
Toggle switch for PROBE			
42 IN.	S1	FREQ RESPONSE - EXERCISE	In FREQ RESPONSE position, function generator output is connected. In EXERCISE position, normal input is provided to actuate servos in test device.
±1/4-IN.	S2		
$\pm 90^{\circ}$	S3		
DROGUE			
±16-IN. VERTICAL	S4		
±1/4-IN. VERTICAL	S5		
$\pm 30^{\circ}$ PITCH	S6		
±16-IN. HORIZONTAL	S7		
±1/4-IN. HORIZONTAL	S8		
$\pm 30^{\circ}$ YAW	S9		

Controls and Indicators - System Test Panel, AMF NO. 359-62502-1 (Sheet 3 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
LEVEL SET			
FREQUENCY RESPONSE controls for PROBE			
42 IN.	R1	None	Adjustment of control increases or decreases function generator output.
±1/4-IN.	R3		
$\pm 90^{\circ}$	R5		
DROGUE			
±16-IN. VERTICAL	R7		
±1/4-IN. VERTICAL	R9		
$\pm 30^{\circ}$ PITCH	R11		
±16-IN. HORIZONTAL	R13		
±1/4-IN. HORIZONTAL	R15		
$\pm 30^{\circ}$ YAW	R17		
EXERCISE controls for PROBE			
42 IN.	R2	None	Adjustment of control increases or decreases normal oscillator output to actuate servos.
±1/4-IN.	R4		
$\pm 90^{\circ}$	R6		
DROGUE			
±16-IN. VERTICAL	R8		
±1/4-IN. VERTICAL	R10		
$\pm 30^{\circ}$ PITCH	R12		

Controls and Indicators - System Test Panel, AMF NO. 359-62502-1 (Sheet 4 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
±16-IN. HORIZONTAL	R14		
±1/4-IN. HORIZONTAL	R16		
±30° YAW	R18		

Controls and Indicators - Circuit Breaker Panel, AMF NO. 359-62508-1 (Sheet 1 of 2)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
DROGUE VALVES indicator lamps			Lights when power is connected to servo valve.
Pitch $\pm 30^{o}$	L4	Green	
Yaw $\pm 30^{o}$	L5	Green	
Horiz ±1/4-IN.	L6	Green	
Vert ±1/4-IN.	L7	Green	
Horiz ±16-IN.	L8	Green	
Vert ±16-IN.	L9	Green	
PROBE VALVES indicator lamps			Lights when power is connected to servo valve.
42 IN.	L1	Green	
±1/4-IN.	L2	Green	
$\pm 90^{o}$	L3	Green	
28-VDC SUPPLY indicator lamp	L10	Green	Lights when power is connected to hydraulic heaters.
120 VAC circuit breakers			
SERVO	CB11	ON-OFF	Connects power to servo motors.
INSTR	CB12	ON-OFF	Connects power to instrumentation.
FORCE MEASURE	CB13	ON-OFF	Connects power to force measurement components.

Controls and Indicators - Circuit Breaker Panel, AMF NO. 359-62508-1 (Sheet 2 of 2)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
DROGUE VALVES Circuit breakers			Connects power to the drogue valves.
Pitch ±30^{o}	CB4	ON-OFF	
Yaw ±30^{o}	CB5	ON-OFF	
Horiz ±1/4-IN.	CB6	ON-OFF	
Vert ±1/4-IN.	CB7	ON-OFF	
Horiz ±16-IN.	CB8	ON-OFF	
Vert ±16-IN.	CB9	ON-OFF	
PROBE VALVES circuit breakers			Connects power to the probe valves.
42 IN.	CB1	ON-OFF	
±1/4-IN.	CB2	ON-OFF	
±90^{o}	CB3	ON-OFF	
28-VDC SUPPLY circuit breaker	CB10	ON-OFF	Connects power to the hydraulic heaters.

Controls and Indicators - Transducer Calibration Panel, AMF NO. 359-62514-1 (Sheet 1 of 3)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
PROBE XDCR FEEDBACK potentiometer			Calibrates test device potentiometer output.
±42 inches	R1	ADJ to -10	
	R2	ADJ to +10	
HORIZ ±1/4-IN.	R5	ADJ to -10	
	R6	ADJ to +10	
$\pm 90^{\circ}$	R9	ADJ to -10	
	R10	ADJ to +10	
PROBE XDCR MONITORING potentiometer			Calibrates monitor panel POSITION control output.
±42 inches	R3	ADJ to -10	
	R4	ADJ to +10	
HORIZ ±1/4-IN.	R7	ADJ to -10	
	R8	ADJ to +10	
$\pm 90^{\circ}$	R11	ADJ to -10	
	R12	ADJ to +10	
DROGUE XDCR FEEDBACK potentiometer			Calibrates test device potentiometer output.
Horiz ±1/4-IN.	R13	ADJ to -10	
	R14	ADJ to +10	

Controls and Indicators - Transducer Calibration Panel, AMF NO. 359-62514-1 (Sheet 2 of 3)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
VERT ±1/4-IN.	R17	ADJ to -10	
	R18	ADJ to +10	
PITCH ±30°	R21	ADJ to -10	
	R22	ADJ to +10	
YAW ±30°	R25	ADJ to -10	
	R26	ADJ to +10	
HORIZ ±16-IN.	R29	ADJ to -10	
	R30	ADJ to +10	
VERT ±16-IN.	R33	ADJ to -10	
	R34	ADJ to +10	
DROGUE XDCR MONITORING potentiometer			Calibrates monitor panel POSITION control output.
HORIZ ±1/4-IN.	R15	ADJ to -10	
	R16	ADJ to +10	
VERT ±1/4-IN.	R19	ADJ to -10	
	R20	ADJ to +10	
PITCH ±30°	R23	ADJ to -10	
	R24	ADJ to +10	
YAW ±30°	R27	ADJ to -10	
	R28	ADJ to +10	
HORIZ ±16-IN.	R31	ADJ to -10	
	R32	ADJ to +10	
VERT ±16-IN.	R35	ADJ to -10	
	R36	ADJ to +10	

Controls and Indicators - Transducer Calibration Panel, AMF NO. 359-62514-1 (Sheet 3 of 3)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
WIPER test point	Odd numbers TJ1 thru TJ18	None	Test point for potentiometer wiper contact.
GND test point	Even numbers TJ19 and TJ20	None	Test point at ground potential.

Controls and Indicators - System Monitor Panel, AMF NO. 359-62511-1 (Sheet 1 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
PROBE DISPLACEMENT 42-inch meter	M1	0 -7" -14" -21" -28" -35" -42"	Indicates probe gross linear displacement.
42-IN. POSITION control	R1	None	To make position displacement adjustment of probe gross linear displacement.
42-IN. POSITION rocker switch	S1	POSITION-OFF	To connect POSITION control R1 into circuit.
PROBE DISPLACEMENT ±1/4-IN. meter	M4	1/4" -1/8" -0 -1/8" -1/4"	Indicates probe fine linear displacement.
±1/4-IN. POSITION control	R4	None	To make position displacement adjustment of probe fine linear displacement.
±1/4-IN. POSITION rocker switch	S4	POSITION-OFF	To connect POSITION control R4 into circuit.
PROBE DISPLACEMENT 42-IN. meter	M7	90^o -60^o -30^o -0 -30^o -60^o -90^o	Indirect probe linear displacement.
±90^o Position Control	R7	None	To make position adjustment of probe linear displacement.
±90^o Position Rocker Switch	S7	POSITION-OFF	To connect POSITION CONTROL R7 in circuit.

Controls and Indicators - System Monitor Panel, AMF NO. 359-62511-1 (Sheet 2 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
DROGUE DISPLACEMENT VERTICAL ±16-IN. meter	M2	16" -8" -0 -8" -16"	Indicates drogue vertical linear displacement.
VERTICAL ±16-IN. POSITION control	R2	None	To make position displacement adjustment of drogue vertical linear displacement.
VERTICAL ±16-IN. rocker switch	S2	POSITION-OFF	To connect POSITION control R2 into circuit.
DROGUE DISPLACEMENT VERTICAL ±1/4-IN. meter	M5	1/4" -1/8" -0 -1/8"	Indicates drogue fine vertical linear displacement.
VERTICAL ± IN. POSITION control	R5	None	To make position displacement adjustment of drogue fine vertical linear displacement.
VERTICAL ±1/4-IN. rocker switch	S5	POSITION-OFF	To connect POSITION control R5 into circuit.
DROGUE DISPLACEMENT VERTICAL $\pm 30^{\circ}$ Meter	M8	30° -20° -10° -0° -10° -20° -30°	Indicates drogue pitch displacement.
VERTICAL $\pm 30^{\circ}$ POSITION control	R8	None	To make position displacement adjustments of drogue pitch displacement.

Controls and Indicators - System Monitor Panel, AMF NO. 359-62511-1 (Sheet 3 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
DROGUE DISPLACEMENT HORIZONTAL ±16-IN. meter	M3	16" -8" -0 -8" -16"	Indicates drogue gross horizontal linear displacement.
HORIZONTAL ±16-IN. POSITION control	R3	None	To make position displacement adjustment to drogue gross horizontal linear displacement.
HORIZONTAL ±16-IN. rocker switch	S3	POSITION-OFF	To connect POSITION control R3 into circuit.
DORGUE DISPLACEMENT HORIZONTAL ±1/4-IN. meter	M6	1/4" -1/8" -0 -1/2" -1/4"	Indicates drogue fine horizontal linear adjustment.
HORIZONTAL ±1/4-IN. POSITION control	R6	None	To make position displacement adjustment of drogue fine horizontal linear adjustment.
HORIZONTAL ±1/4-IN. rocker switch	S6	POSITION-OFF	To connect POSITION control R6 into circuit.
DROGUE DISPLACEMENT HORIZONTAL ±30° meter	M9	30° -20° -10° -0 -10° -20° -30°	Indicates drogue yaw displacement.
HORIZONTAL ±30° POSITION control	R9	None	To make position displacement adjustment of drogue yaw displacement.

Controls and Indicators - System Monitor Panel, AMF NO. 359-62511-1 (Sheet 4 of 4)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
HORIZONTAL $\pm 30^{\circ}$ rocker switch	S9	POSITION-OFF	To connect POSITION control R9 into circuit.
HYDRAULIC PRESSURE meter	M10	PSI x 1000 0 -1 -2 -3 -4 -5	Indicates hydraulic system pressure.

Control and Indicators - Receptacle and Elapsed Time Meter Pane, AMF NO. 359-62521

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
SERVO Synchronous Recorder	None	(Hours)	Indicates the number of hours operation for Servo mechanisms.
INSTR. Synchronous Recorder	None	(Hours)	Indicates the number of hours operation for various control console instrumentation.
FORCE MEASURE Synchronous Recorder	None	(Hours)	Indicates the number of hours operation for the force measurement equipment.

Controls and Indicators - DC Voltmeter Panel Assembly, AMF NO. 359-62509-1 (Sheet 1 of 2)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
DC VOLTS meter	None	Dial Scale - 3 - 2 - 1 - 0 - 1 - 2 - 3 10 - 5 - 0 - 5 - 10	Used to indicate input voltage null.
Range control switch	None	.003 - .01 - .03 - .1 .3 - 1 - 3 - 10 - 30 - 100 - 300	Selects voltage input setting.
ZERO ADJ control	None	None	Meter adjustment.
PUSH TO ZERO push switch	None	None	Permits meter zero indication.
GROUND binding posts	None	Black	Meter ground test point.
Toggle switch	None	None	Turns meter on and off.
POSITION INPUT DROGUE and PROBE binding		Horiz 16 - Horiz 1/4 - Yaw-Vert 16 - Vert 1/4 - Pitch - 42 - 1/4 - Roll	Provides a test point for each servo input voltage.
POSITION FEED-BACK DROGUE and PROBE binding posts		Horiz 16 - Horiz 1/4 - Yaw-Vert 16 - Vert 1/4 - 1/4 Pitch - 42 - 1/4 - Roll	Provides a test point for each servo output voltage.

Controls and Indicators - DC Voltmeter Panel Assembly, AMF NO. 359-62509-1 (Sheet 2 of 2)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
METER INPUT binding posts		HIGH-LOW	Provides a connection to the DC voltmeter for both high and low inputs.
POSITION POT binding post		None	Provides a connection to the arm of the POSITION potentiometer.
POSITION control		0 to 100	Used in conjunction with DC voltmeter and indicates percentage of actuator travel on direct reading dial.

Controls and Indicators - Servo Test Panel, AMF NO. 359-62510-1 (Sheet 1 of 3)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
INPUT SERVO PROBE toggle switches			
42 IN.	S2	NORMAL - TEST	NORMAL position enables normal computer operation. TEST position enables function generator test output.
±1/4-IN.	S7	NORMAL - TEST	
$\pm 90^{\circ}$	S1	NORMAL - TEST	
INPUT SERVO DROGUE toggle switches			
Vertical ±16 IN.	S3	NORMAL - TEST	NORMAL position enables normal computer operation. TEST position enables function generator test output.
Vertical ±1/4 IN.	S8	NORMAL - TEST	
Pitch $\pm 30^{\circ}$	S5	NORMAL - TEST	
Horiz ±16 IN.	S4	NORMAL - TEST	
Horiz ±1/4 IN.	S9	NORMAL - TEST	
Yaw $\pm 30^{\circ}$	S6	NORMAL - TEST	
INPUT VALVE SELECT PROBE toggle switches			
42 IN.	S11	SERVO - DUMMY	SERVO position enables normal operation. In the DUMMY position a dummy load is connected across circuit to check electronics output to servo from binding posts below switch.
±1/4 IN.	S16	SERVO - DUMMY	
$\pm 90^{\circ}$	S10	SERVO - DUMMY	

Controls and Indicators - Servo Test Panel, AMF NO. 359-62510-1 (Sheet 2 of 3)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
INPUT VALVE SELECT DROGUE toggle switches			
Vertical ±16 IN.	S12	SERVO - DUMMY	SERVO position enables normal operation. In the DUMMY position a dummy load is connected across the circuit to check electronics output to servo from binding posts below switch.
Vertical ±1/4 IN.	S17	SERVO - DUMMY	
Pitch $\pm 30^{\circ}$	S14	SERVO - DUMMY	
Horiz ±16 IN.	S13	SERVO - DUMMY	
Horiz ±1/4 IN.	S18	SERVO - DUMMY	
Yaw $\pm 30^{\circ}$	S15	SERVO - DUMMY	
POSITION XDUCER SELECT PROBE toggle switches			
42 IN.	S20	XDUCER A - XDUCER B	XDUCER A position enables normal operation. XDUCER B may be substituted for XDUCER A if defective.
±1/4 IN.	S25	XDUCER A - XDUCER B	
$\pm 90^{\circ}$	S19	XDUCER A - XDUCER B	
POSITION XDUCER SELECT DROGUE toggle switches			
Vertical ±16 IN.	S21	XDUCER A - XDUCER B	XDUCER A position enables normal operation. XDUCER B may be substituted for XDUCER if defective.
Vertical ±1/4 IN.	S26	XDUCER A - XDUCER B	
Pitch $\pm 30^{\circ}$	S23	XDUCER A - XDUCER B	
Horiz ±16 IN.	S22	XDUCER A - XDUCER B	

Controls and Indicators - Servo Test Panel, AMF NO. 359-62510-1 (Sheet 3 of 3)

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
Horiz ± 1/4 IN. Yaw $\pm 30^{\circ}$	S27 S24	XDUCER A - XDUCER B XDUCER A - XCUDER B	XDUCER A position enables normal operation. XDUCER B may be substituted for XDUCER if defective.
CALIBRATE VELOCITY LIMIT control	R1	None	Used to calibrate bi-stable multivibrator. Output of control arm is connected to adjacent binding post.

Controls and Indicators - Chopper Assembly, AMF NO. 312-61004

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
Test point	TP	IN	Test point for input signal.
Test point	TP	CRD	Test point for ground potential.
Test point	TP	OUT	Test point for output signal.

Controls and Indicators - DC Amplifier Assembly, AMF NO. 312-61001

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
GAIN control	R19	None	To adjust gain by changing feedback ratio.
BAL control	R4	None	To balance out any offset in amplifier.
Toggle switch	S1	OP - GRD	In OP position enables amplifier output. In GRD position output is placed at zero plus any offset in amplifier due to temperature changes, draft, etc.
Test point	TP	IN	Test point for input signal.
Test point	TP	GRD	Test point for ground potential.
Test point	TP	OUT	Test point for output signal.

Controls and Indicators - Demodulator Assembly, AMF NO. 312-61002-1 and 312-61014-1

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
Test point	TP	IN	Test point for input signal.
Test point	TP	GRD	Test point for ground potential.
Test point	TP	OUT	Test point for output signal.

Controls and Indicators - Buffer Assembly, AMF NO. 312-61006-1

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
ZERO ADJ 1	R4	None	To adjust for zero offset balance.
ZERO ADJ 2	R8	None	To adjust for zero offset balance.
Toggle switch	S1	OP - GRD	In OP position enables buffer output. In GRD position places output at zero plus any offset.
Test point	TP	IN	Test point for input signal.
Test point	TP	GRD	Test point for ground potential.
Test point	TP	OUT	Test point for output signal.

Controls and Indicators - Amplifier Assembly, AMF NO. 312-61003-1

CONTROL OR INDICATOR	REF DESIG	SETTINGS OR INDICATIONS	FUNCTION
GAIN control	R10	None	To adjust gain by changing feedback ratio.
BAL control	R4	None	To balance out any offset in amplifier.
Toggle switch	S1	OP - GRD	In OP position enables amplifier output. In GRD position output is placed at zero plus any offset in amplifier due to temperature changes, draft, etc.
Test point	TP	IN	Test point for input signal.
Test point	TP	GRD	Test point for ground potential.
Test point	TP	OUT	Test point for output signal.

INSTRUCTION
MANUAL
MODEL 110-1
DC VTVM

TABLE OF CONTENTS

I. GENERAL DESCRIPTION

1-1 INSTRUMENT FUNCTION

The Model 110-1 is a compact multirange DC VTVM that enables low-level measurements from a high impedance or isolated signal source. It occupies only a "half-rack" of panel space.

1-2 SPECIFICATIONS

Ranges: 0 ± .003, .01, .03, .1, .3, 1, 3, 10, 30, 100, 300 VDC each side.
Scaleplate Presentation: 10-0-10/3-0-3 arcs with legend of "DC Volts".
Input Impedance: 10 megohms
Accuracy: ± 2% of full scale
Power Required: 115 VAC ± 10%, 60 cps, 20 watts
Weight: 6 pounds, 6 ounces
Tube Complement: 2-12AX7; 1-6X4; 2-0B2
Connections: 4 solder terminals on sides of shield cover
Color: Black matte meter on light gray panel
Dimensions: 5-1/4" H x 9-1/2" W x 9" D

1-3 CONTROLS AND TERMINALS

Range Selector

A twelve-position Range Selector, located at the left side of the front panel, provides single-knob selection of the full-scale ranges described in the specifications. Since the instrument is designed for panel-mounting in a test console, no power switch or pilot light is included.

Zero Controls

A Push-To-Zero spring-return button switch and a Zero Adj control knob are used to set center zero electrically. Releasing the button automatically restores the instrument to reading condition.

Signal Input Terminals

Two solder terminals for signal connections are located behind the front panel on the left side of the instrument. They are identified by a decal that reads "Signal Hi and Lo".

Power Terminals

Two solder terminals for power input are located behind the front panel on the right side of the instrument. They are identified by a decal that reads "115V to cps".

Meter Mechanical Zero Adjustment Screw

The mechanical zero adjustment screw is located at the front of the meter movement below the meter face and is completely accessible from the front.

Calibration Controls

A calibrating potentiometer control is reached through an access hole on the rear surface of the perforated cover; it is marked "CAL".

II. OPERATING INSTRUCTIONS

2-1 GENERAL

This instrument is delivered to the user in operating condition and requires no preliminary checks and adjustments prior to initial operation.

2-2 POWER INPUT AND WARM-UP

Connect appropriate power to the terminals on the side of the case (see Section I). Allow a warm-up period of approximately 10 minutes. Spurious noise pick-up is minimized when the front panel and the "LO" power terminal are securely connected to the low or ground side of the power line.

2-3 SIGNAL INPUT

The instrument circuits are electrically isolated from the front panel and so measurements may be made independent of ground potentials without hazard by connection to the side terminals. The signal low terminal should be connected to that point of the circuit under test that has the lowest impedance or voltage to power line ground. In addition, on the most sensitive ranges, shielding of the input signal leads--being careful to avoid forming ground loops--will aid in the elimination of stray pick-up voltages.

CAUTION

The maximum input signal--the sum of DC and AC peak voltages--must not exceed 500 volts .

2-4 INDICATING METER

The meter needle should be adjusted for a mechanical zero indication with no power applied to the instrument. With instrument power and signal applied, turn the Range Selector to the desired position. Depress the Press-to-Zero switch and use the Zero Adj control to obtain a precise zero reading. Release the switch and the needle will deflect to indicate the DC signal input voltage.

The amplifier section is designed to saturate before the output current attains a value which can damage the indicating meter. This feature will protect the instrument from occasional overloads up to 100 times full scale--provided that the peak voltage input limitations of Paragraph 2-3 are not exceeded. Input voltages which exceed these limitations may occasionally result in spurious meter indications--but will not damage the meter.

III. THEORY OF OPERATION

3-1 GENERAL

This instrument is a multi-range vacuum tube voltmeter whose function is to measure DC voltages of magnitudes falling within the applicable specifications. The circuit consists of an attenuator, a high-gain chopper amplifier, and a bridge rectifier/meter circuit. The input attenuator reduces all signals to the basic sensitivity of the instrument. The chopper amplifier converts the signal to AC and raises it to the voltage and power levels necessary to drive the bridge rectifier. The signal is then converted back to DC to feed the meter. Overall feedback provides excellent linearity and stability.

3-2 INPUT ATTENUATOR

The input attenuator network (R1 to R13 inclusive) is arranged to permit the selection of proper attenuation ratios by range switch S1. Resistors in the attenuator chain are chosen so that their sum adds up to 10 megohms, the standard input impedance of this instrument. C1 and C2 attenuate undesirable transients and any spurious AC signals that might be carried through the amplifier and cause erroneous readings.

Also associated with the input attenuator is the Push-To-Zero switch, S2. In the NC, or Read position, this switch shorts out R1 and allows the signal to be connected to the resistive network of R2 through R13 for conventional attenuation ratios. When this switch is closed, in the NO position, the functure of R1 and R2 is shorted to signal low. Reference to the schematic will reveal that this places almost 2 megohms across the signal source and at the same time connects the wiper of S1 to signal low (zero volts) through R1 in parallel with part or all of the attenuator network. This two-fold action minimizes changes to the externally-applied signal circuit while presenting a normal working impedance to the input grid circuits, enabling accurate electrical zero (no signal) adjustments by means of the Zero Adj Control, R35.

3-3 AMPLIFIER & BRIDGE RECTIFIER SECTIONS

The attenuated DC signal derived from the range switch S1 is connected to a stationary contact (Terminal 1) of the CH1 chopper. The other stationary chopper contact (Terminal 6) is connected to the feedback voltage source.

The chopper coil drives the vibrating reed contact (Terminal 7) at the same frequency as the power line and the resultant AC signal is coupled through C3 to the grid of V1a. (Note that this signal is an "error" voltage that places the entire amplifier plus meter and rectifier in the feedback loop thus affording an unusual level of stability and linearity.) This signal voltage is then amplified by V1A, V1B, and V2A, appearing at the output of cathode follower V2B.

The phase-sensitive bridge network (CR1, 2, 2, and 4) is excited at points Y and Z with the same voltage that energizes the chopper coil. This reference voltage drives the diodes into conduction for half a cycle and allows them to non-conduct during the other half of the cycle.

The diode network, therefore, acts as a switch which is gated by the reference voltage in synchronism with the chopper contacts in order to establish meter current polarity.

3-4 METER

Since the reference voltage and the chopper driving voltage are from the same source and are in phase, the half cycle of signal voltage which occurs during the conducting half cycle of the diode network will be impressed across the meter circuit and result in a deflection of the indicating meter needle.

If the DC signal input voltage polarity is reversed, a 180° shift will occur in the chopper-converted AC signal. The diode network gating remains constant so that the 'on' gating cycle will now allow that portion of the chopper-amplifier derived AC signal--whose polarity is the same as that of the DC signal input voltage--to be transmitted to the meter circuit.

This instrument is therefore able to distinguish and indicate the polarity of the input signal; deflecting the meter needle to the left ("HI" negative with respect to "LO") and to the right ("HI" positive with respect to "LO").

The calibration control, R30, effectively alters the resistance in part of the feedback path and hence the feedback loop voltage. This sets the amplifier gain. R35, the Zero Adj control, injects a small DC voltage directly to the meter to electrically set this zero level.

IV. MAINTENANCE & SERVICING

4-1 GENERAL

The Model 110-1 employs vacuum tubes and high-quality conponents operated under very conservative conditions for high reliability and long life. The high-gain feedback-stabilized amplifier circuitry assurss gain stability and greatly reduces the effects of component and tube aging upon performance and accuracy.

The following sections of this manual provide maintenance and servicing information required to check instrument accuracy and to maintain the equipment in best operating condition.

4-2 CALIBRATION PROCEDURE

If for any reason the instrument requires calibration or accuracy verification, proceed as follows:

a) Without disassembling the instrument, provide the proper power input. See Specifications page. Allow 20-minute warm-up for best results.

b) Connect a low-ripple, variable DC voltage source and an accurate voltmeter (1%) to the input terminals.

c) Apply a full scale voltage on the 1V range as indicated by the reference voltmeter. Set the zero level as described in para. 2-4. If the instrument reads within the accuracy specifications, re-calibration is not necessary.

d) If the instrument does not indicate properly, adjust potentiometer R30 (through the access hole marked "Cal" on the rear of the perforated cover) for full scale deflection of the indicating meter.

e) Repeat procedure on other ranges, adjusting for minimum over-all error. Calibration is now complete.

4-3 SERVICING CONSIDERATIONS

If the instrument should fail to operate, or if it should read incorrectly, follow the Operating Instructions (Part II) and the Calibration Procedure, paragraph 4-2 in order to establish whether the need exists for further remedial service procedures. The nature of this instrument is such that vacuum tube or chopper replacement, described in paragraph 4-4, will usually restore it to proper operating efficiency.

If it becomes necessary to change tubes or components, CARE SHOULD BE EXERCISED in the selection of replacement parts according to the PARTS LIST in this manual. Newly installed parts should be mounted in the exact manner and position as the original component being replaced. FAILURE TO COMPLY WITH THIS REQUIREMENT MAY ALTER THE OPERATING CHARACTERISTICS OF THIS INSTRUMENT. For ease of service it is recommended that the complete instrument be removed from the mounting panel and examined in a well-lighted area with proper service instrumentation.

4-4 VACUUM TUBE REPLACEMENT

The instrument will accept any vacuum tube--of the types specified in the PARTS LIST--which meets RETMA standards. Pre-selection of replacement tubes is not necessary to maintain instrument accuracy because the feedback stabilization feature of this instrument will maintain the proper amplifier gain over a wide range of tube characteristics. If a tube failure should occur, use the following procedure for tube replacement.

a) TURN OFF THE INSTRUMENT POWER and short out all sections of the electrolytic capacitor at first opportunity.

b) Remove the four truss head screws which hold the rear cover and then slide the cover--without turning or twisting motion--off the instrument.

c) Replace the defective tubes or chopper with the proper replacement type and reassemble the rear terminal board and dust cover.

4-5 COMPONENT REPLACEMENT

Tube or chopper replacement and/or recalibration will, in most instances, restore this instrument to normal operation. Should these procedures fail to accomplish this, the resistors and capacitors should be checked out against the specified values in the Parts List and the Schematic. (Use a suitable capacitor checker which indicates capacity, leakage, and power factor at rated voltages.)

If the foregoing checks do not uncover any faulty components, the remaining diode bridge circuit can be most easily checked by substituting a known good 200UA meter movement in place of the one on the instrument. This will allow the determination of a fault in the bridge circuit or the meter movement. Appropriate action may then be taken.

4-6 METER MOVEMENT

The meter movement should never be taken apart for service by other than qualified meter instrument repair personnel. In the event that a meter movement is suspected or definitely found to be faulty, communicate with the Service Division of Trio Laboratories, Inc. so that we may be able to advise you in this matter.

4-7 ETCHED CIRCUIT REPAIR TECHNIQUES

The replacement of components soldered to etched circuit boards in this instrument requires diligent care and the use of proper techniques in order to preserve the physical and electrical integrity of the board. The following suggestions should be heeded in working with any etched circuit board.

a) Use a pencil type soldering iron of about 35 watts with a 1/8" wide well-tinned soldering tip, heated to a temperature sufficient to melt 60/40 ROSIN cored solder--DO NOT USE ANY SOLDER CONTAINING A CORROSIVE FLUX!

b) UNDER NO CIRCUMSTANCES, SHOULD AN ATTEMPT BE MADE TO PRY A COMPONENT FROM THE ETCHED CIRCUIT BOARD! The wire leads or terminals of all components mounted directly on the board have been inserted through the board and bent over to lie flat upon the etched copper strip. This assures a secure mechanical and electrical connection to the circuit board.

c) In order to accomplish removal of a component from the etched circuit board, it is necessary to remove the solder from the connection and straighten the component lead so that it may easily slide out of its mounting holes.

Apply a properly heated 1/8" wide tinned tip soldering iron directly to the solder, --NOT TO THE COPPER ETCHING--and immediately brush the solder off the board using a stiff bristled brush (1/4" wide brush with 1/4" long bristles). The lead will then be accessible for straightening and removal. After the solder has been cleaned off and the lead properly straightened, apply the soldering lead to the lead--NOT TO THE CIRCUIT BOARD--and lift the component off the circuit board.

It may be necessary to clean and dress two leads (or more) of a component and then heat the leads simultaneously in order to accomplish removal. This is true, for instance, in the case of hermetically sealed capacitors with both leads emerging from the same end. The capacitor is mounted flush against the board for optimum strength.

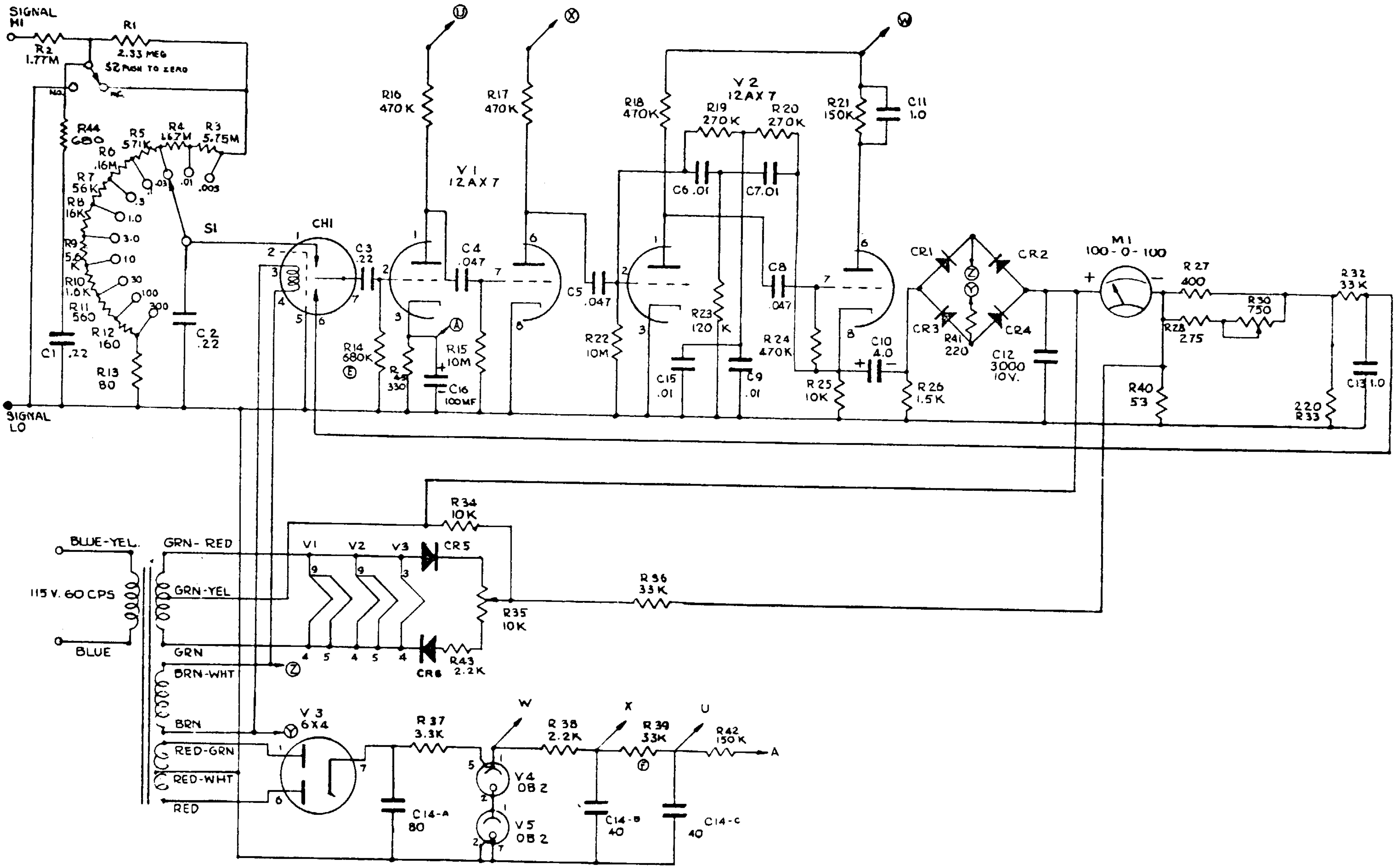
d) The replacement component leads should be tinned PRIOR TO INSTALLATION. Insert the component leads into the proper holes and bend the leads to lie flat on the copper strip; bring the component body up snug against the board. Trim the leads to the proper size and perform the soldering operation by heating the lead and the copper simultaneously--USING THE MINIMUM AMOUNT OF HEAT NECESSARY TO FLOW THE SOLDER ONTO THE JOINT FOR A GOOD BOND. THE APPLICATION OF EXCESS HEAT MAY CAUSE DAMAGE TO THE ETCHED CIRCUIT BOARD.

V. PARTS LIST

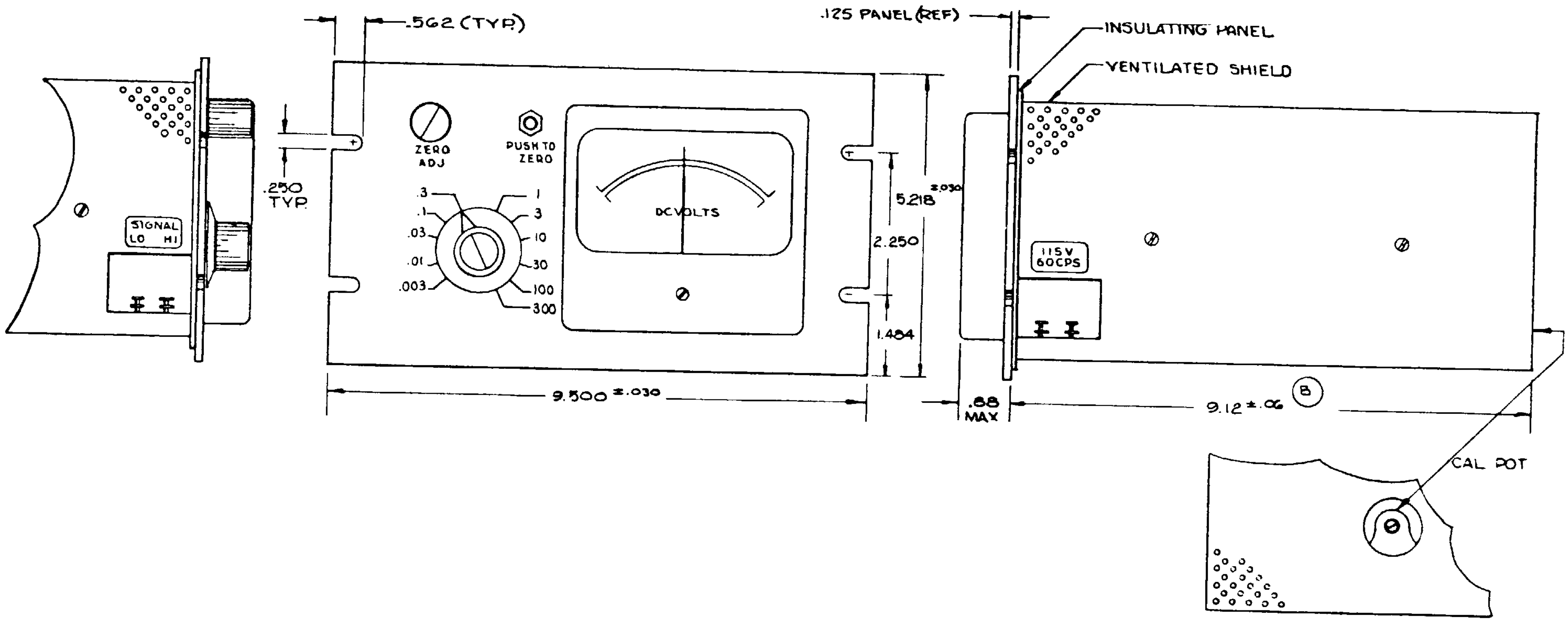
CIRCUIT DESIGNATION	DESCRIPTION	PART NO.
V1, V2	Tube, Electron	13341
V3	Tube, Electron	13296
V4, V5	Tube, Electron	13288
CR1 - CR6	Diode, Silicon	11856-13
C1, C2	Capacitor, Paper, .22MFD, 400V, ± 20%	13209-6
C3	Capacitor, Paper, .22MFD, 400V, ± 20%	13284-7
C4, C5, C8	Capacitor, Paper, .047MFD, 400V, ± 20%	13209-4
C6, C7, C9, C15	Capacitor, Paper, .01MFD, 400V, ± 20%	13209-2
C10	Capacitor, Electrolytic, 4.0MFD, 25V	13181-1
C11	Capacitor, Electrolytic, 1.0MFD, 400V	13278-1
C12	Capacitor, Electrolytic, 3000MFD, 10V	13182-1
C13	Capacitor, Electrolytic, 1.0MFD, 400V	13278-1
C14	Capacitor, Electrolytic, 80-40-40MFD, 300V	13182-8
C16	Capacitor, 100MFD, 6V	13181-4
R1	Resistor, Film, 2.33M, ± 1/2%, 1/4W	13103-2334
R2	Resistor, Film, 1.77M, ± 1/2%, 1/4W	13103-1774
R3	Resistor, Film, 5.75M, 1/2%, 1W	13106-5754
R4	Resistor, Film,1.67M, ± 1/2%, 1/4W	13103-1674
R5	Resistor, Film, 571K,±1/2%, 1/4W	13103-5713
R6	Resistor, Film, 160K,±1/2%, 1/4W	13103-1603
R7	Resistor, Film, 56K, ± 1/2%, 1/4W	13103-5602
R8	Resistor, Film, 16K, ± 1/2%, 1/4W	13103-1602
R9	Resistor, Film, 5.6 K, ± 1/2%, 1/4W	13103-5601
R10	Resistor, Film, 1.6K, ± 1/2%, 1/4W	13103-1601
R11	Resistor, Film, 560 Ohms, ± 1/2%, 1/4W	13103-5600
R12	Resistor, Film, 160 Ohms, ± 1/2%, 1/4W	13103-1600

R13	Resistor, Film, 80 Ohms, ± 1/2%, 1/4W	13103-80R0
R14	Resistor, Fixed, Comp., 680K, ± 10%, 1/2W	13100-684
R15, R22	Resistor, Fixed, Comp., 10M, ± 10%, 1/2W	13100-106
R16, R17, R18, R24	Resistor, Fixed, Comp., 470K, ± 10%, 1/2W	13100-474
R19, R20	Resistor, Fixed, Comp., 270K, ± 10%, 1/2W	13100-274
R21, R42	Resistor, Fixed, Comp., 150K, ± 10%, 1/2W	13100-154
R23	Resistor, Fixed, Comp., 120K, ± 10%, 1/2W	13100-124
R25, R34	Resistor, Fixed, Comp., 10K, ± 10%, 1/2W	13100-103
R26	Resistor, Fixed, Comp., 1.5K, ± 10%, 1/2W	13100-152
R27	Resistor, Film, 400 Ohms, ± 1%, 1/4W	13104-4000
R28	Resistor, Film, 275 Ohms, ± 1%, 1/4W	13104-2750
R30	Resistor, Variable, 750 Ohms	11158-2
R32, R36, R39	Resistor, Fixed, Comp., 33K, ± 10%, 1/2W	13100-333
R33	Resistor, Film, 220 Ohms, ± 1%, 1/4W	13104-2200
R35	Resistor, Variable, 10K	12836-1
R37	Resistor, Fixed, Comp., 3.3K, ± 10%, 2W	13102-332
R38, R43	Resistor, Fixed, Comp., 2.2K, ± 10%, 1/2W	13100-222
R40	Resistor, Film, 53 Ohms, ± 1%, 1/4W	13104-53R0
R41	Resistor, Fixed, Comp., 220 Ohms, ± 10%, 1/2W	13100-221
R44	Resistor, Fixed, Comp., 680 Ohms, ± 10%, 1/2W	13100-681
R45	Resistor, Fixed, Comp., 330 Ohms, ± 10%, 1/2W	13100-331
T1	Transformer	10294
K1	Chopper	13387
M1	Meter	14098-2
S2	Switch, Pushbutton	13362

NOTE: In ordering parts from the factory, be sure to reference the model and serial numbers of the instrument as well as the part description and number.



MODEL 110-1 SCHEMATIC



MODEL 110-1

OUTLINE-

ADDENDUM TO

Technical Manual 759960

Instructions for Accudata 104 D-C Amplifier

Corrections and Additions:

Page 1-1.	Para 1-2: In the second sentence, change "reading" to "recording".
Page 1-2.	Para 1-3, D, 2: Change Output Impedance to read "Less than 500 milliohms....."
Page 1-3.	Para 1-3, E, 6. Change D-C Gain Linearity to read "Better than ±0.1% of full scale....."
Page 2-2.	Figure 2-4. Correct "C" to read "Single-Ended Floating (Inverting)".
Page 6-2.	Table 6-2. Under "No Output signal", delete "Defective transistor" and "Check transistors: refer to para 6-4, 1, C".
Page 7-4.	Change the Honeywell Part Number of capacitor C5 from 759782-201 to 759781-256.

TECHNICAL MANUAL

INSTRUCTIONS
FOR
ACCUDATA 104 D-C AMPLIFIER

APRIL 1965

HONEYWELL -- Denver Division -- 4800 East Dry Creek Road -- Denver, Colorado 80217

759960

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LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I — INTRODUCTION

1-1. PURPOSE OF MANUAL

This manual provides description, installation, operation, and maintenance instructions, and a replaceable parts list for use by both operator and maintenance men.

To gain optimum performance from the amplifier, the user should acquaint himself with its features and operating principles before placing the amplifier into operation.

1-2. UNIT DESCRIPTION

The Accudata 104 D-C Amplifier is a solid state, direct coupled, wideband, medium gain amplifier ideally suited for high speed data acquisition systems. The amplifier design features high impedance input and has output current capability for driving fluid damped galvanometers in reading oscillographs, or driving nagnetic tape recording systems. The integrated solid state power supply operates on line frequencies from 50 to 400 cps and is available for either 115V ac or 230V ac line voltages. Optional gain multipliers are also available to permit the input signal voltage range to 25 volts.

Front panel controls provide a combination of gain range, gain stepping, and vernier gain. Provision is made on the front panel for signal polarity reversal and for signal output terminal shorting to facilitate mechanical positioning of the galvanometer. Optional output terminals are provided to by-pass the polarity reversal feature when driving single-ended devices. In addition to other front panel controls, a continuously variable control is provided to zero the amplifier d-c output with no input signal.

When used in oscillographic recording, the Accudata 104 provides positive galvanometer protection when properly loaded. The amplifier prevents transients from damaging the galvanometer when gain ranges are switched, when an open circuit exists, or when the amplifier is turned on or off. If overloads are applied to the amplifier, the output clips or limits, so the galvanometer does not receive excess currents.

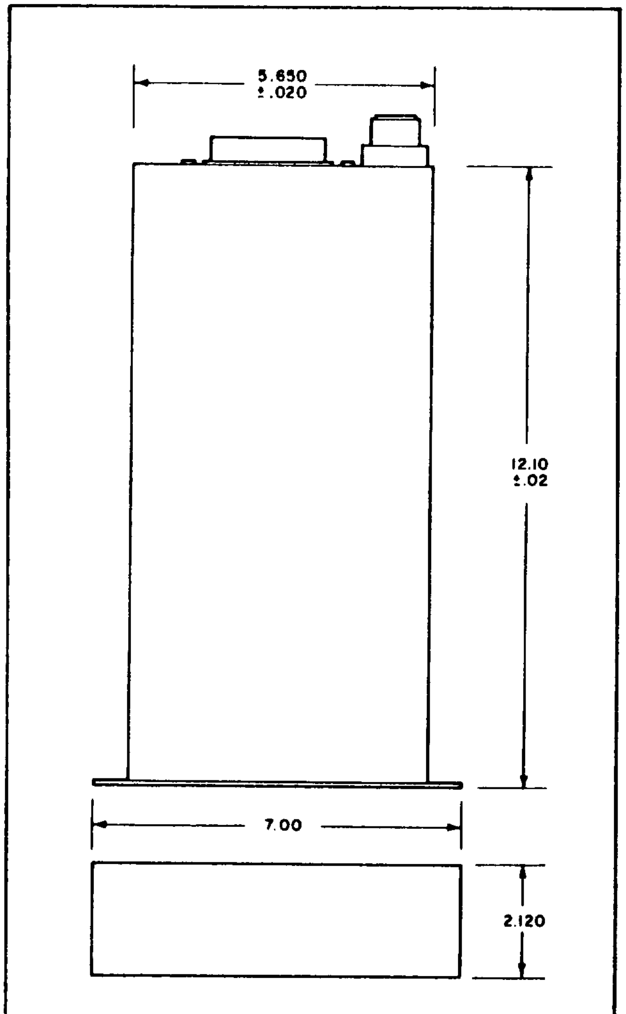


Figure 1-1. Accudata 104 Dimension Drawing

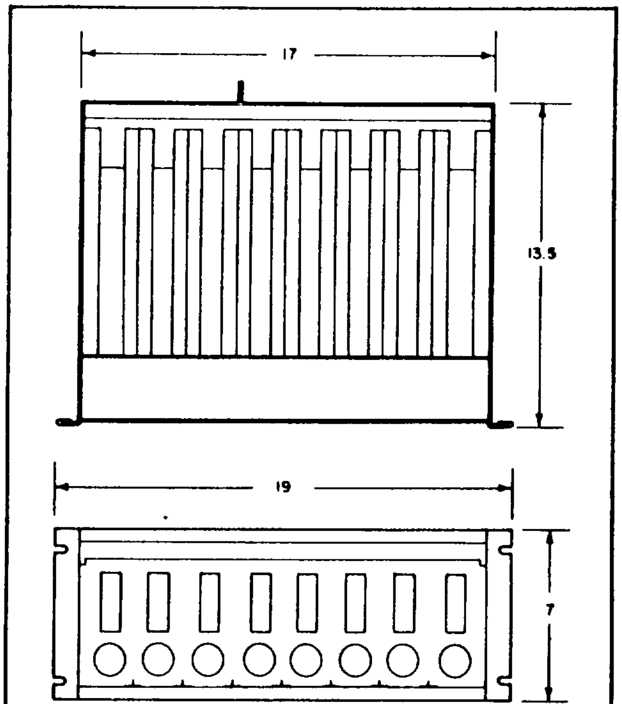


Figure 1-2. Rack Adapter Dimension Drawing

Up to eight amplifiers may be mounted in the standard Honeywell rack adapter (Part No. 902634) available for simple installation in a standard 19 inch enclosure. Operating power, input and output receptacles are mounted on the rear panel of the amplifier. Refer to Figures 1-1 and 1-2 for dimension diagrams of the amplifier and rack adapter.

The Honeywell part numbers for the Accudata 104 with all standard options are shown below.

115V AC Line Voltage:

790779-001 Accudata 104-1 (standard version)
790779-002 Accudata 104-2 (.04 gain multiplier)
790779-003 Accudata 104-3 (.01 gain multiplier)

230V AC Line Voltage:

790779-004 Accudata 104-4 (standard version)
790779-005 Accudata 104-5 (.04 gain multiplier)
790779-006 Accudata 104-6 (.01 gain multiplier)

1-3. SPECIFICATIONS

A. POWER REQUIREMENTS

1. Line Voltage and Frequency:

   a. 790779-001, -002, -003: 105-129 VAC, 50-400 cps

   b. 790779-004, -005, -006: 210-258 VAC, 50-400 cps

2. Power Consumption: 10 watts maximum with full scale output.

   Six watts maximum with no input signal.

B. ENVIRONMENTAL

1. Operating Temperature Range: 0° to 50°C

2. Storage Temperature Range: -55°C to +60°C

3. Vibration: MIL-T-21200A, Class 3

4. Humidity: 0 to 95% relative

5. Operating Altitude: Sea level to 10,000 feet

6. Storage Altitude: Sea level to 50,000 feet

C. INPUT

1. Input Voltage Range for Full Scale Output:

   a. 10 mv to 250 mv (standard version)

   b. 250 mv to 6.25 volts (with .04 gain multiplier)

   c. 1 volt to 25 volts (with .01 gain multiplier)

2. Input Impedance:

   a. 10 megohms minimum at dc

   b. 1 megohm minimum at dc with optional gain multipliers

3. Source Resistance:

   a. All specifications on the standard amplifier apply for 0-1000 ohms with up to 1000 ohms unbalance.

   b. All specifications on the amplifiers with optional gain multipliers apply for 0-10K ohms with up to 1000 ohms unbalance, unless otherwise noted.

4. D-C Current at Input:

   a. 1.5 ua maximum (500 na typical) at each input maximum difference between input currents is less than 300 na (50 na typical). An external return path of less than 100K ohms must be provided between the source and amplifier common (output low side) for this current.

   b. No input current flows with gain multipliers, and no external return path is required from the source to amplifier common (true differential input).

D. OUTPUT

1. Output Capability:

   a. Resistive Load: ±2.5 volts and/or 65 ma dc or peak ac from dc to 10 kc.

   b. Paralled RC Loads: ±2.5 volts across resistances greater than 38 ohms and capacitances less than .1 ufd from dc to 10 kc. ±2.5 volts across resistances greater than 1000 ohms and capacitances less than .01 ufd from dc to 40 kc.

2. Output Impedance: Less than 5000 milliohms from dc to 10 kc.

3. Maximum Capacitive Load: .1 ufd.

E. GAIN

1. Gain Ranges:

a. 10-50 in the "50" position of the GAIN RANGE control; 50-250 in the "250" position of the GAIN RANGE control.

b. .4-2 and 2-10 when modified by the optional .04 GAIN MULTIPLIER.

c. .1-.5 and .5-2.5 when modified by the optional .01 GAIN MULTIPLIER.

2. Calibrated Gain Steps (Vernier in CALIBRATED position):

a. 10, 20, 30, and 50 in the "50" position of the GAIN RANGE control; 50, 100, 150, and 250 in the "250" position of the GAIN RANGE control.

b. With optional .04 GAIN MULTIPLIER:
.4, .8, 1.2, and 2 in the "50" position of the GAIN RANGE control; 2, 4, 6, and 10 in the "250" position of the GAIN RANGE control.

c. With optional .01 GAIN MULTIPLIER:
.1, .2, .3, and .5 in the "50" position of the GAIN RANGE control; .5, 1, 1.5, and 2 in the "250" position of the GAIN RANGE control.

3. Vernier Gain Control: Continuously increases the gain between fixed, calibrated steps.

4. D-C Gain Accuracy:

a. Better than ±.5% when the Vernier Gain control is fully counterclockwise (CALIBRATED).

b. Better than ±1% under the same conditions with optional gain multipliers.

5. D-C Gain Stability:

a. Less than .02%/°C change, with the Vernier Gain control in the CALIBRATED position. Less than .05%/°C change with the Vernier Gain control in any position.

b. With optional gain multipliers: Less than .05%/°C change with the Vernier Gain control in the CALIBRATED position. Less than .1%/°C change with the Vernier Gain control in any position.

6. D-C Gain Linearity: Better than ±1% of full scale output (±2.5 mv) up to full scale output.

F. FREQUENCY RESPONSE

1. Resistive load greater than 38 ohms and capacitive load less than .1 ufd:

a. Standard Version:
±1% dc to 10 kc, up to full scale output;
±5% dc to 20 kc, up to 80% of full scale output.

b. With optional .04 GAIN MULTIPLIER:
±1% dc to 1 kc, up to full scale output;
±3% dc to 10 kc, up to full scale output.

c. With optional .01 GAIN MULTIPLIER, same as (a).

2. Resistive load greater than 1000 ohms, and capacitive load less than .01 ufd:

a. Standard Version:
±1% dc to 10 kc, up to full scale output voltage;
±5% dc to 40 kc, up to full scale output voltage;
±3 db dc to 100 kc, up to 30% of full scale output voltage.

b. With optional .04 GAIN MULTIPLIER:
±1% dc to 1 kc, up to full scale output voltage;
±3% dc to 10 kc, up to full scale output voltage;
±3 db dc to 40 kc, up to full scale output voltage.

c. With optional .01 GAIN MULTIPLIER, same as (a).

G. PHASE SHIFT

1. Standard Version: Less than 10° from dc to 10 kc.
2. With .04 GAIN MULTIPLIER: Less than 10° from dc to 1 kc.

3. With .01 GAIN MULTIPLIER: Same as (1).

H. DRIFT

1. At a constant temperature, including line voltage changes, over a 24-hour period:

a. Standard Version: Less than ±10 uv RTI (referred to the input) ±200 uv at output.

b. With .04 GAIN MULTIPLIER: Less than $\frac{\pm 40 \text{ uv}}{.04}$ RTI ±200 uv at output.

c. With .01 GAIN MULTIPLIER: Less than $\frac{\pm 20 \text{ uv}}{.01}$ RTI ±200 uv at output.

2. Temperature Coefficient:

a. Standard Version: Less than ±25 uv/°C RTI ±250 uv/°C at output (typically less than ±10 uv/°C RTI ±100 uv/°C at output).

b. With .04 GAIN MULTIPLIER: Less than $\frac{\pm 40 \text{ uv/°C}}{.04}$ RTI ±250 uv/°C at output.

c. With .01 GAIN MULTIPLIER: Less than $\frac{\pm 40 \text{ uv/°C}}{.01}$ RTI ±250 uv/°C at output.

I. NOISE

1. Full Bandwidth

a. Standard Version: Less than 10 uv rms RTI +2 rms at output (5 uv rms RTI +1 mv rms at output with a balanced source).

b. With .04 GAIN MULTIPLIER: Less than $\frac{15 \text{ uv rms}}{.04}$ RTI +500 uv at output.

c. With .01 GAIN MULTIPLIER: Less than $\frac{\pm 10 \text{ uv rms}}{.01}$ RTI +500 uv at output.

2. D-C to 10 kc Bandwidth

a. Standard Version: Less than 3 uv rms RTI +100 uv rms at output.

b. With .04 GAIN MULTIPLIER: Less than $\frac{8 \text{ uv rms}}{.04}$ RTI +100 uv rms at output.

c. With .01 GAIN MULTIPLIER: Less than $\frac{5 \text{ uv rms}}{.01}$ RTI +100 uv rms at output.

J. COMMON-MODE REJECTION

1. Common-mode voltage applied between amplifier common and the input terminals, with the guard shield driven by the CMV:

a. Standard Version Gains from 50-250: Greater than 90 db from dc to 60 cps, with up to 1000 ohms unbalance (100 db with no source unbalance).

b. Standard Version Gains from 10-50: Greater than 80 db from dc to 60 cps, with up to 1000 ohms source unbalance (90 db with no source unbalance).

c. With .04 GAIN MULTIPLIER: Greater than 60 db from d-c to 60 cps with up to 350 ohms source unbalance (80 db with no source unbalance).

d. With .01 GAIN MULTIPLIER: Greater than 55 db from d-c to 60 cps with up to 350 ohms source unbalance (70 db with no source unbalance).

K. COMMON-MODE VOLTAGE

1. Maximum common-mode voltage is ±10 volts dc or peak ac.

2. With optional gain multipliers, maximum common-mode voltage is 250 volts dc or peak ac.

L. TRANSIENT RESPONSE (Capacitive loads up to .01 ufd)

1. Standard Version:

a. Rise time (10-90%): Less than 5 microseconds.

b. Settling time: Less than 20 microseconds to within ±1% of final value.

2. With .04 GAIN MULTIPLIER:

a. Rise time (10-90%): Less than 12 microseconds.

b. Settling time: Less than 30 microseconds to within ±1% of final value.

3. With .01 GAIN MULTIPLIER: Same as (1).

M. OVERLOAD RECOVERY

1. Less than 2 milliseconds to within ±1% of normal output, with up to 10 times overload.

SECTION II — INSTALLATION

2-1. GENERAL

The Accudata 104 D-C Amplifier is wrapped in padding and shipped in a single carton if ordered individually. It may be shipped in a relay rack if it is a component part of an entire system. Exercise the same care in unpacking this amplifier as would be given any precision instrument.

Installation of the instrument consists of mounting (if used in an equipment rack), and making necessary power and signal connections. Carefully inspect the unit according to paragraph 2-2 before installing. This section also includes repackaging instructions.

2-2. INCOMING INSPECTION

This instrument was carefully inspected both mechanically and electrically before shipment. After unpacking, visually inspect the unit for shipping damage. Check for dents, bent panels, cracked or broken control knobs or connectors. Remove the top cover and inspect the circuit card for cracks or damaged components. If physical damage is found, immediately report the extent of damage to the carrier agency and to your Honeywell Sales Representative.

2-3. INSTALLATION

The Accudata 104 D-C Amplifier can operate on a bench with or without a Honeywell 790793 Portable Adapter, or mount in a Honeywell 902634 Rack Adapter (see Figure 2-1 and schematic diagram at rear of manual). Electrical connections are made to the amplifier through two connectors on the rear panel; a standard 24 pin Blue Ribbon type connector, Honeywell Number 100790, and AN-type connector, Honeywell Number 100058. Mating connector, Honeywell Number 750103-025, is available for the AN-type connector. The mating connector for the Blue Ribbon type connector is installed in the Rack Adapter and Portable Adapter, or can be purchased separately as Honeywell Number 200053.

Prior to installing the Portable Adapter, remove the Blue Ribbon connector and connect wires to the output terminals, routing them through the grommet provided on the rear of the adapter.

Install the amplifier in the Portable Adapter by sliding the adapter on the amplifier chassis from the rear, mating the Blue Ribbon connector and hold screw on the top of the amplifier front panel. Secure the hold screw to the Portable Adapter. Attach the Support Block, Honeywell Number 760396, behind the bottom of the front panel with the hold screw in the front panel.

2-4. SIGNAL CONNECTIONS

A. OUTPUT. Figure 2-2 shows the physical location and designation of connectors on the rear of the Accudata 104. Pin connections are illustrated in Figure 2-3. Power is applied to the amplifier power supply on pins 1 and 13 of connector P1. A chassis connection is available on pins

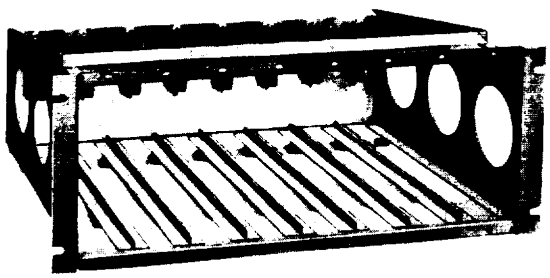


Figure 2-1. Model 902634 Rack Adapter

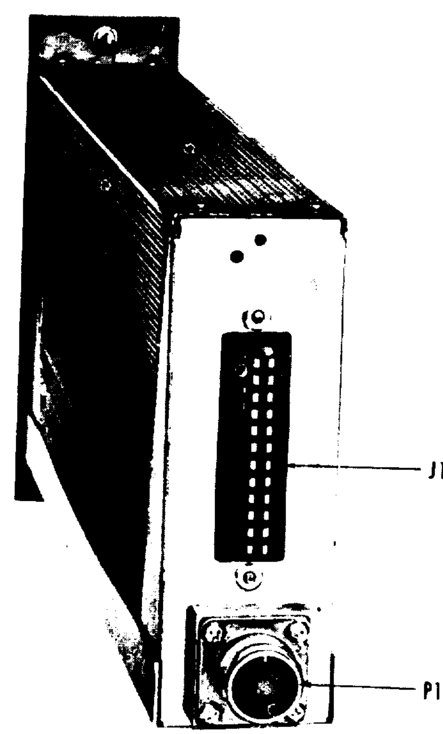


Figure 2-2. Accudata 104 D-C Amplifier - Rear View

2 and 14 and should be connected to power line ground via the ground wire on the line cord, or a separate wire. When plugging the amplifier into the 902634 Rack Adapter or 790793 Portable Adapter, pins 2 and 14 connect to the ground wire in the line cord. Two sets of amplifier output terminals are provided - a fixed pair and a reversible pair. The fixed output terminals are on pins 3 and 15. Pin 3 is the low side of the output and the common connection for the internal power supplies. The amplifier output connects to pin 15 regardless of the OUTPUT switch position. Pins 8 and 20 are reversible output terminals. Pin 20 connects to pin 15 and pin 8 to pin 3 in the NORM position of the OUTPUT switch. Pin 20 connects to pin 3 and pin 8 to pin 15 in the REV position.

Output connections showing the functions of the output polarity reversal switch are illustrated in Figure 2-5.

B. INPUT. Input connections to the amplifier are available on connector J1. Pins A and C are the input terminals. Pin A is the "non-inverting" input terminal; i.e., when pin A is positive with respect to pin C, the high side of the output (pin 15) is positive with respect to the low side (pin 3). Pin C is the "inverting" terminal; i.e., when pin C is positive with respect to pin A, the high side of the output is negative. The shield around the input wires inside the amplifier is brought out on pin B as a guard. The guard shield should be driven by the source of common-mode voltage in a system installation. The amplifier common, or output low side, is also available on pin D. An additional chassis connection is provided on pin E. Paragraph 5-3 provides additional information for signal return path wiring.

Input connections for differential or single-ended operation are shown in Figure 2-4.

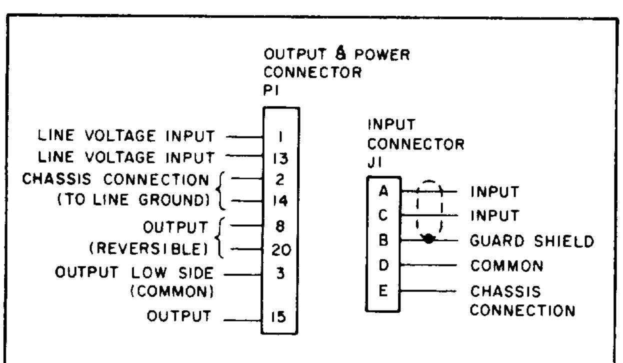


Figure 2-3. Connector Pin Identification

These connections also apply when the optional gain multipliers are installed. The single-ended non-inverting connection provides an output signal at pin 15 (or pin 20 when output polarity is NORMAL) of the same phase as the input signal. The single-ended inverting connection provides an output signal at pin 15 (or 20 when output polarity is NORMAL) that is 180° out of phase with the input signal.

2-5. GALVANOMETER MATCHING

A. ELECTROMAGNETICALLY DAMPED GALVANOMETERS. Each Honeywell M-Series electromagnetically damped galvanometer must be matched to its critical damping resistance R_d to obtain the best compromise between overshoot and frequency response. Proper damping reduces overshoot to a minimum while providing the best flat frequency response. Matching the Accudata 104 output to these galvanometers requires the addition of a series and shunt resistor between the output and galvanometer as shown in Figure 2-6.

R_{se} and R_{sh} can be mounted on a Honeywell

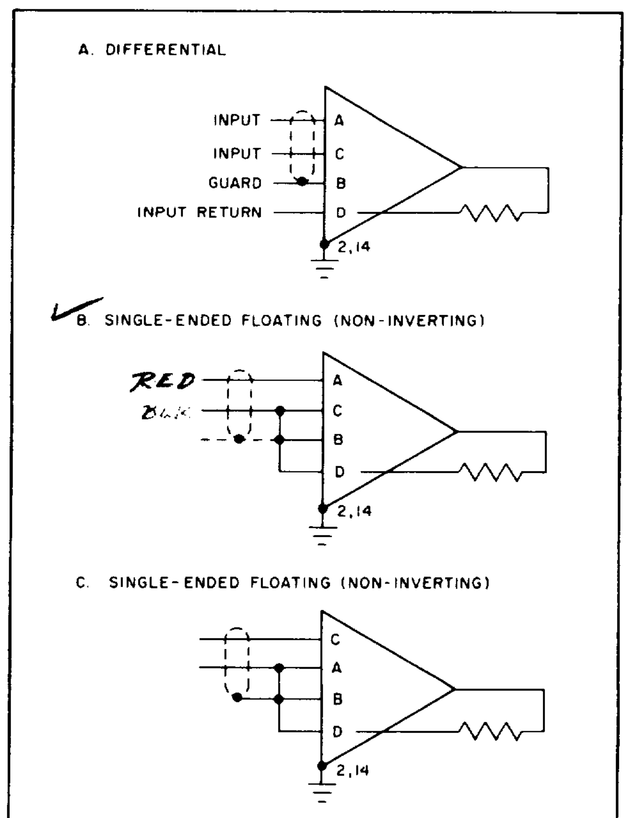


Figure 2-4. Input Connections

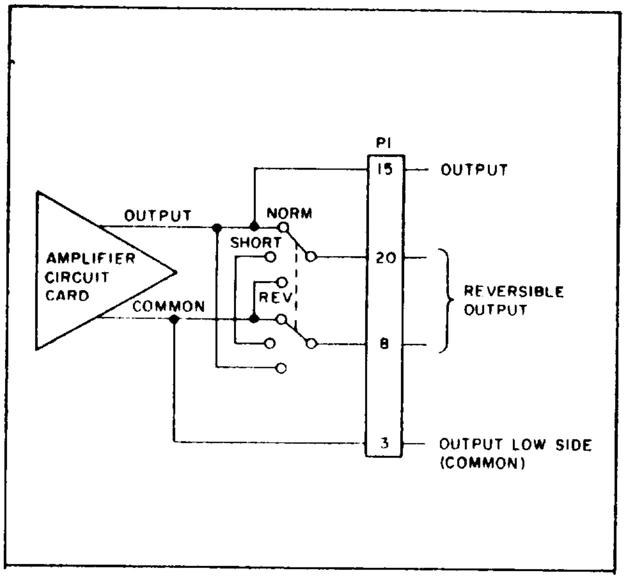


Figure 2-5. Output Connections

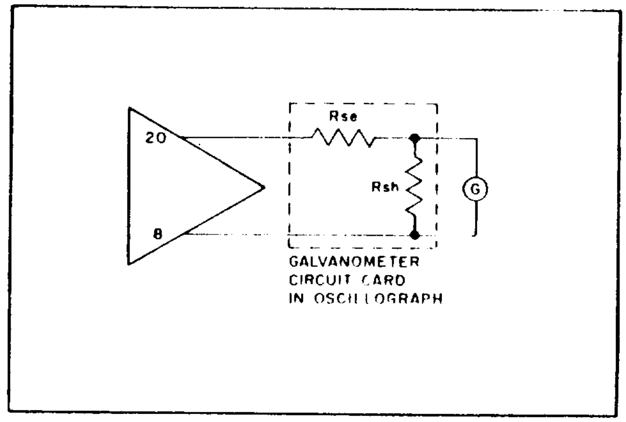


Figure 2-6. Galvanometer Connection

Damping Resistor Card 306470 in the Visicorder oscillograph.

The values of R_{se} and R_{sh} required to obtain a specific galvanometer deflection from a known amplifier output voltage can be calculated from the following equations:

$$R_{se} = \frac{R_d E_o}{I_g(R_d+R_g)}$$

$$R_{sh} = \frac{R_{se}\, R_d}{R_{se} - R_d}$$

where E_o = Amplifier output voltage
R_g = Galvanometer coil resistance
R_d = Critical damping resistance
I_g = Galvanometer current for the required deflection.

The closest MIL values of R_{se} and R_{sh} which provide full rated deflection of each galvanometer type for full scale amplifier output (2.5 volts) are listed in Table 2-1.

HONEYWELL GALVANOMETER	R_d (Ohms)	R_{se} (Ohms)	R_{sh} (Ohms)
M40-120A	120	63.4K	121
M40-350A	350	130 K	357
M-100-120A	120	44.2K	121
M100-350	350	82.5K	357
M200-120	120	16.5K	121
M200-350	350	21 K	357
M400-120	120	4.32K	124
M400-350	350	6.19K	357

Table 2-1. Damping Resistors for Electromagnetically Damped Galvanometers for 8 Inch Peak-To-Peak Deflection

B. FLUID DAMPED GALVANOMETERS.
Honeywell M-Series fluid damped galvanometers are damped primarily by fluid action. Source impedances up to 100 ohms have a negligible effect on frequency and transient response. These galvanometers can be driven directly from the Accudata 104 with the following PRECAUTIONS: The maximum safe current for all Honeywell fluid damped galvanometers, and most other similar galvanometers, is 100 ma. The ACCUDATA 104 will limit current to less than 100 ma only if the load resistance is greater than 35 ohms. Galvanometers of less than 35 ohms coil resistance must have sufficient resistance in series to total at least 35 ohms if the amplifier is to limit its current output when overdriven, or open input circuit. See Section V, paragraph 5-5 C for suggested series resistance values.

2-6. OPERATIONAL CHECKOUT

Test the electrical performance of the amplifier per paragraphs 6-6 B and 6-6 D.3 through 6-6 D.4

2-7. REPACKAGING FOR SHIPMENT

If the original shipping carton is not available, repackage the instrument as follows:

1. Wrap the instrument in heavy paper or plastic before placing in an inner container.
2. Place the unit in a heavy corrugated cardboard inner carton having approximately the inside dimensions as the outside instrument dimensions.
3. Pack dunnage on all sides of the instrument, filling and tightly packing all open areas. Protect panel faces with cardboard strips.

4. Seal the inner carton and place in it a heavy corrugated outer carton. The outer carton should be large enough to allow a minimum of two inches of dunnage on all sides of the inner package.

5. Tightly pack dunnage between the inner and outer cartons, making certain no voids remain.

6. Seal the container with strong tape or metal bands. Mark the package "DELICATE INSTRUMENT - FRAGILE."

Note

If the instrument is to be shipped to Honeywell - Denver for service or repair, attach a tag to the instrument identifying the owner, and indicate the service or repair to be done. Include the model number and full serial number of the instrument. In any correspondence, always identify the instrument by model number and serial number.

SECTION III — OPERATION

3-1. GENERAL

This section includes a description of controls and operating procedures. Thoroughly acquaint yourself with the proper procedures before operating the amplifier and any associated equipment.

3-2. DESCRIPTION OF CONTROLS

A. FRONT PANEL CONTROLS. The following controls are located on the front panel of the Accudata 104 D-C Amplifier and perform the functions described. Paragraph numbers are the same as the index numbers to the controls on Figure 3-1.

1. OUTPUT ZERO: Screwdriver control (accessible through the front panel) used to zero any amplifier d-c output present with no input signal.

2. GAIN RANGE: A two position screwdriver controlled rotary switch (accessible through the front panel) to select one of two gain ranges (50 or 250). The gain ranges are modified by the optional gain multipliers, when installed.

3. GAIN: A four position rotary switch that varies the amplifier gain in fixed, calibrated steps (10-20-30-50 or 50-100-150-250), plus a concentric vernier control that increases the gain between steps. The vernier control has no effect when placed in the fully CCW position. The vernier control does not vary the gain when the calibrated control is in the highest position of either gain range. The positions of the calibrated control are modified by the gain multipliers, when installed.

4. OUTPUT: The output switch is a three position (NORM-REV-SHORT) rotary switch. The NORM position provides normal signal polarity output. The REV position reverses the polarity of the signal output. The SHORT position provides an output short to facilitate mechanical positioning of a galvanometer.

3-3. OPERATING PROCEDURES

The following general procedure should be followed when operating the Accudata 104 in an oscillographic recording system.

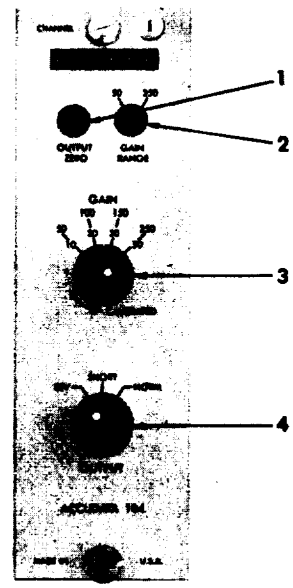


Figure 3-1. Front Panel Controls

A. Before applying power to the system, set the amplifier OUTPUT switch to the SHORT position.

B. Mechanically position the galvanometer light spot on the record.

C. Set the amplifier GAIN switch to 10.

D. With no input signal, but with a source attached (or input shorted and returned to common), set the OUTPUT switch to NORM (normal) or REV (reverse) polarity.

E. Adjust the amplifier OUTPUT ZERO control with a small screwdriver to return the galvanometer light spot to its mechanical zero position.

F. Increase the amplifier gain gradually (if required) and adjust the OUTPUT ZERO as required to return the galvanometer to mechanical zero.

G. Return the amplifier gain to 10, and apply the input signal. Increase the amplifier gain gradually until reaching the desired galvanometer deflection.

SECTION IV—PRINCIPLES OF OPERATION

4-1. INTRODUCTION

The ACCUDATA 104 is a solid state d-c amplifier capable of amplifying low level signals to the level required to drive fluid damped galvanometers or other data recording devices. The amplifier features a high impedance differential input and a low impedance single-ended output to provide maximum flexibility of application and minimize loading of the source. A high degree of d-c stability and good common-mode rejection is achieved without the use of choppers or transformer coupling. A well regulated d-c power supply is an integral part of the amplifier package.

4-2. AMPLIFIER CIRCUIT DESCRIPTION

The over-all amplifier consists of two independent feedback amplifiers in tandem as shown in Figure 4-1. Both amplifiers are supplied plus and minus 22 volts dc from a common power supply. The gain of the over-all amplifier is the product of the gain of the preamplifier and the attenuation of the power amplifier. The preamplifier has two fixed gain settings (50 or 250), selectable by the GAIN RANGE control. The attenuation of the power amplifier is varied in fixed steps of .2, .4, .6, and 1.0 by the GAIN control and varied between fixed positions by the vernier gain control. Optional .04 or .01 gain multipliers may be provided with the unit. Refer to the schematic diagram at the rear of this manual as an aid during review of the following circuit descriptions.

A. PREAMPLIFIER. The preamplifier section consists of three stages of differential amplification, followed by a single-ended output stage. The open loop gain of these stages ia a minimum of 100 db. This high loop gain provides good linearity, a stable and accurate closed loop gain and low drift. The gain accuracy and stability are determined primarily by the characteristics of the wirewound feedback resistors; the drift is a function of the source resistance and the matching of the input transistors. Common-mode feedback is applied around the first two stages to improve the rejection of common-mode voltages.

The input signal is applied to the preamplifier through pins A and C of the printed circuit connector J-2. The first stage consists of a differential transistor pair Q1, with a controlled current source common to both emitters. When a .04 or .01

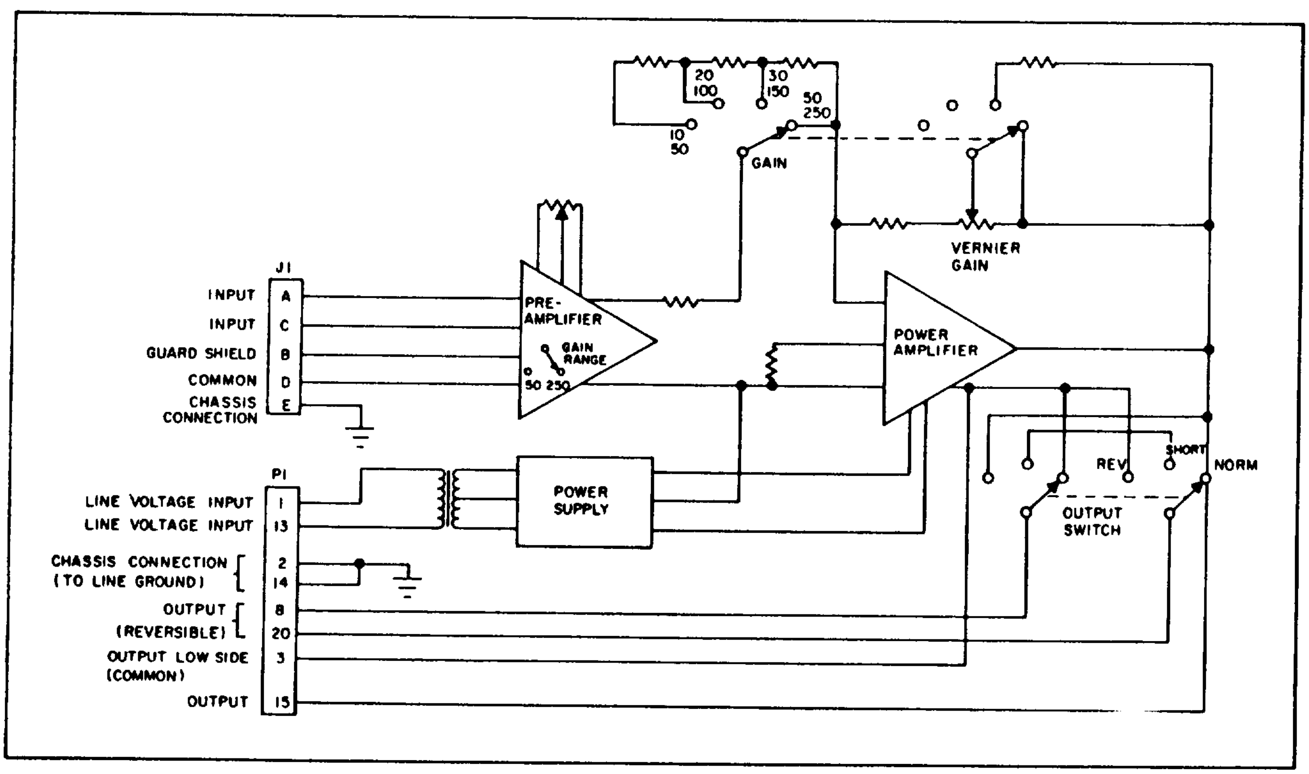


Figure 4-1. ACCUDATA 104 - Block Diagram

gain multiplier is included in the amplifier, the input signal is fed through the multiplier circuit before entering the first differential amplifier stage Q1. Components of the current source are transistor Q9, zener diode VR3, and associated resistors. The collector circuit of Q1 is composed of R1, R2, and the OUTPUT ZERO trimpot R3, which adjusts the collector current balance between the two transistors. Emitter resistor R4 and trimpot R5 compensate for the base-emitter voltage mismatch of Q1 to prevent the d-c voltage level at the output of the preamplifier from changing with the gain of the preamplifier. R5 also acts as a coarse output zero control. Q1 is a pair of silicon planar transistors mounted in a common TO-5 package. The d-c current gains (H_{FE}) and base-emitter voltages are closely matched at room temperature, and remain within a specified range of each other as temperature varies. The change in base-emitter voltage difference with temperature is less than 20 uv/°C, and is the most important factor in determining the over-all drift of the amplifier. Other resistors in the emitter circuit of the first stage are associated with the over-all feedback network and are discussed later. The amplifier signal appearing between the collectors of transistor pair Q1 is applied to the second differential stage consisting of Q2-A and B, Q3-A and B, and R14 through R21. Each side of the second differential stage is composed of a Darlington connected transistor pair. The Darlington connection boosts the input impedance of the stage, thus keeping the gain of the first stage high. Emitter resistors R16 and R17 provide some degeneration to stabilize the gain of the stage and increase its input impedance. The common emitter resistance of this stage consists of R14 and R15. The junction of R14 and R15 connects to the base of common-mode amplifier Q8. Q8 amplifies common-mode signals appearing at the junction of R16 and R17 and inverts the phase of these signals. The amplified signal is applied to the emitter of controlled current source Q9. The base of Q9 is biased at a fixed voltage by diode VR3, and variations in the emitter voltage change the collector current of Q9. The change in collector current adds or subtracts current from transistor pair Q1 to maintain its collector currents constant. If the collector currents are constant, as the common-mode signal is applied to the base terminals, the common-mode voltage will not be amplified. The R-C networks between the collector and base terminals of the second stage shape the open loop gain and phase characteristics of the preamplifier to provide a stable feedback loop. The output of the second stage is applied to the third differential stage, composed of Q4, Q5, R26, R27, and R28. Emitter resistors R26 and R27 stabilize the gain of the stage and increase its input impedance. The common-emitter resistor R28 is returned to the -22 volt supply. The amplified output of this stage is taken between the collector of Q5 and amplifier common to convert to a single-ended output. The signal is applied to the output stage consisting of transistors Q6 and Q7, bias diodes CR1 and CR2, and associated resistors. The signal is amplified by Q6 and applied to the output and to Q7 through CR1 and CR2. Q7 provides current amplification and acts as a dynamic collector resistor for Q6 to improve the efficiency of the stage. The voltage across diodes CR1 and CR2, the base-emitter voltage of Q7, and resistors R31 and R32 determine the no-signal current through Q6 and Q7. Over-all feedback is applied around the preamplifier through feedback resistor R34. The feedback network consists of R34, and R6 through R11. R34 and R8 determine the gain when GAIN RANGE switch S1 is in the 50 position. Emitter resistor R7 and the resistance to common, consisting of R9, R10, and R11, are necessary to complete the symmetry of the feedback network, but have a small effect on the closed loop gain. In the 250 position of the GAIN RANGE control, R6 is shunted across R7 and R8 to increase the gain to 250. Shunting R7 and R8 with R6 is equivalent to shunting one half of R6 across feedback resistor R8. This method of changing the gain does not affect the balance of the first stage, and reduces switching transients to a minimum. Trimpots R9 and R10 are switched into the balance network individually by the GAIN RANGE control. These trimpots are adjusted to cancel common-mode output signals which are not rejected by the common-mode feedback. These common-mode signals are the result of unbalances between the two input transistors. They are fed back to the emitters of the first stage, and canceled by unbalancing the feedback network.

The output of the preamplifier is routed through R61 to pin K of connector J2. From J2 the signal passes through GAIN switch S2 on the front panel, and returns to the power amplifier on the circuit card through J2-L. R56 through R61 are components of the resistive operational feedback around the power amplifier. This network establishes the calibrated gain steps of the over-all amplifier.

B. POWER AMPLIFIER. The power amplifier section if an inverting current amplifier with operational voltage feedback around it. The amplifier consists of two stages of voltage gain followed by three stages of current amplification. The output voltage is fed back to the input terminal of opposite phase and summed with the signal from the preamplifier. The closed loop gain (or attenuation) of the power amplifier is determined by the ratio of the feedback resistance from the output to the input, divided by the resistance from the preamplifier output to the input of the power amplifier. The ratio of these resistors provides fixed attenuation steps, rather than gain. The lack of closed loop gain assures that the power amplifier will have a small effect on the drift and noise of the over-all amplifier. It also eliminates output transients when switching gain positions of the over-all amplifier. The attenuation steps are .2, .4, .6, and 1.0. Vernier gain control R60 is in series with feedback resistor R59 and varies the attenuation of the power amplifier between the fixed, calibrated values.

The first stage of the power amplifier is a balanced differential stage, consisting of Q10-A and B, and resistors R36 through R40. The base of Q10-A is the input to the amplifier, and the base of Q10-B is returned to common through drift stabilizing resistor R35. Q10-A and Q10-B are matched for d-c current gain (H_{FE}) and base-emitter voltages, and cemented together with thermal conducting epoxy. Matching these transistors and reducing the thermal gradient between them insures that the power amplifier contribution to the over-all drift will be small.

The R-C network across the output of the first stage shapes the open loop gain and phase characteristics.

The output of the first differential stage is applied to second stage transistors Q11 and Q12. This stage is differential, with emitter resistors R43 and R44 connected to common emitter resistor R46. The emitter resistors stabilize the gain of this stage and increase its input impedance. Use of PNP transistors allows placement of the collector bias near the zero volt level, required by the remaining emitter follower stages.

The output of the second stage is taken between the collector of Q12 and common and applied to emitter followers Q13 and Q14. Transistors Q13 and Q14 provide sufficient current gain to drive the output stage. The output stage is a PNP-NPN stage, operating class AB to minimize the no-signal power dissipation. The no-signal current through Q15 and Q16 is determined by the voltage across CR3, CR4, CR5, the base-emitter voltages of Q16 and Q17, and resistors R49 and R50. Resistors R47 and R48 limit the dissipated power in Q15 and Q16 at full scale output, and in conjunction with R49 and R50, limit the maximum current output of the amplifier. The signal at the emitter of transistor Q14 is applied directly to the base of Q15, and to the base of Q16, through diodes CR3, CR4, and CR5. Since the transistors are of complementary types, the same base drive signal reduces the collector current through one, while increasing the current through the other.

The output of the amplifier is fed back to the input terminal through feedback resistor R59 and vernier control R60. The feedback network consists of resistors R56 through R58, and R61 and R62. Close tolerance wirewound resistors are used to insure long term stability and a stable attenuation with changes in temperature. The output of the power amplifier is routed through J2-U to the OUTPUT switch. Capacitor C7 is a permanent capacitive load on the amplifier, reducing the range of capacitive loads over which the amplifier must be stable.

C. POWER SUPPLY. The power supply section provides regulated plus and minus 22 volts dc from either a 115V AC or 230V AC line voltage.

The line voltage is applied to transformer T1. The primary of T1 is divided into two identical windings, externally connected in series or parallel. The windings are connected in parallel for 115-volt inputs, and in series for 230-volt inputs.

The center-tapped secondary voltage of T1 is applied to a full wave diode bridge, connected to provide full wave positive and negative rectification with respect to the center-tap. The positive and negative d-c voltages are filtered by capacitors C8 and C9, and applied to separate regulating circuits. Both regulators are identical, except for the polarity of transistors and diodes; a PNP series pass transistor Q18 is used in the negative voltage regulator, and an NPN transistor Q17, in the positive regulator.

The unregulated d-c voltages are applied to a preregulator, consisting of VR4 and R53 in the negative regulator, and VR5 and

and R52 in the positive regulator. The fixed 24 volts across VR4 and VR5 is used as a stable, relatively ripple free voltage supply for reference diodes VR1 and VR2. Current through VR1 and VR2 is determined by the voltage across resistors R54 and R55 and is relatively constant. VR1 and VR2 provide a stable reference voltage of 22 volts ±1% to the base of the series pass transistors. The output of the regulated supplies is filtered further by capacitors C10 and C11. C10 and C11 also reduce the output impedance of the supplies.

SECTION V—APPLICATIONS

5-1. SOURCE CONSIDERATIONS AND TRANSDUCERS

A. GENERAL. Transducers basically convert energy from one form to another. In this section, transducers are considered low level and high level signal sources and are treated separately. Certain other sources, best handled by other amplifier techniques, are also discussed.

Generally, a transducer can be dealt with in terms of its Thevenin equivalent, the EMF acting in series with an impedance, and the bandpass specifications of the transducer. Figure 5-1 illustrates a Thevenin equivalent. Source outputs appear to the amplifier as either a variation in E_s, the source voltage, R_s, the source impedance, or both.

B. LOW LEVEL INPUTS. The majority of transducers falls into the low level input category. This discussion defines low level inputs (those inputs best handled by the Accudata 104-1) as those having an output voltage in the range from 10 to 250 mv, with source impedances between 0 and 1000 ohms. The Accudata 104-1 can also satisfactorily handle source impedances higher than 1000 ohms. The 1000 ohm specification defines the other points in the published specifications, especially noise. Normally the noise level of the amplifier doubles as the source impedance quadruples (with a 4000 ohm source, twice the published specification noise can be expected). Often this noise level increase is negligible, considering the published specifications are worst-case conditions.

C. THERMOCOUPLE SOURCES. Typical thermocouple source EMF varies between 0 and 1 mv and 0 to 80 mv, depending on the type of thermocouple material and the temperature range involved. Thermocouple EMF tables are available from all Honeywell Branch Sales Offices.

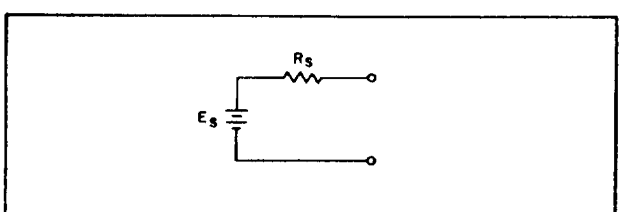


Figure 5-1. Thevenin Equivalent Circuit

The reference junction, shown in Figure 5-2, varies in complexity from a triple point cell to an ice bath, to a bottle of water or a heavy metal heat sink. The only requirement at the reference junction is that it be more stable than the least signal of interest at the measuring junction.

The output EMF of the thermocouple is proportional to the difference between the reference junction and the measuring junction. Positive output signals are generated when the measuring junction is above the reference junction temperatures, with negative output signals generated when the measuring junction is below the reference junction temperature. A commonly used reference junction is similar in construction to a crystal oven, and the reference temperature is maintained above the ambient by external heating.

When working with thermocouple EMF tables, it is necessary to subtract the EMF generated, at a given temperature of the reference, from the EMF generated at the measuring junction. A small error, which often becomes significant, results if the two temperatures are subtracted directly, as the thermocouple EMF curve is slightly parabolic.

Often electrical zero suppression networks are required, particularly when the area of measurement differs greatly from the reference temperature area. For example: In jet engine exhaust temperature measurements, the only area of interest lies between 1200 and 1400 degrees. The area between 32° and 1200° offers no significant data. In this case, an EMF is generated in the box marked "ZERO" in Figure 5-2, which is equal in amplitude and opposite in polarity to the EMF of the thermocouple at 1200°.

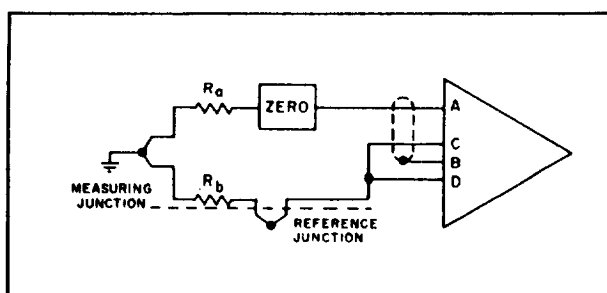


Figure 5-2. Thermocouple Circuit

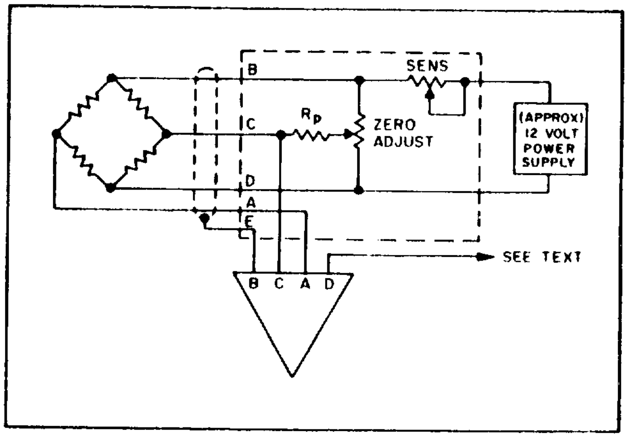


Figure 5-3. Strain Gage Circuit

The thermocouple source impedances, as seen by the amplifier inputs are:

1. Combination of resistance of the hot leg and cold leg, and depend upon the:

   a. Wire diameter.

   b. Wire material.

   c. Length of thermocouple wire.

   d. Ambient temperature.

   For example: A copper constantan usually has negligible resistance in the copper lead. With a grounded thermocouple, the ideal location for the ground return would be at some point close to the measuring junction. Refer to paragraph 5-3 for a detailed explanation of this requirement.

D. STRAIN GAGE MEASUREMENTS. Figure 5-3 illustrates schematically the strain gage input configuration. The output voltage of a typical strain gage varies between 0 and 10 mv; output impedance is either 120 or 350 ohms. Output voltage may be adjusted by adjusting the rheostat illustrated in the control unit. An increase in the exciting voltage of one volt usually increases the output of the gage by 1 mv or 2 mv, depending on the gage factor. The gage factor is the ratio of the input or

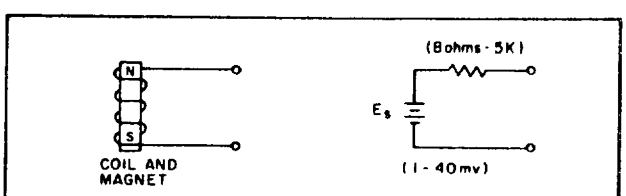


Figure 5-4. Velocity Pickup

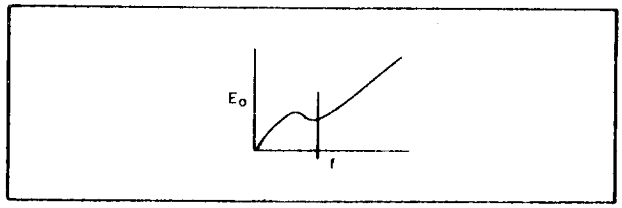


Figure 5-5. Frequency Response of Vibration Pickup

excitation voltage in volts to the output voltage in millivolts. The unit of the gage factor is millivolts per volt.

The power supply output is approximately 12 volts, and the series resistor for sensitivity should reduce this by a factor of 10 to 1. The zero adjust resistor is usually a fairly high impedance (approximately 50K) resistor and the movable contact serves to bias point C, shifting the reference point, or adjusting the zero.

The output millivoltage is developed across pins C and A of the control unit and coupled to amplifier input pins C and A. Pad resistor R_p serves as a replaceable resistor, adjusting the sensitivity of the zero adjustment.

Note

Exercise care when using strain gage circuits (especially those using a common power supply for more than one channel) to prevent the development of ground loops, thereby causing the amplifier to see high stray levels across its input.

With floating power supplies, pin D may be connected to the low side of the power supply to provide the signal return path (half the excitation voltage appears as a common mode voltage to the amplifier). The system ground reference point can

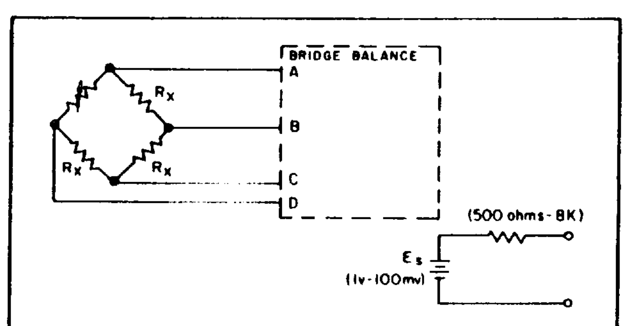


Figure 5-6. Thermistor Circuit

then be placed at the power supply amplifier, or at the recording device.

With grounded power supplies, pin D should be connected to the ground reference point of the power supply, which then becomes the ground reference point for the system.

E. VELOCITY PICKUPS OR VIBRATION PICKUPS. Figure 5-4 illustrates a typical velocity pickup. These pickups are composed of a magnetic coil of wire, similar to a permanent magnet loud speaker. Motion of the coil, relative to the magnet, results in generation of an output current. Either the coil or magnet may be fixed to the vibrating object, allowing the other member to vibrate at the frequency and amplitude of the test sample. E_O increases both with an increased distance of coil motion, or in frequency. Doubling the frequency with a constant motion results in a doubled output.

Doubling the amplitude of the excursion, at a given frequency, also doubles the amplitude of the output. Figure 5-5 shows the output voltage of the transducer plotted against frequency. These devices are commonly used above their resonant frequency to get into the linear portion of the curve. The rise at this linear portion is 6 db per octave (doubling frequency doubles the output voltage).

F. THERMISTOR TEMPERATURE SENSING DEVICES. Thermistors are semi-conductor materials having a large change in resistance for a small change in temperature. They are widely used for measurement of temperatures displaying very narrow temperature ranges.

Figure 5-6 illustrates the input configuration of a thermistor bridge to a bridge balance. Values for R_t, the dummy resistors used in the external bridge, should be adjusted to equal the thermistor resistance at the middle of the thermistor operation range. This information is normally available from the manufacturer's specifications.

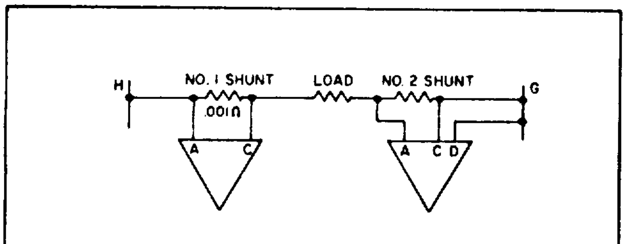


Figure 5-7. Shunt Circuit

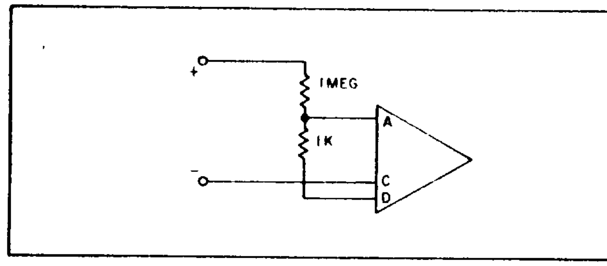


Figure 5-8. Single Ended Attenuator

A typical thermistor output, for use with the Accudata 104, would be source voltages varying between approximately 10 and 100 millivolts, and source impedances running from 500 to as high as 8000 ohms. The resistance of the device generally varies inversely with the size of the thermistor.

G. CURRENT MEASUREMENTS WITH SHUNTS. A shunt is a calibrated resistor inserted in the line for the measurement of current. The voltage drop across the shunt is thereby proportional to the current flowing (Ohms Law). The necessity in constructing a shunt is that the mechanical construction provides self-cooling, and resistance (R) should remain constant. As shown in Figure 5-7, a one milliohm shunt produces a one millivolt output per ampere flowing through the load. This is an example of a differential voltage measurement. If the hot line is 10 volts, and 10 amperes are flowing through the load, pin A will be at a 10.00 volt level. Pin C of the amplifier will see 9.99 volts, virtually matching the common mode specification of the amplifier.

By connecting the shunt as shown in position 2, pin A would see 10 millivolts. Pin C would see 0 volts, as the 10 volt drop has occurred at the load. This leaves the common-mode rejection ability unimpaired to handle pickup of any stray signals.

H. VOLTAGE DIVIDERS. Voltage dividers reduce higher signal levels to the working range of the amplifier. Figure 5-8 illustrates a 1 megohm to 1000 ohm voltage divider, which reduces a voltage appearing across the inputs by a factor of 1000 to 1, converting millivolts to volts. As illustrated, this provides basically a single ended divider. Potentially hazardous conditions can exist by driving the negative or unattenuated side to some relatively high voltage.

Figure 5-9 illustrates the attenuators constructed for the Accudata 104-2 and -3 versions. The use of attenuator resistors

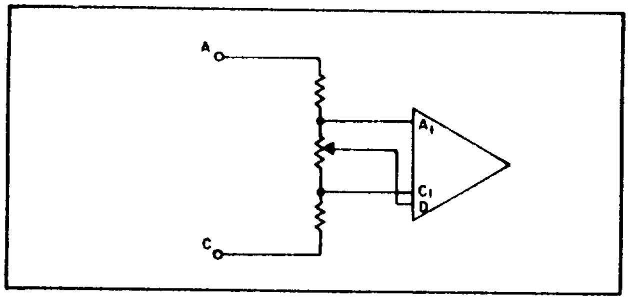


Figure 5-9. Differential Attenuator

in each leg eliminates the problem noted in the preceding paragraph.

In the -2 and -3 versions, these attenuators are located behind the input connector plug. Amplifier inputs here are noted A_1 and C_1.

I. HIGH LEVEL INPUTS. The Accudata 104-2 and -3 have internal input attenuators which reduce the effective range of the instrument from 250 millivolts to 6.25 volts for the -2 version, and from 1 to 25 volts for the -3 version. These devices are configured as noted in Figure 5-9, and find their widest usage coupling high level sources to low impedance loads, such as galvanometers. In addition to this, the calibrated range switching is still available to produce desired deflections.

Figure 5-10 illustrates a common signal, such as an amplifier output in the range of 0 to 20 volts, which is usually adjustable by an output adjust knob delivered from a constant 600 ohm communication-type impedance. Note that no connection is required to pin D, with ground return path internal through the attenuator.

Figure 5-11 illustrates a commonly encountered form of transducer, the potentiometer pickoff. Here 10 volts are developed across a 10K potentiometer, the center tap of which is mechanically linked to a moving member to detect motion, or perhaps to a bellows to detect pressure. This once presented difficult measuring problems because the voltage level changes from 10 volts to 0 volts, as the potentiom-

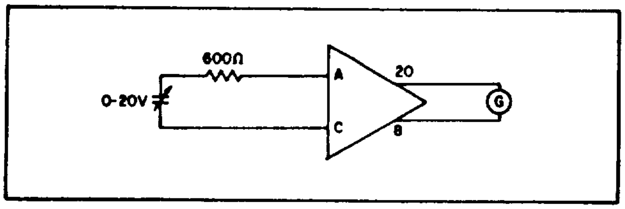


Figure 5-10. Typical Preamplifier Output (0-20V)

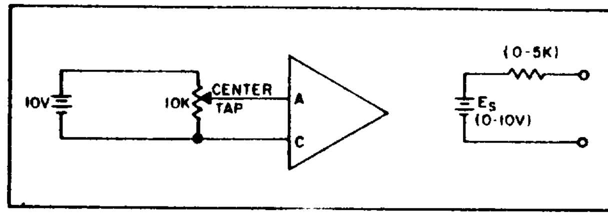


Figure 5-11. Potentiometer Pickoff

eter moves downward, while the source impedance changes from 0 ohms, reaching a maximum of 5000 ohms at the center, and again decreasing to 0 ohms. The high input impedance, always over 1 megohm, of the Accudata 104-2 or -3, holds any non-linearities of reading to less than 1/2 of 1 per cent.

J. CATHODE AND EMITTER FOLLOWER AND OTHER ELECTRONIC OUTPUTS. Figure 5-12 illustrates the output of a typical transistorized amplifier, showing a common problem. This output, which is actually from a Honeywell 8100 tape recorder, is a high level voltage signal developed out of a low source impedance. If these were the only considerations, one would assume a current draw from this source equaling 2 volts, divided by 40 ohms, or 50 milliamperes. However, limitations in the output transistor limit the maximum current draw to 5 ma, as shown. Exceeding this output current limitation results in non-linearity of the output. Interposing the Accudata 104 amplifier between the output and the galvanometer is similar to connecting a one megohm resistor (min) in series with this load. In this case, the output current of the 8100 tape recorder will not exceed 2 ua, insuring a linear output of the device under test.

K. SOURCES BEST HANDLED BY OTHER AMPLIFIER TECHNIQUES.

1. Carrier Amplifiers. There are three common transducers available today requiring a-c excitation. These are:

   a. Linear variable differential transformers.

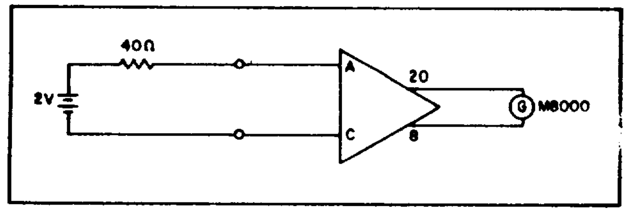


Figure 5-12. Typical Cathode and Emitter Follower Connection

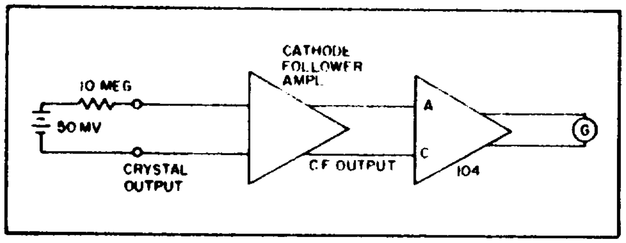


Figure 5-13. Equivalent Output of Crystal Pickup

b. Capacitive pickups.

c. Variable reluctance pickups.

As these devices require a-c excitation, their output is also in the a-c domain and requires discrimination and filtering before the transduced signal becomes readily apparent. As carrier amplifiers furnish both the exciting voltage to the transducers, together with the necessary discrimination and filtering functions, they are the preferred amplifiers of usage in this case.

2. Crystal Accelerometer and Pressure Pickups. Figure 5-13 illustrates, in simplified form, the equivalent output of a crystal pickup. Although the output signal is at a usable level, the very high output impedance of this device completely exceeds the source impedance requirement of the Accudata family of amplifiers. These devices are usually accompanied by a cathode follower amplifier, furnished by the manufacturer of the transducer. These cathode follower amplifiers serve to decouple the high impedance and provide a workable output to the Accudata 104. Typical outputs may be 1 volt rms out of several hundred, or a thousand ohms. This signal is well within the capabilities of the Accudata 104 amplifier.

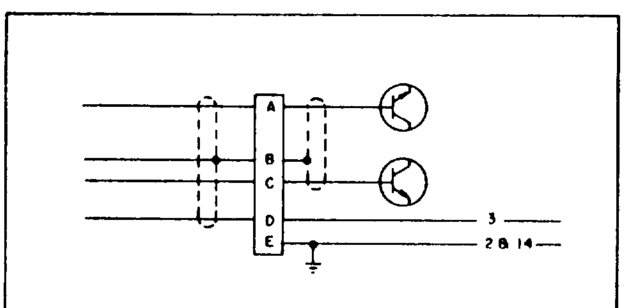


Figure 5-14. Input Connections to -1 and -4 Versions

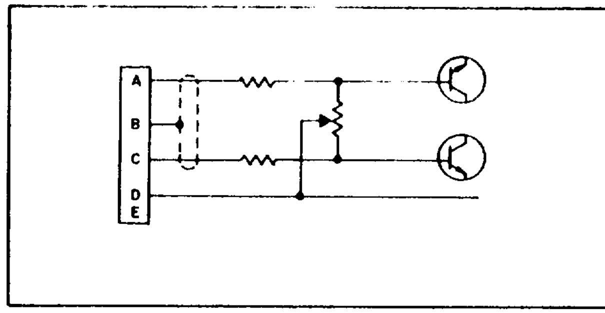


Figure 5-15. Input Connections to -2, -3, -5, and -6 Versions

5-2. INPUT WIRING

Figure 5-14 illustrates the basic input wiring of the Accudata 104-1 amplifier. Pin A is the high side of the input; pin C is the low side of the input. Pin B is the shield connection. This is an isolated input terminal which enables the external shielding, together with the internal shielding preceding the first stages of the amplifier, to be driven and used as a guard shield. The technique used here raises the potential of the guard shield to the potential of the stray voltage. Leakage of stray currents will occur between the guard shield and case ground E, thus bypassing the input stages of the amplifier and having little or no effect on measurement.

Pin D of the input, and Pin 3 at the output plug, are the power supply common. To secure proper amplifier operation, this pin must connect to some ground reference point at the source (preferred) at the amplifier case, or the load. Optimum connections of this ground point vary with environment in which the equipment is installed. In most cases, it is feasible to make the connection at the input plug.

Figure 5-15 shows the input connections with the -2 and -3 versions. Here, the signal return path is established internally through the attenuator, and no external connections need be made.

5-3. AMPLIFIER SIGNAL RETURN PATH

Refer to Figure 5-16. A resistive return path must be provided between the input circuit (pins A

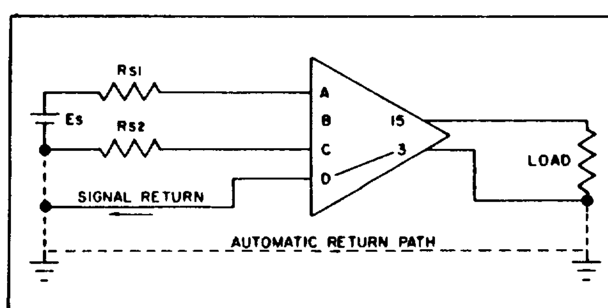


Figure 5-16. Alternate Return Path

and C) and the amplifier common (pins D and E). Normally this path can be between the ground reference of the source and the ground reference of the load. The quality of this connection need not be high. Resistances from 0-100K ohms will suffice. If either the source or load is floating from ground, some other means must be found to complete this circuit. For example, in a strain gage system, one side of the gage power supply can be connected to pin D.

5-4. OUTPUT WIRING

Coaxial cables should NOT be used for the output wiring of these d-c amplifiers. The low source impedance, less than .5 ohm, makes stray pickup unlikely. The very high shield-to-center conductor capacitance of coaxial cabling can cause problems in termination and result in ringing. This ringing results as the capacitive load exceeds .1 microfarad which is easy to exceed using coaxial cabling.

5-5. CONNECTIONS TO OSCILLOGRAPHS AND TAPE RECORDERS

A. OSCILLOGRAPH CONNECTIONS. Output connector pins 8 and 20 are connected through the output switch on the front panel to produce normal (NORM), shorting (SHORT), and reversing (REV) operation. These pins can be connected to galvanometers or any other good differential input device.

B. TAPE RECORDER CONNECTIONS. The negative side of the input of a tape recorder is always at ground potential. Reversing operation is not feasible. Tape recorders should be connected across pins 15 (high) and pin 3 (low).

C. GALVANOMETER LOAD CONSIDERATIONS. The Accudata 104 was designed to drive all fluid-damped Visicorder oscillograph sub-miniature galvanometers to their full scale deflections, as determined by galvanometer specifications. The amplifier was also designed to protect galvanometers on the output, through current limiting. Because of their somewhat lower resistance, the M1650 galvanometer (24 ohms) and the M3300 galvanometer (28 ohms) should have series resistance added to increase their combined value to at least 35 ohms. Refer to Table 5-1.

5-6. SYSTEMS

The low output impedance of the Accudata 104 (less than .5 ohm) permits direct driving of galvanometers, oscilloscopes, and tape recorders. Assuming a 2.5 volts full scale output is required to produce 40 milliamps through a proper series resistor and the M10,000, the IR loss in the output impedance of the amplifier will be .040 x .5 or 20 mv. This results in an error at the output of 20 parts in 2500, or less than 1/10 of 1 per cent, which will not be noted either on the tape system or the oscilloscope.

Galvanometer	R_g (ohms)	I_g (ma/in.)	V_g (volts/in.)	Approximate R_{se} (ohms)	Approximate V_c (V/in.)	Resulting operational Range at input (mv/in.)
M1000	35	2.63	.092	3 350	.100 1.00	.4 ----► 10 4 ----► 100
M1650	24	9.39	.223	29 82	.500 1.00	2 ----► 50 4 ----► 100
M3300	28	20	.564	22	1.00	4 ----► 100
M5000	35	31.3	1.10	5	1.25	5 ----► 125
M8000	34	40	1.36	28	2.5	10 ----► 250
M13000	70	83	5.8	0	5.8	12 ----► 250 (for ±1/2")

Table 5-1. Resistor Values for Various Galvanometer Deflections

Note

Other values may be calculated by $\frac{V_c \text{ (desired)}}{I_g} - R_g = R_{se}$

V_c = desired circuit voltage sensitivity = $I_g (R_g + R_{se})$

V_g = galvanometer voltage sensitivity = $I_g R_g$

Figure 5-17 shows the proper output connections to such a system. Using terminals 8 and 20 for galvanometer connections enables a reverse of the galvanometer deflection.

Figure 5-18 illustrates a typical example of a difficult measuring problem frequently encountered when the test site is isolated by perhaps 1500 feet from the block house, and by as much as one mile between the block house and the central data facility. In this case, the shield, together with the amplifier guard, is driven at the ground potential of the test site. The signal circuitry is not referenced to block house ground, but is isolated by the impedance of the amplifier.

The tape system introduces another ground at the central data facility location. The input signal return path in this configuration is from the central data facility, back to the source ground through the ground connections at each location.

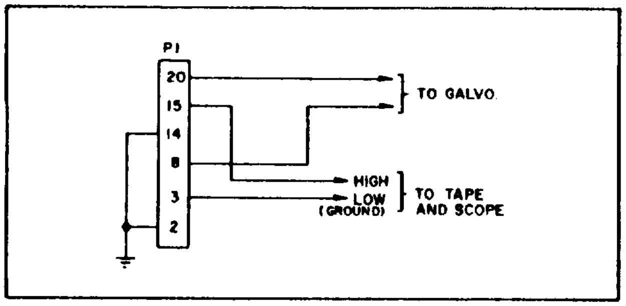


Figure 5-17. Output Connections

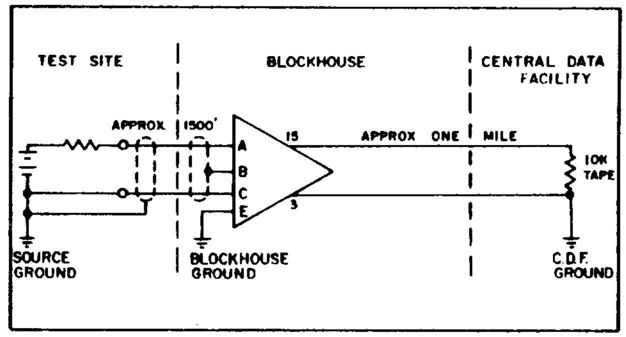


Figure 5-18. Grounding at Isolated Sites

SECTION VI — MAINTENANCE

6-1. GENERAL

This section contains procedures for preventive and corrective maintenance. Preventive maintenance outlines routine procedures to be performed at regular intervals without special tools and test equipment. Corrective maintenance includes basic troubleshooting, replacement, and adjustment information. Use the schematic diagram at the rear of this manual as an aid during performance of corrective maintenance.

The information provided under corrective maintenance aids the technician in determining the location of a malfunction, but does not detail the action to be taken upon localizing the defect. Using the schematic diagram, the technician should determine the best method for correcting the malfunction.

6-2. PREVENTIVE MAINTENANCE

Periodically perform the following procedures to maintain the operability of the equipment and to prevent future malfunctions.

A. INSPECTION. Perform over-all visual inspection of the unit before each operation. See that the printed circuit card is securely fastened, all receptacles tight, no loose or broken connections, no bent or corroded pins, and the equipment is clean.

B. CLEANING. Remove dust and loose dirt from the unit with a brush and a vacuum hose. Remove deposits of dirt, grease, or oil from metallic parts with a cloth moistened with any commercial dry cleaning solvent (petroleum solvent). Clean nonmetallic parts with a lint-free cloth moistened with plain water.

6-3. TEST EQUIPMENT

The tools and test equipment recommended for troubleshooting and checkout of the Accudata 104 D-C Amplifier are listed in Table 6-1. This list is not mandatory, but should be used as a standard if alternate equipment is selected.

MANUFACTURER	MODEL NO.	DESCRIPTION
John Fluke	803A	AC-DC Differential Voltmeter
Hewlett-Packard	HP400H	AC VTVM
Hewlett-Packard	HP3400A	AC VTVM (True RMS)
Hewlett-Packard	HP200CD	Oscillator
Tektronix	531	Oscilloscope
Triplett	630-NA	Multimeter
Unger	30 watt	Soldering iron
		Regulated D-C Power Supply
		Bench Test Adapter Cable
		Standard Shop Tools

Table 6-1. Recommended Tools and Test Equipment

6-4. CORRECTIVE MAINTENANCE

A. GENERAL. Malfunctions are normally indicated by irregular action of galvanometer light spot on the recording plane. If the malfunction is isolated to the amplifier, remove it from the rack adapter and carefully check all leads, connectors, and components for visible damage, such as broken leads, burnt or damaged components, or poor solder connections. If visual inspection fails to pinpoint the defect, refer to the subsequent troubleshooting procedures.

Note

If proper test facilities and equipment are not available to troubleshoot and repair this unit, contact your local Honeywell Sales and Service representative. Honeywell branch offices are staffed with factory trained engineers, equipped to make effective repairs in a minimum amount of time.

B. TROUBLESHOOTING. This paragraph contains troubleshooting tables and step-by-step procedures for maintaining the preamplifier, power amplifier, and the power supply. Determine the cause of amplifier malfunctions as follows:

Note

Before troubleshooting this unit, the maintenance man should thoroughly acquaint himself with Section IV, Principles of Operation.

1. Preamplifier

a. General. A preamplifier malfunction is normally indicated by a saturated output (J2-K). With the preamplifier at saturation, the OUTPUT ZERO control has no effect on the output level. Troubleshoot the preamplifier with the amplifier unit removed from the rack adapter. Refer to the schematic diagram for normal voltage levels.

b. Troubleshooting Table. Table 6-2 shows possible causes and remedies for various preamplifier malfunctions.

Note

Resistance and capacitance values and transistor parameters in this unit are critical. Replace only with recommended parts listed in the electrical parts list, Section VII.

c. Troubleshooting Procedure. When troubleshooting the preamplifier printed circuit card, use the following procedures.

1) Using a high impedance voltmeter, check voltage levels starting from the output stage and working backward. Correct voltage levels, as listed on the schematic diagram, indicate correctly operating stages on the output side of the measurement location.

2) Check transistors by measuring the base-to-emitter voltages. Indications should be between .5 and .7 volts dc.

2. Power Amplifier

a. General. The power amplifier circuit contains the gain attenuator switch assembly. Before troubleshooting, make certain that all switch positions and connections are proper. Troubleshoot the power amplifier with the amplifier unit removed from the rack adapter. Refer to the schematic diagram for normal voltage levels.

b. Troubleshooting Table. Table 6-3 provides information on possible causes and remedies for various power amplifier malfunctions.

Note

Resistance and capacitance values and transistor parameters in this unit are critical. Replace only with recommended parts listed in Section VII.

c. Troubleshooting Procedure. When troubleshooting the power amplifier printed circuit card, use the following procedures.

SYMPTOM	POSSIBLE CAUSE	REMEDY
No output signal.	Improper input connection to amplifier. No power to amplifier. Defective transistor.	Make certain inputs are connected. Check power input connections. Check transistors; refer to para. 6-4 1.C.
Excessive drift.	Defective transistors Q1-A, Q1-B. Power supply drift.	Replace transistor assembly Q1. See Table 6-4.
Noise - 120 cps - 60 cps - Wideband	Power supply defect. Improper input cable shielding. Value change of components C1, R22, R24, C3, C12, C2, R23, R25, C4, C5.	See Table 6-4. Check shields for proper grounding. Check values and replace if necessary.
Failure to obtain zero output using OUTPUT ZERO control.	Improper adjustment of R5. Defective control R3, R5. Defective transistor assembly Q1.	Adjust R5; refer to para. 6-7. Replace R3, R5. Replace Q1.
Improper gain.	Gain switch S1 in wrong position. Value change in feedback circuit components R34, R6, R7, R8. When using .04 or .01 gain multiplier: Value change in components in multiplier circuit.	Properly position S1. Check values and replace if necessary. Adjust for proper output. Check values and replace if necessary.

Table 6-2. Preamplifier Troubleshooting Table

1) Using a high impedance voltmeter, check voltage levels starting from the output stage and working backward. Correct voltage levels, as listed on the schematic diagram, indicate correctly operating stages on the output side of the measurement location.

2) Check transistors by measuring the base-to-emitter voltages. Indications should be between .5 and .7 volts dc.

3. Power Supply

a. General. The power supply components, with the exception of transformer T1, mount on the amplifier printed circuit card. The supply provides positive and negative 27 to 38 volts dc at the output of the diode bridge rectifier. This voltage drops to positive and negative 22 volts dc at the supply output.

b. Troubleshooting Table. Table 6-4 provides possible causes and remedies for various power supply malfunctions.

c. Component Checkout. Check power supply components using an ohmmeter. Starting at source pins 1 and 13 of connector, check continuity of the transformer primary and secondary. Check capacitors C8, C9, C10, and C11 for a charge indication on the ohmmeter. Check resistance values of R52 through R55.

SYMPTOM	POSSIBLE CAUSE	REMEDY
No output signal.	No input signal to power amplifier. Switch S2 or S3 in wrong position or defective. Defective transistors.	Refer to preamplifier; see Table 6-2 Properly position S2 and S3, or replace if necessary. Check transistors. Refer to para. 6-4, 2.C.
VERNIER GAIN control has no effect on amplifier sensitivity.	Defective potentiometer R60.	Replace R60.
Improper gain.	Value change in attenuator circuitry.	Check values and replace if necessary.
Excessive change in d-c output level when GAIN RANGE control switched.	Improper alignment of R5 in preamplifier. Defective transistor pair Q10A, B.	Refer to calibration procedure, para. 6-7. Replace transistor.

Table 6-3. Power Amplifier Troubleshooting Table

SYMPTOM	POSSIBLE CAUSE	REMEDY
No Power Supply output.	Improper a-c source connection. Transformer T1 primary or secondary open. Defective diode bridge. Shorted filter capacitors. Transistors Q17 or Q18 defective.	Check a-c line voltage pins 1 and 13 of connector P1. Replace T1. Replace bridge CR6. Replace C8, C9, C10, or C11. Replace Q17 or Q18.
Noise on supply output.	Deteriorated or open filter capacitors.	Replace C8, C9, C10, or C11.
Incorrect power supply output.	Defective regulator zener diodes, transistors, or resistors. Defective diode bridge.	Replace VR1, VR2, VR4, VR5, R52 thru R55, or Q17, Q18. Replace bridge.

Table 6-4. Power Supply Troubleshooting Table

6-5. REPAIR AND REPLACEMENT

A. GENERAL. Determine the need for repair or replacement of parts by inspecting the amplifier according to paragraph 6-2. Replace any defective parts and resolder any loose leads or poor solder connections.

B. REPLACEABLE PARTS. Refer to Section VII for a complete list of electrical parts. To ensure safe, efficient operation, use only parts with the electrical characteristics and tolerances listed.

C. CIRCUIT CARD REPAIR. Exercise caution when removing or replacing components from the amplifier printed circuit card, especially when a component has multiple pins and each pin must be unsoldered individually. Too much heat applied to a small area may scorch the copper clad and loosen it from the card. To remove or replace circuit card components, use an iron of the Unger type with no more than a 30 watt tip and perform the following:

1. Dip the end of a braided shield or ground type strap in solder flux, and place the flux end of the strap over the point where solder is to be removed.

2. Place the iron on the strap, directly over the terminal. Capillary action will draw the solder from the hole into the strap.

6-6. PERFORMANCE TESTS

A. GENERAL. The Accudata 104 D-C Amplifier was thoroughly tested prior to shipment from Honeywell. The following procedures are intended to familiarize the user with the test methods used by Honeywell during final checkout of the Accudata 104. The use of these procedures is recommended in any further tests performed at the user's facility to provide consistency in the results. Procedures are included for the standard Accudata 104-1 (790779-001), the Accudata 104-2 with .04 GAIN MULTIPLIER (790779-002), and the Accudata 104-3 with .01 GAIN MULTIPLIER (790779-003). The procedures are also applicable to the Accudata 104 models which are modified for 230 volt line operation (790779-004, -005, and -006, respectively).

B. INITIAL PREPARATIONS. The following preparations should be made before performing any tests on the Accudata 104.

1. Connect the amplifier input to the test circuitry recommended for the specific test to be performed.

2. Allow the amplifier 15 minutes warm-up.

3. Set the amplifier to the desired gain setting and the OUTPUT switch to NORM.

4. With no input signal applied, connect a differential voltmeter to the output and adjust the OUTPUT ZERO control until the d-c output voltage is 0 ±10 millivolts.

C. TEST PROCEDURES

1. Frequency Response

a. The following procedures are applicable to the standard amplifier at any gain setting, or amplifiers with gain multipliers at gain settings greater than 1.0.

1) Connect the amplifier as shown in Figure 6-1. R2 should be a multiturn potentiometer to provide the required resolution. Select R1 to provide the necessary attenuation at the desired gain setting of the amplifier. The load resistance and capacitance can be any value within the load specifications.

2) See Initial Preparations (paragraph 6-6. B).

3) Adjust the oscillator to 1.8 volts rms or less at 100 cps with the H-P 400H VTVM.

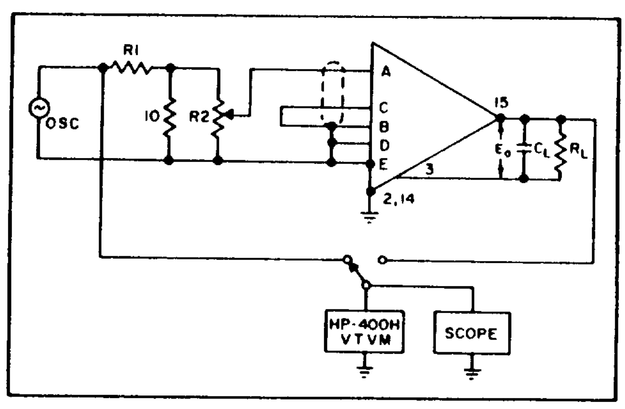


Figure 6-1. Frequency Response Test Circuit (G >1)

4) Adjust R2 until the amplifier output voltage is precisely the same as the oscillator voltage. Switch the voltmeter between the oscillator and amplifier output several times, adjusting R2 until no difference exists between the voltage readings.

5) Observe the output voltage on the oscilloscope for distortion. If distortion is present, determine the cause and correct it before proceeding.

6) With no further adjustment of R2, switch the oscillator frequency through settings of 500, 1000, 3000, 5000, and 10,000 cps. Adjust the oscillator amplitude at each frequency to maintain the original voltage. Record the amplifier output voltage at each frequency. Calculate the deviation from a flat response at each frequency relative to 100 cps.

Note

This procedure uses a response reference point of 100 cps. If desired, use dc as the reference by replacing the oscillator with a d-c power supply and adjusting R2 with a d-c voltmeter instead of the H-P 400H.

7) Response to frequencies above 10 kc is specified at less than full scale output (see specifications). Reduce the oscillator output to the appropriate level for the specific load impedance being used and the highest frequency to be tested. Return the oscillator frequency to 100 cps and repeat steps (4), (5), and (6); then check the frequencies above 10 kc.

b. The following procedure is applicable to amplifiers with gain multipliers at gain settings less than 1.0.

1) Connect the amplifier as shown in Figure 6-2. R2 is a multiturn potentiometer, as before.

2) See Initial Preparations (paragraph 6-6.B).

3) Adjust the oscillator until the amplifier output voltage is 1.8 volts rms or less at 100 cps, with the H-P 400H.

4) Repeat steps (4), (5), (6), and (7) of the previous procedure.

2. D-C Gain Linearity

a. The following procedure is applicable to the standard amplifier at any gain setting, or amplifiers with gain multipliers at gain settings greater than 1.0.

1) Connect the amplifier as shown in Figure 6-3. Use a well regulated d-c power supply capable of supplying at least 2.5 volts. R1 and R2 should be 1000 ohm, multiturn potentiometers to provide adequate resolution. Select R3 to provide the necessary attenuation at the desired gain setting of the amplifier.

2) See Initial Preparations (paragraph 6-6.B).

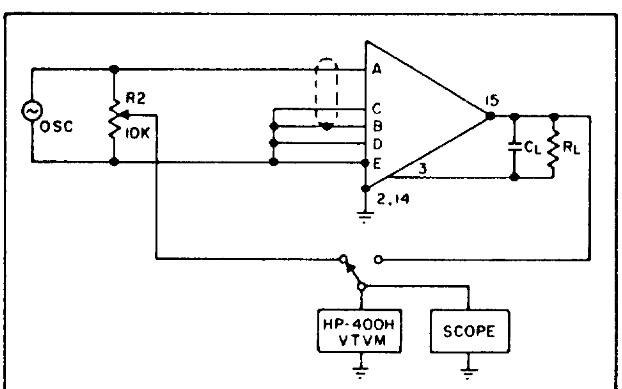


Figure 6-2. Frequency Response Test Circuit (G<1)

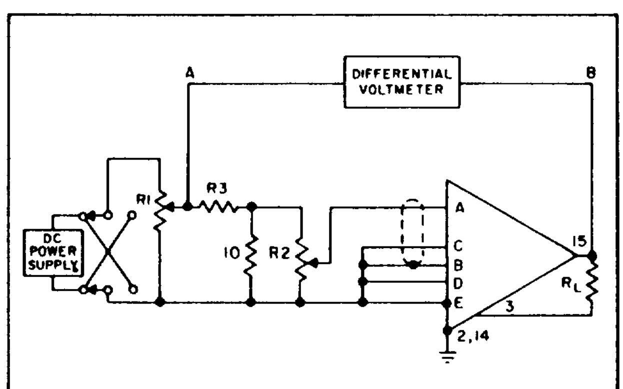


Figure 6-3. D-C Gain Linearity Test Circuit (G <1)

3) Set R1 and R2 so that no voltage is applied to the amplifier.

4) Adjust the amplifier OUTPUT ZERO until the voltage indicated by the differential voltmeter is zero.

NOTE

Due to the resolution of the zero control, it will only be possible to zero the amplifier to within +5 mv.

5) Adjust the voltage dials on the voltmeter until the voltmeter indicates a null.

6) Set the power supply to +2.5 volts and rotate R1 until the voltage at point A is also +2.5 volts.

7) Adjust R2 until the voltage between A and B, as indicated on the differential voltmeter, returns to the null point established in step (5).

8) Rotate R1 until the voltage at point A is again zero volts. If the reading differs from that established in step (5), repeat steps (5), (6), and (7), until the differential voltmeter indicates a null at each step when applying zero or +2.5 volts.

9) Vary the voltage at point A from +2.5 volts to zero, then to -2.5 volts. Note the maximum change on the differential voltmeter.

10) Using the voltage figures obtained in step (8), calculate the linearity (in % of full scale) output using the following equation:

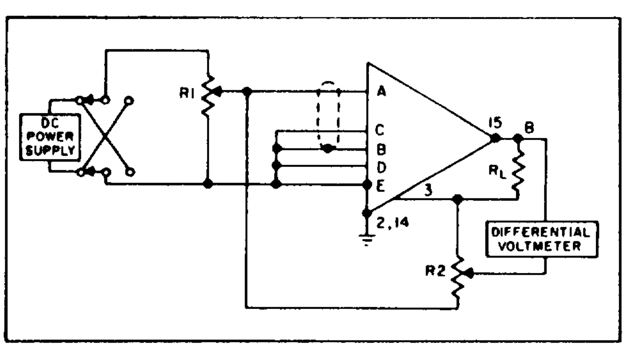


Figure 6-4. D-C Gain Linearity Test Circuit (G<1)

Linearity (%) =

$$\frac{\text{Max. Voltage Diff. (between A \& B)} \times 100}{\text{Full scale output voltage (2.5 volts)}}$$

A voltage difference between A and B of 2.5 mv or less gives .1% linearity or better.

b. The following procedure is applicable to amplifiers with gain multipliers, at gain settings less than 1.0.

1) Connect the amplifier as shown in Figure 6-4. R1 and R2 are the same as before.

2) See Initial Preparations (paragraph 6-6.B).

3) Set R1 so that no voltage is applied to the amplifier.

4) Adjust the amplifier OUTPUT ZERO until the voltage indicated by the differential voltmeter is zero ±5 mv.

5) Adjust the voltage dials on the differential voltmeter until the voltmeter indicates a null.

6) Adjust the power supply to +6.25 volts (if .04 GAIN MULTIPLIER is installed) or +25 volts (if .01 GAIN MULTIPLIER is installed), and rotate R1 until the voltage at the amplifier input is +6.25 or +25 volts.

7) Adjust R2 until the voltage between A and B, as indicated on the differential voltmeter, returns to the null point established in step (5).

8) Rotate R1 until the voltage at the amplifier input is again zero volts. If the reading differs from that established in step (5), repeat steps (5), (6), and (7) until the voltmeter indicates a null at each step when applying zero or full scale input voltage (+6.25 volts or +25 volts).

9) Vary the input voltage from plus full scale to zero, then to minus full scale input voltage, and note the maximum change on the differential voltmeter.

10) Determine the linearity as in step (10) of the previous procedure.

3. Common-Mode Rejection

a. The following procedure is applicable to amplifiers with or without optional gain multipliers.

1) Connect the amplifier as shown in Figure 6-5. Use an H-P 200CD oscillator or equivalent for the common-mode generator when testing the standard amplifier; use a step-up transformer between the oscillator and amplifier to provide up to 250 volts peak when testing amplifiers with gain multipliers. Use an oscilloscope capable of measuring 10 millivolts. R1 and R2 are 0-1000 ohm resistors. RCM is a 0-100K ohm resistor.

2) See Initial Preparations (paragraph 6-6. B).

3) Set the oscillator output to a voltage within the common-mode voltage specifications (0-20 volts P-P for standard amplifier; 0-500 volts P-P with optional gain multipliers).

4) Measure the peak-to-peak value of common-mode voltage at the amplifiers output $(E_o)_{cm}$.

5) Calculate common-mode rejection (in db) using the following equation:

$$CMR\ (db) = 20 \log \left[\left(\frac{E_{in}}{E_o}\right)_{cm} \times G\right]$$

Where: $\left(\frac{E_{in}}{E_o}\right)_{cm}$ =

$$\frac{\text{CM voltage input (P-P)}}{\text{CM voltage output (P-P)}}$$

G = Amplifier gain setting

6) To measure d-c common-mode rejection, replace the oscillator and transformer with a d-c power supply. Measure the common-mode voltage at the output with a differential voltmeter.

a) Connect the d-c power supply and differential voltmeter to the amplifier.

b) With d-c power supply OFF, connect a jumper across the output of the power supply to assure that no voltage is present. Measure the d-c voltage at the output of the amplifier. If more than 100 millivolts is present, adjust the OUTPUT ZERO control.

c) Remove jumper from power supply, and apply and adjust the power supply to the desired level of common-mode voltage. Note the change in amplifier d-c output voltage from the value noted in step (b).

d) Calculate CMR using equation in step (5). Note that the "common-mode voltage output" is only the change in amplifier output observed upon application of the d-c common-mode voltage.

4. Noise

a. The following procedure is applicable to the standard amplifier.

1) Connect the amplifier as shown in Figure 6-6. R1, R2, and R3 are wirewound or metal film resistors. R1 and R2 are 0-1000 ohms, and R3 is 0-100K

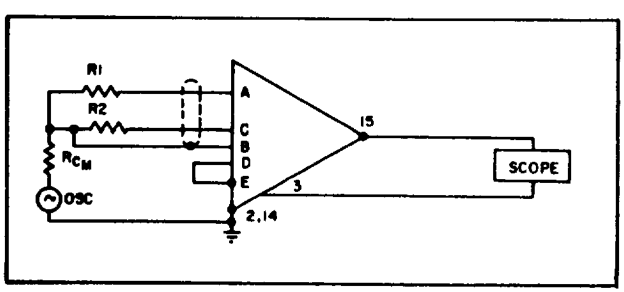


Figure 6-5. Common-Mode Rejection Test Circuit

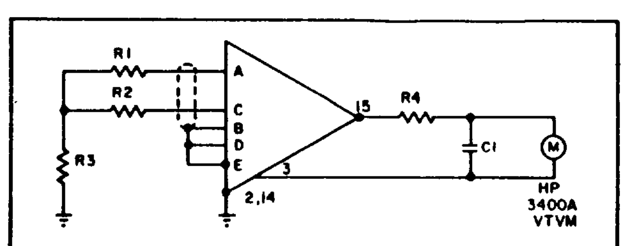


Figure 6-6. Noise Test Circuit

ohms. R4 and C1 are a 10 kc filter; R1 is 1500 ohms, and C1 is .01 ufd.

2) See Initial Preparations (paragraph 6-6.B).

3) Measure the rms output noise with the H-P 3400A True RMS Voltmeter.

4) Remove the 10 kc filter (R4 and C1) and repeat step (3) over the whole amplifier bandwidth.

Note

Be sure that R1, R2, and R3 are well shielded from stray fields.

b. The following procedure is applicable to amplifiers with optional gain multipliers.

1) Connect the amplifier as shown in Figure 6-7. R1 is a 0-10K ohm wirewound or metal film resistor. R2 is the same as R4 in Figure 6-6.

2) Repeat steps (2), (3), and (4) of the previous procedure.

5. Output Impedance

a. The following procedure is applicable to amplifiers with or without gain multipliers.

1) Connect the amplifier as shown in Figure 6-8. Select R1 to provide the amplifier output, specified below. No attenuator is required when testing the amplifiers with gain multipliers at low gain settings. R_L is a 20 ohm resistor.

2) See Initial Preparations (paragraph 6-6.B).

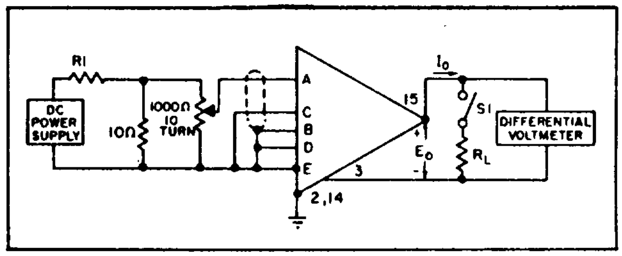


Figure 6-8. Output Impedance Test Circuit

3) Connect a d-c differential voltmeter to the output, and a d-c power supply to the input, as shown.

4) With no load on the amplifier (S1 open) adjust the d-c power supply until the amplifier output voltage is 1.3 volts d-c.

5) Close S1, placing R_L across the amplifier output, and observe the change in amplifier output voltage on the differential voltmeter.

6) Calculate output resistance, R_O, using the following equation:

$$R_O = \frac{\Delta E_O}{\Delta I_O} = \frac{(\text{Change in } E_O) x R_L}{E_O\ (\text{loaded})}$$

7) To measure output impedance at frequencies up to 10 kc, replace the d-c power supply with a H-P 200 CD oscillator, and the differential voltmeter with a H-P 400H VTVM.

8) Repeat steps (2) and (4), except adjust the output to 92 millivolts rms (1.3 volts peak).

9) Repeat step (5).

10) Calculate output impedance, Z_O, using the following equation:

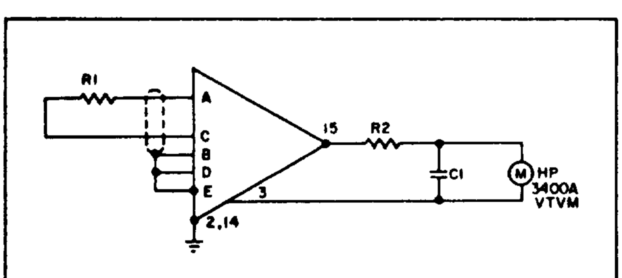


Figure 6-7. Noise Test Circuit (With Multipliers)

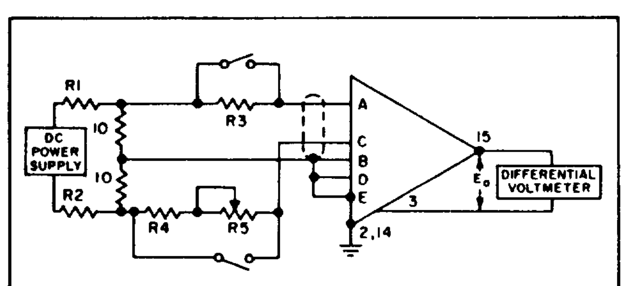


Figure 6-9. Input Resistance Test Circuit

$$Z_o = \frac{\Delta E_o}{\Delta I_o} = \frac{(\text{Change in } E_o) \times R_L}{E_o \text{ (loaded)}}$$

6. Input Impedance at DC

a. The following procedure is applicable to the standard amplifier.

1) Connect the amplifier as shown in Figure 6-9. Select R1 and R2 to provide the necessary attenuation for the selected amplifier gain (R1 and R2 are the same value). R3 and R4 are 50,000 ohm ±1% wirewound resistors. R5 is a 10,000 ohm wirewound trimpot. It may be necessary to place R5 in series with R3 instead of R4 (as shown) depending on the characteristics of the amplifier under test. The output meter is a d-c differential voltmeter.

2) See Initial Preparations (paragraph 6-6. B).

3) With the switches closed and the power supply off, adjust the amplifier OUTPUT ZERO control until the output voltage is zero ±2 mv dc.

4) Open the switches and adjust R5 until the amplifier output is again zero ±2 mv dc.

5) Close the switches and adjust the d-c power supply voltage until the amplifier output voltage is 2.5 volts.

6) Open the switches and, after the initial transient has passed, note the change in output voltage.

7) Calculate the input resistance (R_{in}) from the following equation:

$$R_{in} = \frac{E_o\,(R3 + R4 + R5)}{\Delta E_o} = \frac{2.5\,(10^5 + R5)}{\Delta E_o}$$

b. The following procedure is applicable to amplifiers with optional gain multipliers.

1) Connect the amplifier as shown in Figure 6-10. Select R1 and R2 to provide the necessary attenuation (R1 and R2 are the same value). If attenuation is not required, jumper R1 and R2 and remove the 10 ohms resistor. R3 and R4 are 10,000 ohm, ±1% resistors. R5 is a 1000 ohm wirewound trimpot. It may be necessary to place R4 in series with R3 instead of R4 (as shown), depending on the characteristics of the amplifier under test.

2) Repeat steps (2), (3), (4), (5), and (6) of the previous procedure.

3) Calculate the input resistance (R_{in}) from the following equation:

$$R_{in} = \frac{E_o\,(R3 + R4 + R5)}{\Delta E_o} = \frac{2.5\,(2 \times 10^4 + R5)}{\Delta E_o}$$

7. Gain Accuracy

a. The following procedure is applicable to the standard amplifier at any gain setting or amplifiers with gain multipliers at gain settings greater than 1.0.

1) Connect the amplifier as shown in Figure 6-11. Use R2 = 10 ohms ±.01% with the standard

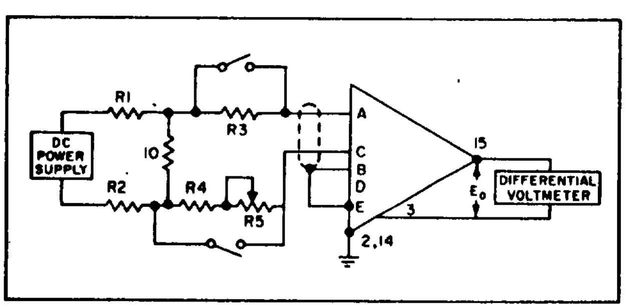


Figure 6-10. Input Resistance Test Circuit (With Gain Multipliers)

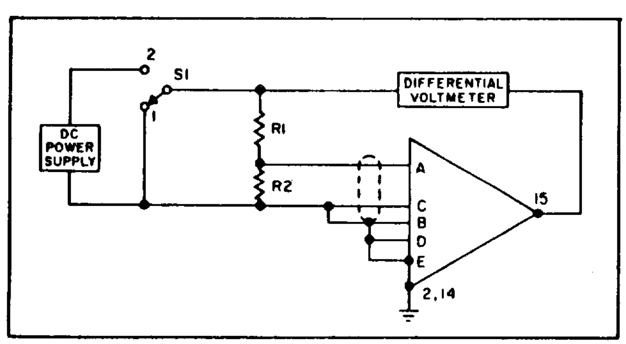


Figure 6-11. Gain Accuracy Test Circuit (G > 1)

amplifier, and R2 = 1000 ohms ±.01% with gain multiplier versions. The value of R1 is given by:

R1 = R2(G-1), ±.01%, where G is the gain of the amplifier. R1 and R2 attenuate by a factor equal to the reciprocal of the theoretical amplifier gain.

2) See Initial Preparations (paragraph 6-6.B).

3) Rotate the vernier gain control to the fully CCW position.

4) With switch S1 in the 1 position, zero the amplifier output with the OUTPUT ZERO control. If the output cannot be exactly zeroed, due to the resolution of the control, record the residual voltage.

5) Switch S1 to position 2, and adjust the power supply voltage to approximately 2.5 volts with a d-c voltmeter (not shown).

6) Note the change in reading of the differential voltmeter. A change of less than ±12.5 millivolts indicates an amplifier gain accuracy of ±.5% or better.

b. The following procedure is applicable to amplifiers with gain multipliers, at gain settings less than 1.0.

1) Connect the amplifier as shown in Figure 6-12. Use R2 = 1000 ohms ±.01%. R1 is given by:

$$R1 = \frac{R2\ (1 - A)}{A}$$

Where A is the amplifier attenuation setting.

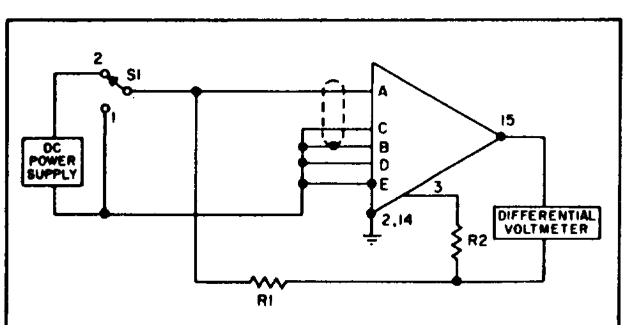


Figure 6-12. Gain Accuracy Test Circuit (G < 1)

2) Repeat steps (2), (3), (4), (5), and (6) of the previous procedure, with the following exceptions: In step (5), the power supply voltage is set to a value which provides a 2.5 volt amplifier output. In step (6), a change of less than ±25 millivolts indicates an amplifier gain (or attenuation) accuracy of ±1% or better.

6-7. CALIBRATION PROCEDURE

A. Perform calibration of the Accudata 104 during periodic maintenance or subsequent to any corrective maintenance. Adjustments are located on the printed circuit card.

1. D-C Output Shift - Zero Source Resistance

a. Connect the amplifier as shown in Figure 6-6 (Noise Test Circuit) with R1, R2, and R3 = 0.

b. Set the GAIN RANGE switch to the 250 position, and the GAIN switch to 250.

c. Switch the GAIN RANGE switch between 50 and 250 and adjust trimpot R5 until the shift in d-c output of the amplifier is minimized.

d. Adjust the OUTPUT ZERO control until the output is zero ±10 millivolts.

e. Repeat steps c and d until the shift in output level is less than ±10 millivolts around zero volts dc.

2. Common-Mode Rejection - Balanced Source

a. Accudata 104-1 or 104-4.

1) Connect the amplifier as shown in Figure 6-5. Set R1, R2, and R_{cm} = 0.

2) Set the GAIN switch to 250.

3) Adjust the test oscillator to 20 volts peak-to-peak at 60 cps.

4) Adjust trimpot R9 until the common-mode voltage appearing at the amplifier output is minimized.

5) Switch the GAIN RANGE switch to the 50 position.

6) Repeat step (4) with trimpot R10.

b. Accudata 104-2, -3, -5, -6 (optional gain multipliers installed).

1) Connect the amplifier as shown in Figure 6-5, Set R1, R2, and $R_{cm} = 0$.

2) Set the GAIN RANGE switch to 250 and the GAIN switch to 250.

3) Adjust the test oscillator to 30 volts peak-to-peak at 60 cps.

4) Adjust potentiometer 1R4 or 2R4 until the common-mode voltage appearing at the amplifier output is minimized.

5) Adjust trimpot R9 to obtain a small additional reduction in the common-mode output.

6) Switch the GAIN RANGE switch to the 50 position.

7) Repeat step (5) with R10.

SECTION VII — PARTS LIST

7-1. GENERAL

This section lists all unit electrical parts by assembly sequence, in alpha-numeric order. Parts of a particular assembly are indented and listed directly below the assembly listing. The following explains the column headings used in the parts list.

A. SCHEMATIC REFERENCE. This column lists the schematic reference designations of electrical components in alpha-numeric order. Refer to paragraph 7-2 for a listing of reference designators.

B. DESCRIPTION. This column lists the component name and specifications as required for proper identification.

C. MANUFACTURER AND PART NUMBER. This column lists the suggested manufacturer and the manufacturer's part number for components not manufactured by Honeywell. In some cases, more than one manufacturer can supply the part, but only one is listed. Direct questions, concerning alternate suppliers, to Honeywell-Denver Division. Refer to paragraph 7-4 for coded manufacturers' complete names and addresses.

D. HONEYWELL PART NUMBER. This column lists the number by which an item or assembly may be ordered directly from Honeywell-Denver Division.

E. QUANTITY PER UNIT. This column reflects the total quantity of each item used in that assembly.

F. INSTRUMENT MODEL NUMBER. This column identifies usage of components with various instrument model configurations.

7-2. REFERENCE DESIGNATORS

The following lists the abbreviations used with schematic reference designators:

A - amplifier or assembly
B - motor
C - capacitor
CR - diode
DS - device signaling (lamp)
E - misc electronic part
F - fuse
FL - filter
J - jack
K - relay
L - inductor
M - meter
MP - mechanical part
P - plug
Q - transistor
R - resistor
RT - thermistor
S - switch
T - transformer
TP - test point
V - vacuum tube, neon bulb, photocell, etc.

7-3. ABBREVIATIONS

The following abbreviations are used in the "Description" column of the parts list:

A = amperes
AFC = automatic frequency control
AMP = amplifier
BFO = beat frequency oscillator
BP = bandpass
CER = ceramic
CMO = cabinet mount only
COEF = coefficient
COM = common
COMP = composition
CONN = connector
CRT = cathode-ray tube
DEPC = deposited carbon
DIE = dielectric
ELECT = electrolytic
ENCAP = encapsulated
F = farads
FXD = fixed
GE = germanium
GL = glass
GND = ground(ed)
H = henries
HR = hour(s)
IMPG = impregnated
INCD = incandescent
INS = insulation(ed)
K = kilo = 1000
LIN = linear taper
LOG = logarithmic taper
LPF = low pass filter
MEG = meg = 10^6
M = milli = 10^{-3}
MINAT = miniature
METFLM = metal film
MFR = manufacturer
MOM = momentary
MTG = mounting
MY = mylar
NC = normally closed
NE = neon
NO = normally open
NPO = negative positive zero (zero temperature coefficient)
P = peak
PC = printed circuit board
PF = picofarads = 10^{-12} farads
P-P = peak-to-peak
PIV = peak inverse voltage
POR = porcelain
POS = position(s)
POLY = polystyrene
POT = potentiometer
RECT = rectifier
RF = radio frequency
RMS = root-mean-square
RMO = rack mount only
S-B = slow-blow
SE = selenium
SEMICON = semiconductor
SI = silicon
SIL = silver
SP = special
TA = tantalum
TD = time delay
TI = titanium
TOG = toggle
TOL = tolerance
TRIM = trimmer
U = micro = 10^{-6}
V = volts
VAC = vacuum
VAR = variable
W/ = with
W = watts
WW = wirewound
W/O = without

7-4. MANUFACTURERS

Abbreviated manufacturers' names used in the parts list are listed below with complete names and addresses.

Amp	Amphenol Electronics Corporation 1858 South 54 Street Chicago 50, Illinois
Arco	Arco Electronics, Inc. New York 13 New York
Borg	Borg Equipment Janesville Wisconsin
C-D	Cornell-Dubilier Electrical Corp. 50 Paris Street Newark 1, New Jersey
Cinch	Cinch Manufacturing Corp. 1026 South Homan Avenue Chicago 24, Illinois
Claro	Clarostat Manufacturing Co., Inc. Dover New Hampshire
FC	Fairchild Semiconductor Box 670 Mt. View, California
GE Semi	General Electric Semiconductor Prod. Electronics Park Syracuse, New York
GI	General Instrument 65 Gouverneur Street Newark, New Jersey
IRC	International Resistance Co. Burlington Iowa
M-E	Miniature Electronics Components Corporation Holbrook, Massachusetts
Mot	Motorola Semiconductor Prod. Div. P.O. Box 2929 Phoenix 2, Arizona
Ohm	Ohmite Manufacturing Company 3604 Howard Street Skokie, Illinois
Omt	Omtronics Mfg., Inc. 2406 Leavenworth St. Omaha, Nebraska
P-C	Power Components, Inc. P.O. Box 421 Scottsdale, Pennsylvania
RCA Semi	RCA Semiconductor and Materials Sommerville New Jersey
Sprague	Sprague Electric Company 149 Marshall Street N. Adams, Massachusetts
TE	Transformer Electronics Boulder Industrial Park Boulder, Colorado
TI	Texas Instruments, Inc. 13500 N. Central Expressway Dallas, Texas
XYTAN	XYTAN 1755 Placentia Costa Mesa, California

7-5. PARTS LIST

See the following pages. Refer to Figures 7-1, 7-2, and 7-3 for parts location.

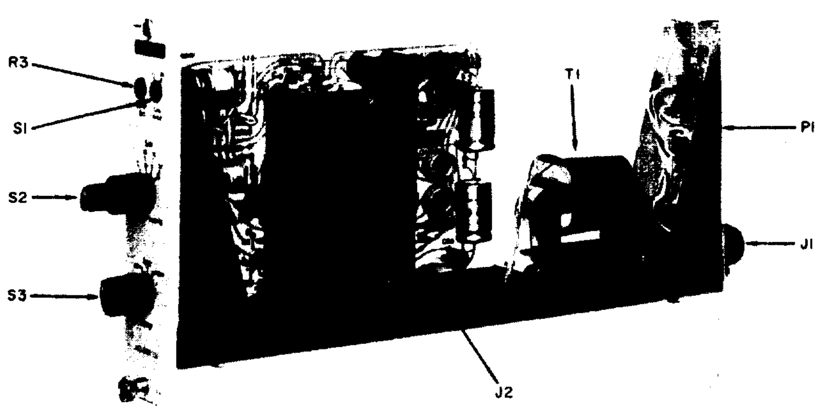


Figure 7-1. Chassis Parts Location

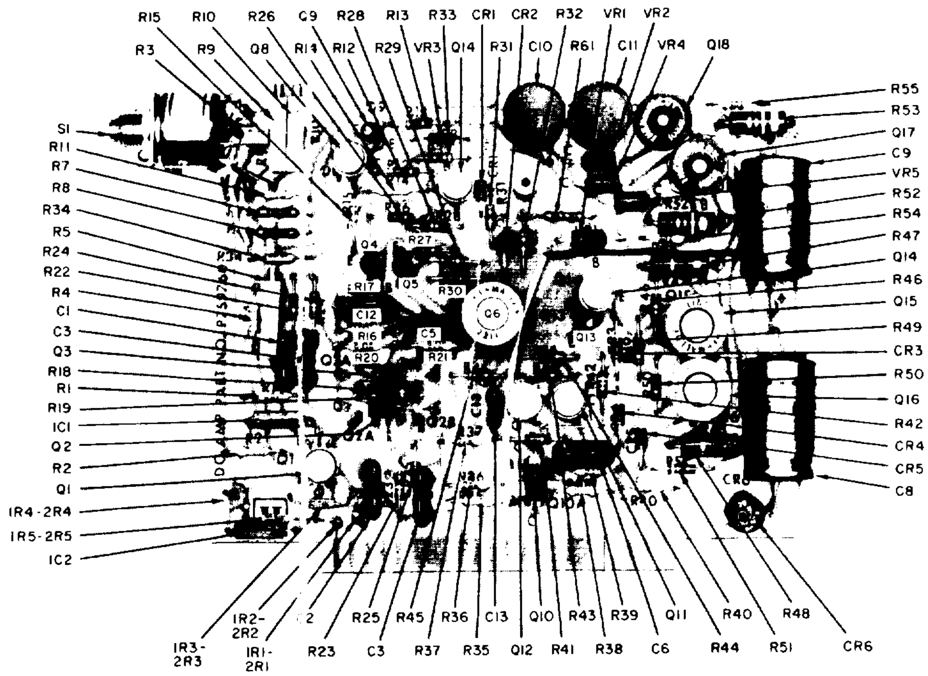


Figure 7-2. Circuit Card, Parts Location

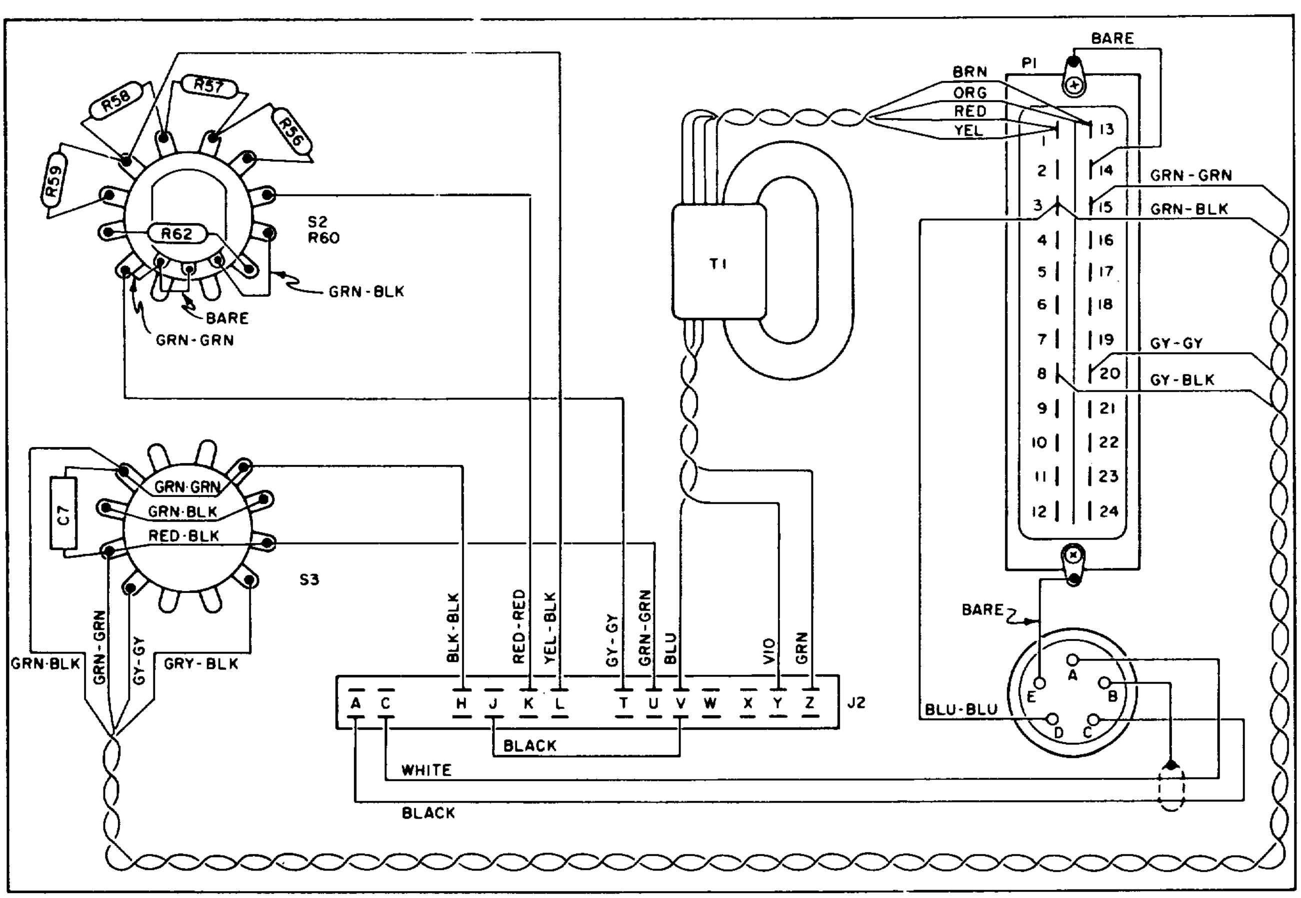
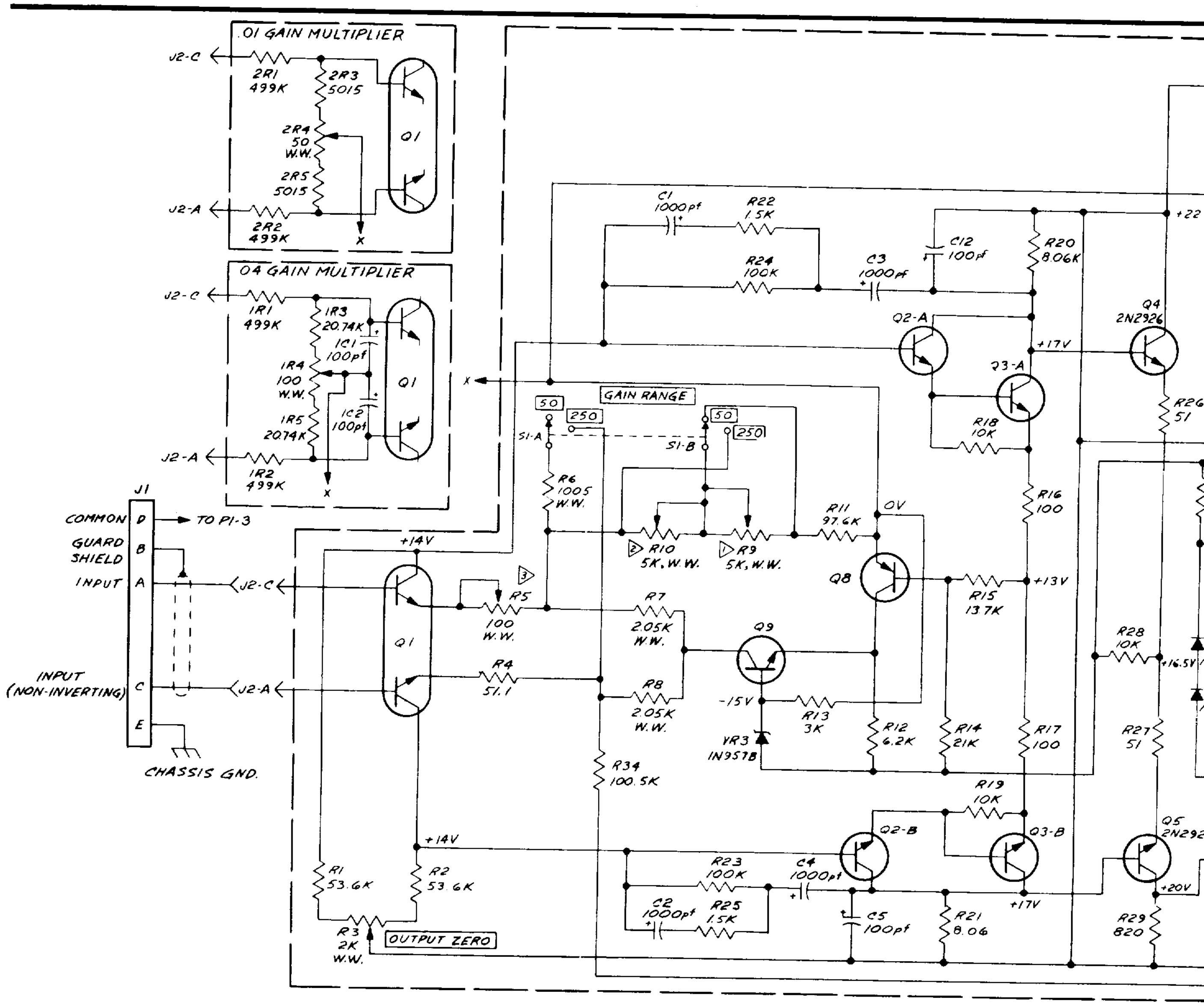


Figure 7-3. Accudata 104 Wiring Diagram

SCHEM. REF.	DESCRIPTION	INSTR. MODEL NO.	MFG. & PART NO.	HONEYWELL PART NO.	QTY/ UNIT
	AMPLIFIER ASSY - ACCUDATA 104 D-C				
	Final assy, 115V AC	104-1		790779-001	Ref.
	Final assy, 115V AC, .04 gain multiplier	104-2		790779-002	Ref.
	Final assy, 115V AC, .01 gain multiplier	104-3		790779-003	Ref.
	Final assy, 230V AC	104-4		790779-004	Ref.
	Final assy, 230V AC, .04 gain multiplier	104-5		790779-005	Ref.
	Final assy, 230V AC, .01 gain multiplier	104-6		790779-006	Ref.
	Chassis Assembly	All		759661-001	1
	Circuit Card Assembly	104-1		759760-001	1
	Circuit Card Assembly	104-2		759760-002	1
	Circuit Card Assembly	104-3		759760-003	1
	Circuit Card Assembly	104-4		759760-001	1
	Circuit Card Assembly	104-5		759760-002	1
	Circuit Card Assembly	104-6		759760-003	1
C1 thru C4	C, Fxd, Mica, 1000pf, 500V	All	C-D, Type CD19	759782-262	4
C5	C, Fxd, Mica, 100pf, 500V	All	C-D, Type CD19	759782-201	2
C6	C, Fxd, My, 0.0015uf, 600V 10%	All	C-D, DPMS-6D15	756580-008	1
C8, C9	C, 250uf, 64V	All		758518-364	2
C10, C11	C, Fxd, Elect Alum, 100uf, 25V	All	Sprague, 89D226	750030-013	2
C12	Same as C5				
C13	C, Fxd, Mica, 56pf, 500V	All	C-D, Type CD15	759781-251	1
CR1 thru CR5	R, Semicon, Diode	All	Mot, 1N4002	756961-002	5
CR6	R, Semicon, Diode	All	GI, WO-2	759755-002	1
Q1	Transistor Assembly	All	FC, SP9892	759695-001	1
Q2, Q3	Transistor, Assembly	All		756917-001	2
Q4, Q5	Transistor, Sl, NPN	All	GE Semi, 2N2926	758481-003	3
Q6, Q7, Q8	Transistor, Sl, PNP	All	XYTAN, 3083	757723-001	6
Q9	Transistor, Sl, PNP	All	GE Semi, 2N2926	758481-005	1
Q10	Transistor, Assembly	All		756917-002	1
Q11, Q12	Same as Q6				
Q13	Same as Q4				
Q14, Q15	Transistor, Sl, NPN	All	FC	307537	2
Q16	Same as Q6				
Q17	Transistor, Sl, NPN	All	RCA Semi, 2N2270	759874-001	1
Q18	Transistor, Ge, PNP	All	TI, 2N2552	757825-001	1
R1, R2	R, Fxd, Metflm, 53.6K ±1%, 1/8W	All	IRC	757165-371	2
R3	R, Var WW, 2K ±10%, 1W	All	Borg, Series 2600	757711-004	1
R4	R, Fxd, Metflm, 51.1 ohms ±1%, 1/8W	All	IRC	757165-069	1
R5	R, Var, WW, 100 ohms ±10%, 1W	All	Borg, Series 2600	757711-003	1
R6	R, Fxd, WW, 1005 ohms ±0.1% 1W	All	Omt, Type T1A	759694-005	1
R7, R8	R, Fxd, WW, 2.05K ±0.1%, 1W	All	Omt, Type T1A	759694-006	2
R9, R10	R, Var, WW, 5K ±10%, 1W	All	Borg, Series 2600	757711-002	2
R11	R, Fxd, Metflm, 97.6K &1%, 1/8W	All	IRC	757165-396	1
R12	R, Fxd, Carbon, 6.2K Δ5%, 1/4W	All	Ohm, LIDED-12K	750079-052	1
R13	R, Fxd, Carbon, 3K ±5%, 1/4W	All	Ohm, LIDED-3K	750079-044	1
R14	R, Fxd, Metflm, 21K ±1%, 1/8W	All	IRC	757165-332	1
R15	R, Fxd, Metflm, 13.7K ±1%, 1/8W	All	IRC	757165-314	1
R16, R17	R, Fxd, Metflm, 100ohms ±1%, 1/8W	All	IRC	757165-101	2
R18, R19	R, Fxd, Carbon, 10K ±5%, 1/4W	All	Ohm, LIDED-10K	750079-057	3
R20, R21	R, Fxd, Metflm, 8.06K ±1%, 1/8W	All	IRC	757165-288	2
R22	R, Fxd, Carbon, 1.5K ±5%, 1/4W	All	Ohm, LIDED-1.5K	750079-037	2
R23, R24	R, Fxd, Carbon, 100K, ±5%, 1/4W	All	Ohm, LIDED-100K	750079-081	2
R25	Same as R22				
R26, R27	R, Fxd, Carbon, 51 ohms ±5%, 1/4W	All	Ohm, LIDED-51	750079-002	3
R28	Same as R18				
R29	R, Fxd, Carbon, 820 ohms ±5%, 1/4W	All	Ohm, LIDED-820	750079-031	1
R30	Same as R26				
R31, R32	R, Fxd, Carbon, 33 ohms ±5%, 1/4W	All	Ohm, LIDED-33	750079-144	2
R33	R, Fxd, Carbon, 4.3K ±5%, 1/4W	All	Ohm, LIDED-4.3K	750079-048	2
R34	R, Fxd, Metflm, 100.5K ±0.1%, 1/8W	All	IRC	759698-970	1
R35	R, Fxd, Metflm, 953 ohms ±1%, 1/8W	All	IRC	757165-195	1
R36, R37	R, Fxd, Metflm, 28K ±1%, 1/8W	All	IRC	757165-344	2
R38, R39	R, Fxd, Metflm, 249 ohms ±1%, 1/8W	All	IRC	757165-139	2
R40	R, Fxd, Metflm, 20K ±1%, 1/8W	All	IRC	757165-330	1
R41	R, Fxd, Carbon, 510 ohms ±5%, 1/4W	All	Ohm, LIDED-510	750079-026	1

SCHEM. REF.	DESCRIPTION	INSTR. MODEL NO.	MFG. & PART NO.	HONEYWELL PART NO.	QTY/ UNIT
R42	R, Fxd, carbon, 24K ±5%, 1/4W	All	Ohm, LIDED-24K	750079-066	1
R43, R44	R, Fxd, Carbon, 2K ±5%, 1/4W	All	Ohm, LIDED-2K	750079-040	2
R45	R, Fxd, Carbon, 5.1K ±5%, 1/4W	All	Ohm, LIDED-5.1K	750079-050	1
R46	R, Fxd, Carbon, 27K ±5%, 1/4W	All	Ohm, LIDED-27K	750079-067	1
R47, R48	R, Fxd, WW, 200 ohms, ±5%, 2W	All	IRC	756611-003	2
R49, R50	R, Fxd, Carbon, 20 ohms ±5%, 1/4W	All	Ohm, LIDED-20	750079-142	2
R51	Same as R33				
R52, R53	R, Fxd, WW, 390 ohms ±5%, 2W	All	IRC	756611-004	2
R54, R55	R, Fxd, Metflm, 301 ohms ±1%, 1/8W	All	IRC	757165-147	2
R61	R, WW, 947.5 ohms ±0.1%, 1W	All	Omt, Type T1A	759694-003	1
S1	Switch, Rotary, 2P2P	All	Claro, CM32861	759696-001	1
VR1, VR2	Semicon Device, Diode, Zener, 22V ±1%	All	P-C, TZ22C	759870-016	2
VR3	Semicon Device, Diode, Zener, 6.8V ±5%	All	Mot, IN957B	756688-107	1
VR4, VR5	Semicon Device, Diode, Zener, 24V ±1%	All	P-C, TZ24C	759870-017	2
	.04 GAIN MULTIPLIER	104-2 & 104-5			
1C1, 1C2	C, Fxd, Sil Mica, 100 pf, 500V	104-2 & 104-5	Arco, CM-15-E-101-J	750001-027	2
1R1, 1R2	R, Fxd, Metflm, 499K ±0.1% 1/8W	104-2 & 104-5	IRC	759708-468	2
1R3, 1R5	R, Fxd, Metflm, 20.74K, ±0.1%, 1/8W	104-2 & 104-5	IRC	759698-971	2
1R4	R, Var, WW, 100 ohms ±10%, 1/4W	104-2 & 104-5	M-E, PC-2	755293-002	1
	.01 GAIN MULTIPLIER	104-3 & 104-6			
2R1, 2R2	R, Fxd, Metflm, 499K ±0.1%, 1/8W	104-3 & 104-6	IRC	749698-478	2
2R3, 2R5	R, Fxd, Metflm, 5015 ohms	104-3 & 104-6	IRC	759698-972	2
2R4	R, Var, WW, 50 ohms ±10%, 1/4W	104-3 & 104-6	M-E, PC-3	455293-003	1
J1	Connector	All	Amp, AN3102A-145-5S	100058	1
	Cable and Component Assembly 115V	104-1 104-2 104-3		759820-001	1
	Cable and Component Assembly, 230V	104-4 104-5 104-6		759820-002	1
	Switch Assembly, Output	All		759818-001	1
C7	C, Fxd, My, 200V, 0.01 uf	All		750035-002	1
S3	Switch, Rotary, 2P3P	All	CTS, 54035	759697-001	1
	Switch Assembly, Gain	All		749819-001	1
R56	R, Fxd, WW, 2375.5 ohms ±0.1%, 1W	All	Omt, Type T1A	759694-007	1
R57	R, Fxd, WW, 792 ohms ±0.1% 1W	All	Omt, Type T1A	759694-002	1
R58	R, Fxd, WW, 633 ohms ±0.1% 1W	All	Omt, Type T1A	759694-001	1
R59	R, Fxd, WW, 953 ohms ±0.1% 1W	All	Omt, Type T1A	759694-004	1
R62	R, Fxd, Metflm, 1960 ohms ±1%, 1/8W	All	IRC	757165-229	1
S2	Switch, Var, Resistor, 2P4P, 1000 ohm	All	CTS, 54036	759692-001	1
J2	Connector, Card	All		200578	1
P1	Connector, Plug, 24 pin	All	Cinch, 36-4100-24P (345)	100790	1
R60	R, Var, WW, 1K ±10%	All			1
T1	Transformer, Power	All	TE, 1447000	749765-001	1



NOTES: 1. ALL RESISTANCE VALUES ARE IN OHMS AND ALL CAPACITANCE VALUES ARE IN MICROFARADS UNLESS OTHERWISE SPECIFIED.

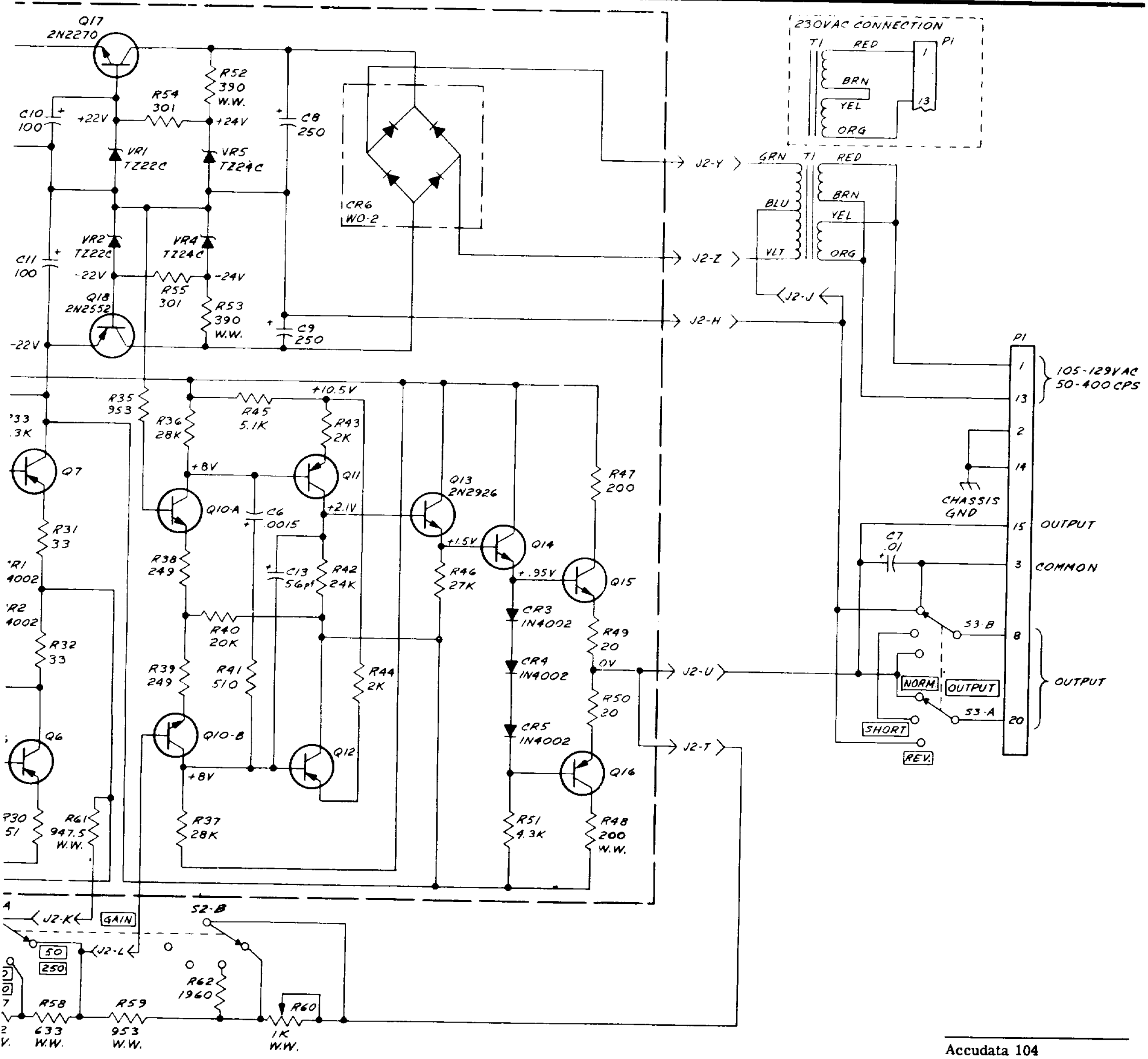
2. 1 COMMON-MODE ADJUSTMENT - 250 GAIN RANGE.

3. 2 COMMON-MODE ADJUSTMENT - 50 GAIN RANGE.

4. 3 OUTPUT OFFSET ZERO.

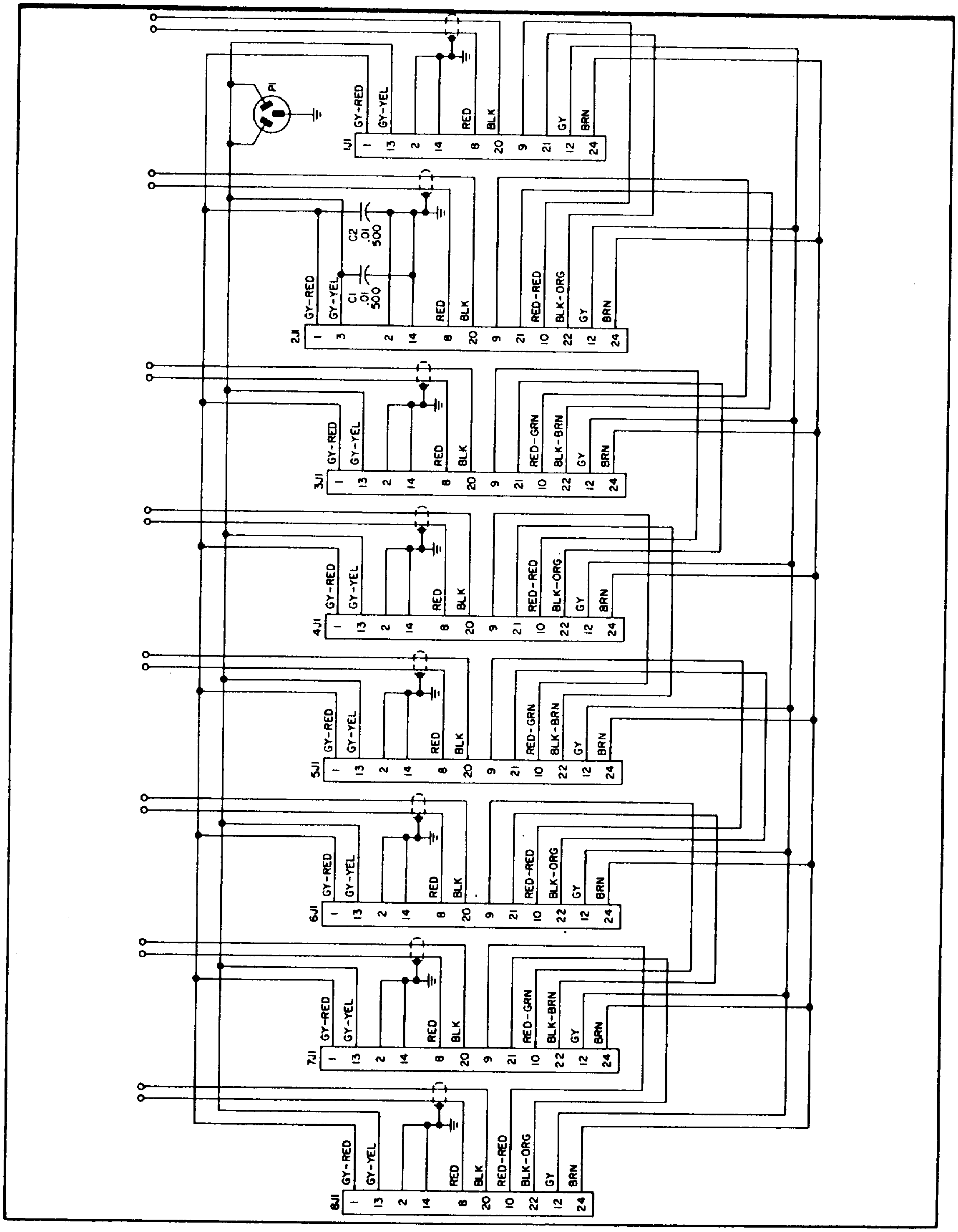
5. ▭ DENOTES PANEL NOMENCLATURE.

6. BIAS VOLTAGES SPECIFIED WITHIN ±5%.



Accudata 104
Schematic Diagram

2



Rack Adapter Schematic Diagram

Cubic Publication COM/OP AMP/1300-1

INSTRUCTION MANUAL

FOR

CUBIC MODEL 1300

DIFFERENTIAL DC AMPLIFIER

Serial No. ________

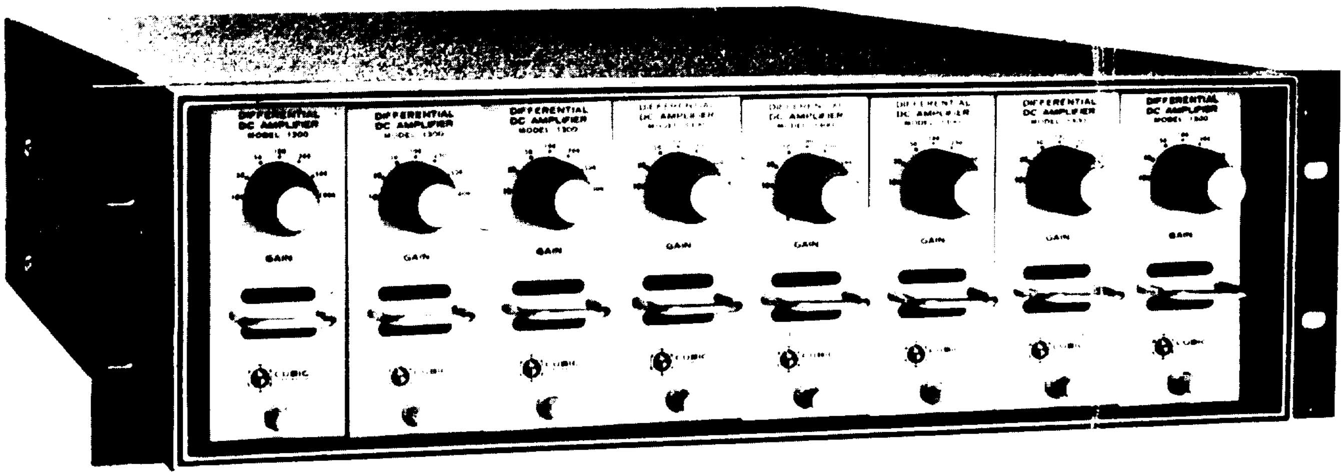
Manufactured by:

CUBIC CORPORATION
9233 Balboa Avenue
San Diego 23, California

NOTICE

It is Cubic Corporation policy to supply instruments and instrument systems tailored as closely as possible to the specific requirements of the individual customer, but without incurring the prohibitive costs of custom design. This is accomplished by substituting new components modifying standard components, etc., wherever necessary to provide conformance to individual requirements. Since this instruction manual has basically been written to cover the standard equipment, it may not concur in every respect with the equipment actually supplied. It is felt, however, that a technically qualified person will find the manual fully adequate for understanding, operating, and maintaining the equipment.

Effective 1 July 1965, Cubic Corporation no longer furnishes maintenance kits with instruments. Items furnished are an input cable and a power cable.



Frontispiece. Cubic Model 1300 Differential DC Amplifiers in Model 1390 Rack Mount Assembly

SPECIFICATIONS

DC Gain:	Fixed gains of 10, 20, 50, 100, 200, 500, and 1000. Vernier control provides adjustable gain upward 2-1/2 to 1 or more on all fixed gain settings.
DC Gain Accuracy at Fixed Steps:	±0.02 per cent at 25 ±5°C
DC Gain Stability at Fixed Steps:	±0.01 per cent at 25 ±5°C ±0.001 per cent per degree C
DC Gain Stability and Resolution With Vernier Control in Operation:	±0.2 per cent
Linearity:	±0.01 per cent of full scale from dc to 1 kc ±0.2 per cent of full scale from dc to 10 kc
Drift with Zero Source Impedance:	±0.02 per cent of full scale for 200 hours at a constant temperature and line voltage
DC Drift Line Voltage Coefficient:	±0.002 per cent of full scale per volt line change
Zero Stability with Worst Case Range Change and Zero Source Impedance:	±0.05 per cent of full scale (front panel zero control used to eliminate this offset)
Maximum DC Drift Temperature Coefficient with a Zero Source Impedance:	0.005 per cent of full scale per degree C
Maximum DC Input Current Offset:	±1 nanoampere at 25°C, plus 0.5 nanoampere per degree C
Maximum Differential DC Input Offset Current Temperature Coefficient:	0.1 nanoampere per degree C
Noise:	2 microvolts peak-to-peak (0 - 100 cps) 4 microvolts rms (0 - 50 kc)
Input Impedance:	Greater than 30 megohms at dc. (Shunt capacitance less than 200 pf.)
Maximum Source Impedance:	1K ohms to meet published specifications. Degradations in noise, CMR, and gain accuracy will occur with higher source impedance; however, amplifier is usable with up to 100K-ohms source impedance.

Frequency Response:	±1 per cent dc to 2 kc ±3 per cent dc to 10 kc ±1 db dc to 20 kc
Common Mode Rejection:	120 db at dc with 1K-ohm imbalance 120 db at dc to 60 cps with balanced source 110 db at dc to 60 cps with 1K-ohm imbalance
Maximum Operating Common Mode Voltage:	±10 volts dc or peak ac to 500 cps
Output Characteristics	
Resistive Load:	±10 volts at ±120 ma dc or peak ac to 20 kc
Capacitive Load:	±10 volts into 0.1 μf capacitor at frequencies to 20 kc
Parallel RC Load (typical):	±10 volts dc or peak ac to 20 kc into 100 ohms in parallel with 0.05 μf capacitor
Maximum Output Impedance:	20 milliohms at dc
Maximum Capacitive Load for Amplifier Stability:	Unlimited on any range
Short Circuit Protection:	Amplifier will be undamaged by short circuit of any duration
Linear Settling Time:	200 microseconds maximum to ±0.01 per cent of final value
Overload Recovery Time for 1000 Per Cent Overload of Any Duration:	5 milliseconds maximum to ±0.01 per cent of final value
Maximum Safe Normal Mode Input:	±10 volts dc or peak ac
Maximum Safe Common Mode Input:	±20 volts dc or peak ac
Operating Temperature Range:	Amplifier will meet all specifications over the range from 0 to 50°C
Storage Temperature Limits:	-20°C to +85°C
Warmup Time:	3 minutes for operation; 2 hours to meet drift with time
Power Requirements	
Single Unit:	104 to 127 volts ac, 48 to 420 cps, 10 watts maximum
Rack Mount Assembly:	104 to 127 volts ac, 55 to 65 cps, 10 watts maximum

NOTES:

(1) Noise and common mode rejection (CMR) are referred to the input at a gain of 1000. Noise will be somewhat greater and CMR will be somewhat lower at lower gain settings.

(2) For single-ended operation all specifications apply except CMR, and the bandwidth is limited to 10 kc for full scale output.

(3) All specifications apply when the instrument is used in Cubic Model 1390 Rack Mount Assembly. Inter-channel interference will be negligible in this rack mount.

(4) It is mandatory that amplifiers are mounted in a 1390 rack mount assembly to meet long term drift. Drift is ±0.05 per cent of full scale for single channel bench use.

(5) A single-pole filter that provides limited bandwidth for narrow band is available at extra cost. The 3-db break point of this filter can be selected between 10 cps and 10 kc.

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

SECTION I
INTRODUCTION AND GENERAL DESCRIPTION

1.1 Introduction. This instruction manual describes the Cubic Model 1300 Differential DC Amplifier, explains the theory of operation, and provides installation, operation, and maintenance instructions.

1.2 General Description. The Cubic Model 1300 Differential DC Amplifier is a precision instrumentation amplifier for use with low-impedance sensors such as thermocouples, strain gauges, potentiometric pickups, etc. This amplifier has adequate gain to match almost any transducer to any data acquisition system. In its design, state-of-the-art semiconductor devices and circuit concepts are employed which have resulted in an amplifier that provides low drift without the use of a mechanical chopper, extremely low noise, high common-mode rejection without extensive use of guard shields or shielded transformers, excellent linearity, and wide bandwidth.

1.2.1 The model 1300 amplifier will furnish an output up to ±10V dc (or 10V peak ac for frequencies up to 20 kc) at currents up to 120 ma for driving oscillographs, tape systems, long output cables, commutators, digital voltmeters, or other instrumentation systems. It effectively rejects common-mode dc voltages up to ±10V and common-mode ac voltages up to 10V peak, even when a large output impedance imbalance exists in the source.

1.2.2 Each model 1300 amplifier is packaged with its own isolated, regulated power supply in a case measuring 2 by 4.5 by 13.5 inches. (See figure 1.) The front panel contains a GAIN selector switch coaxially mounted with a vernier GAIN control. A zero-adjust potentiometer is accessible through a slot in the front panel, and a gain calibration potentiometer is accessible through a hole in the top of the case.

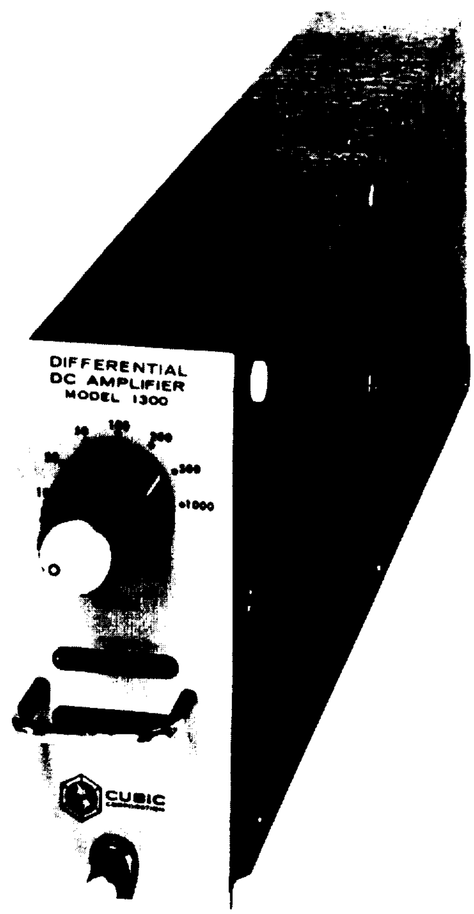


Figure 1. Cubic Model 1300 Differential DC Amplifier

1.2.3 A single model 1300 amplifier can be used in conjunction with a Single Unit Adapter, Cubic Part No. 87-1012-1 (figure 2). One or more can be used with a Cubic Model 1390 Rack Mount Assembly (figure 3) which provides a bench-mount or standard EIA rack-mount capability for accommodating up to eight amplifiers. In both cases the circuit board connectors for the amplifier extend beyond the rear of the amplifier case and plug into the mating receptacles on the front of the single-unit adapter or at the rear of the rack mount assembly. Signal input and output receptacles, the power cable, and a fuseholder are located on the rear panel of the single-unit adapter (B, figure 2). Similar arrangements are provided for the rack mount assembly (figures 3 and 4). The frontispiece illustrates a rack-mount assembly with eight amplifiers installed.

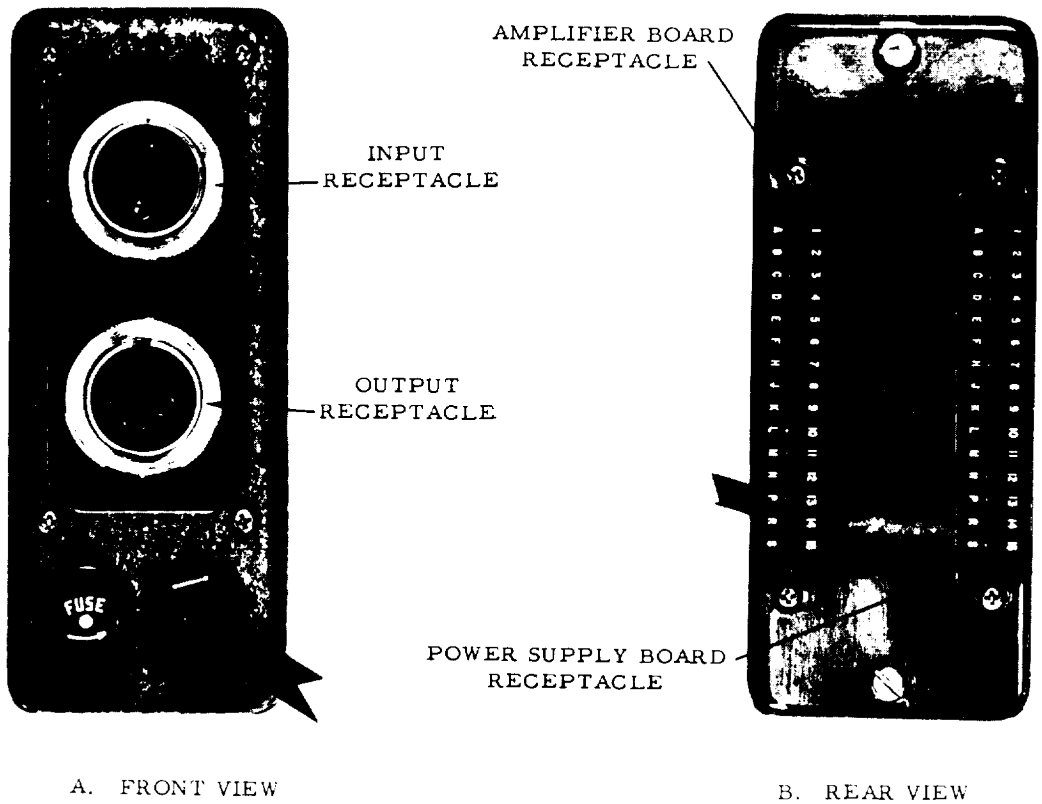


Figure 2. Single Unit Adapter

1.3 <u>Equipment Supplied</u>. When a model 1300 amplifier is purchased as a single unit, it is recommended that a Single Unit Adapter PN 87-1012-1 be purchased at the same time. When amplifiers are purchased in quantity it is recommended that an adequate number of 1390 rack mount assemblies be purchased also. One complete set of input and output receptacles with mating connectors is shipped with each single unit adapter. Eight complete sets of input and output receptacles with mating connectors are shipped with each rack mount assembly. Blank filler panels also are available for unused amplifier positions in the rack mount assembly.

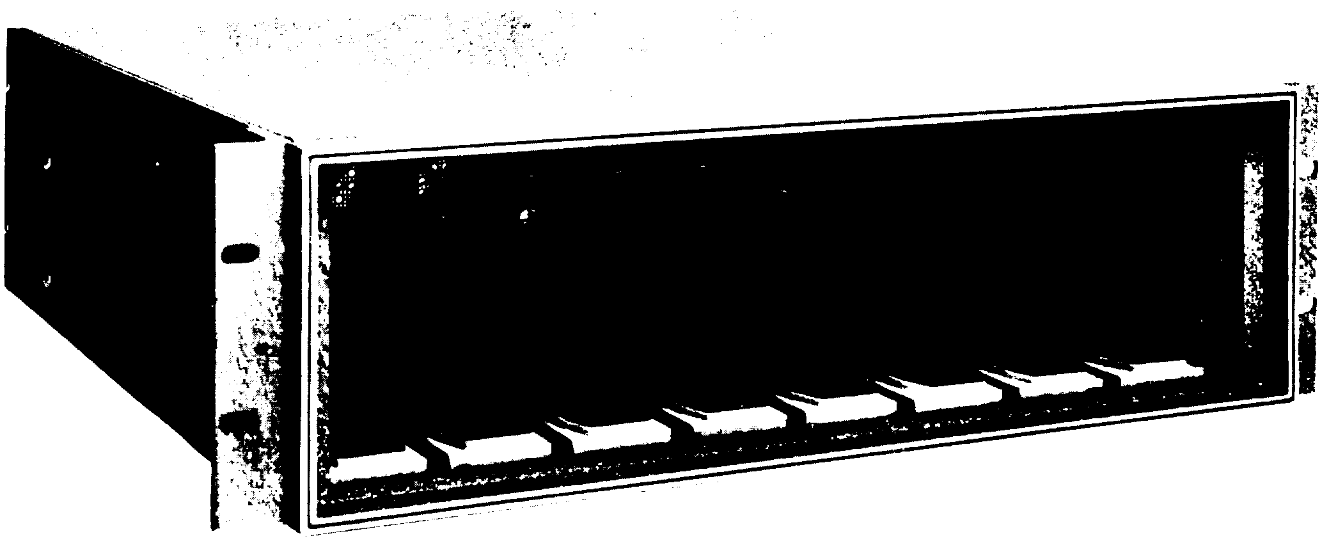


Figure 3. Cubic Model 1390 Rack Mount Assembly

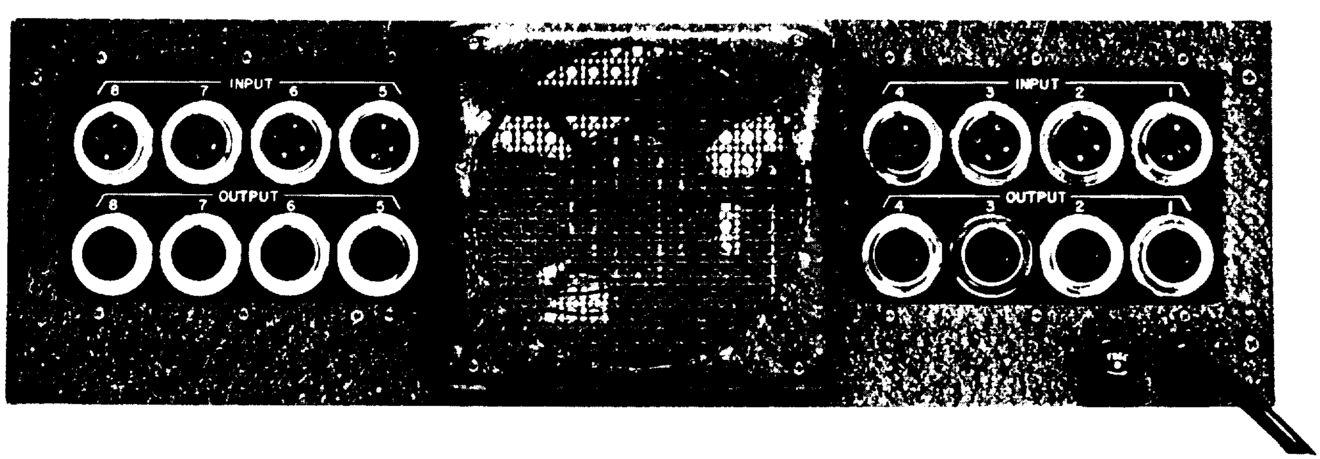


Figure 4. Rear View of Rack Mount Assembly

SECTION II
INSTALLATION AND OPERATION

2.1 General. This section contains instructions for installing and operating the Cubic Model 1300 Differential DC Amplifier.

2.2 Unpacking and Storage. When purchased either as a single amplifier unit or as a group installed in the Cubic Model 1390 Rack Mount Assembly, the equipment is packed in a cardboard shipping carton and protected by shock-resistant packing material. Mating connectors for the input and output receptacles are packed with the equipment. As the carton is unpacked, check that the equipment has not been damaged in shipment and that all specified parts are included. Save the shipping carton and packing material for future reshipment or storage of the equipment. If the amplifier is stored, protect it against dust, moisture, and temperatures that exceed -20°C or +85°C.

2.3 Preliminary Inspection. When the amplifier has been removed from the shipping carton, examine it carefully for damage. If any of the equipment is missing or damaged, or if the amplifier does not operate as specified, refer to the warranty instructions included in this manual.

2.4 Installation Methods and Considerations. When shipped as a single unit, the amplifier has four rubber bench-mounting feet attached to the bottom cover. For bench use, the single unit must be plugged into a single unit adapter to provide power and signal input and output connections. When the amplifier is shipped as one of a group installed in a rack mount assembly, its bottom cover is removed and the unit is mounted on a phenolic board guide at the bottom of the rack mount assembly. The rack mount assembly is shipped with four rubber bench-mounting feet installed on the bottom cover. For rack mounting, remove the rubber feet and fasten the assembly to the rack in the desired location. A blower subassembly at the rear of the rack mount assembly provides adequate cooling. Since the rack mount assembly contains no power on-off control, the blower and amplifiers operate continuously as long as power is applied.

2.4.1 Signal Cable Fabrication. Since the amplifier can be used with input and output cables ranging in length from a few feet to several thousand feet, such cables appropriate to the particular installation must be fabricated for each amplifier. Plugs that mate with the input and output signal receptacles are supplied with the equipment. Figure 5 shows the plug connections required for the input and output cables.

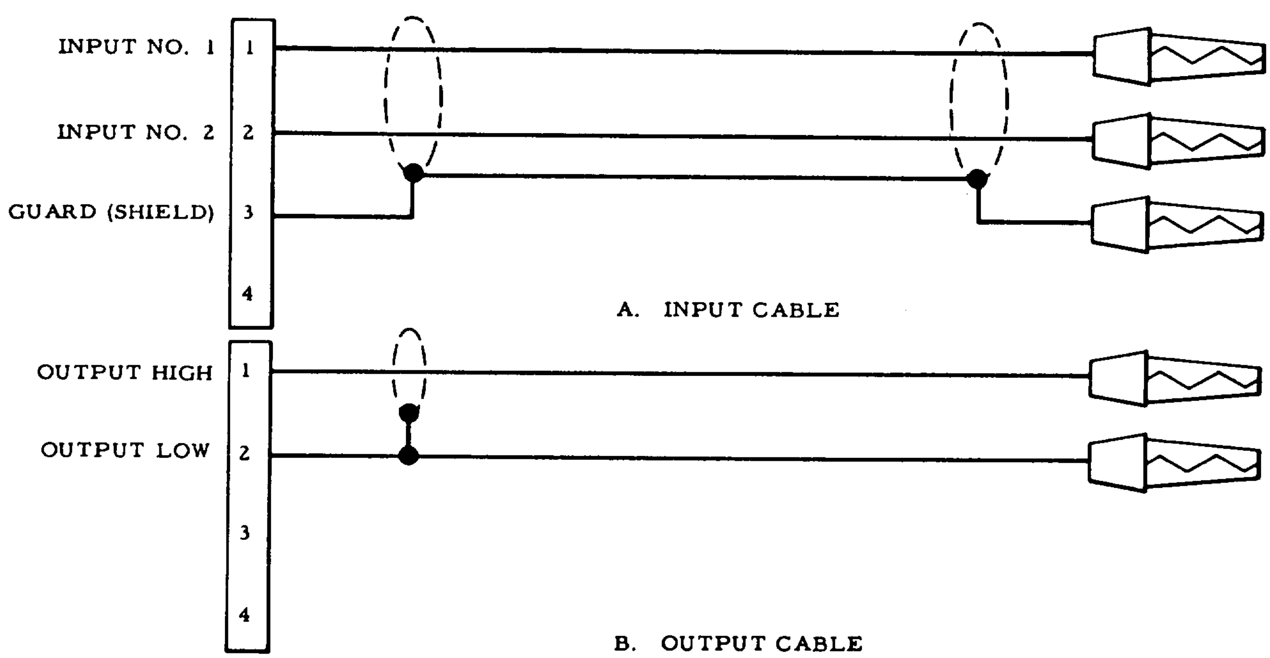


Figure 5. Input and Output Signal Cable Connections

2.4.2 Primary Power Connections. The combined model 1300 amplifier and model 1390 rack mount assembly require 104V to 127V, single-phase, 55- to 65-cps ac power. Although a single-unit amplifier operates at power frequencies from 48 to 420-cps, the blower subassembly of the model 1390 rack mount assembly requires 55- to 65-cps power. (A blower motor that operates on 48- to 420-cps power is available on special order.) A power cord with three-prong plug is mounted on the rear of the single unit adapter and the rear of the model 1390 rack mount assembly. The third wire of the power cord is connected internally to the case of the model 1390 rack mount assembly; this can be disconnected, however, and the rack mount assembly grounded elsewhere if desired. If a mating power receptacle is not available, use a three-prong to two-prong adapter and connect the adapter grounding lug to electrical ground.

2.5 Preliminary Checkout Procedure. To conduct a preliminary check of the model 1300 amplifier, place the amplifier in the rack mount assembly or plug it into the single unit adapter, as applicable, and proceed as follows:

(1) Apply primary power and allow a 3-minute warmup period.

(2) Short together and ground the two differential input leads.

(3) Connect the amplifier output to an oscilloscope (Tektronix 531 or equivalent).

(4) Check that the vernier GAIN control (smaller of the two knobs) is set to the calibrate position (rotated fully counterclockwise until a click is heard).

(5) Set the GAIN selector to 1000 and observe the peak-to-peak noise output as displayed on the oscilloscope. Amplitude should be less than 25 mv peak-to-peak (4 mv if measured on an rms-type meter in place of the oscilloscope). The dc offset at the output should be less than 20 mv after a 10-minute warmup, and should decrease to less than 5 mv after 2 hours.

(6) If the dc offset measured in step (5) is excessive, adjust the zero set potentiometer as required. This adjustment is accessible at the left side of the lower ventilation slot in the front panel.

(7) Set the GAIN selector to each position in turn and check that the noise drops significantly as the GAIN selector is rotated counterclockwise.

2.6 Operation.

2.6.1 Operating Controls. The operating controls (figure 1) consist of the two coaxially-mounted GAIN controls mounted on the front panel. The GAIN selector switch provides a means for selecting fixed gain values of 10, 20, 50, 100, 200, 500, or 1000. The continuously variable vernier control and its in-out switch provides a means for switching this GAIN vernier into the circuit and increasing the amplifier gain up to slightly more than two and one-half times the fixed gain value selected. For example, with the GAIN selector switch set to 100, the GAIN vernier permits the amplifier gain to be adjusted against a calibrated input to any value between 100 and slightly more than 250. In addition to the front-panel controls the model 1300 amplifier contains two operational adjustments: a zero-adjust potentiometer accessible through the lower ventilation slot in the front panel, and a gain calibration potentiometer accessible through a hole in the top of the case. An output section zero adjust potentiometer also is provided, accessible only when the amplifier is removed from its case. All other adjustments require precision test equipment not normally available in the field; these have been carefully set at the factory and should not be disturbed.

CAUTION

To avoid damaging the input circuit, do not apply normal-mode input signals that exceed ±10V or common-mode input signals that exceed ±20V.

2.6.2 Input and Output Connections. Input and output receptacles are provided on the rear of the single-unit adapter and at the rear of the rack mount assembly. Mating plugs are provided for fabricating input and output cables in accordance with paragraph 2.4.1.

2.7 Application. The model 1300 amplifier was designed primarily for use as a preamplifier with low-impedance sensors such as thermocouples, strain gauges, potentiometric pickups, etc. It has sufficient gain (10 to 2500) to match almost any transducer to any data acquisition system. Figure 6 shows a typical instrumentation system application of the model 1300 amplifier. Since each amplifier contains its own regulated and isolated power supply, the output from each amplifier can be grounded at the optimum system location.

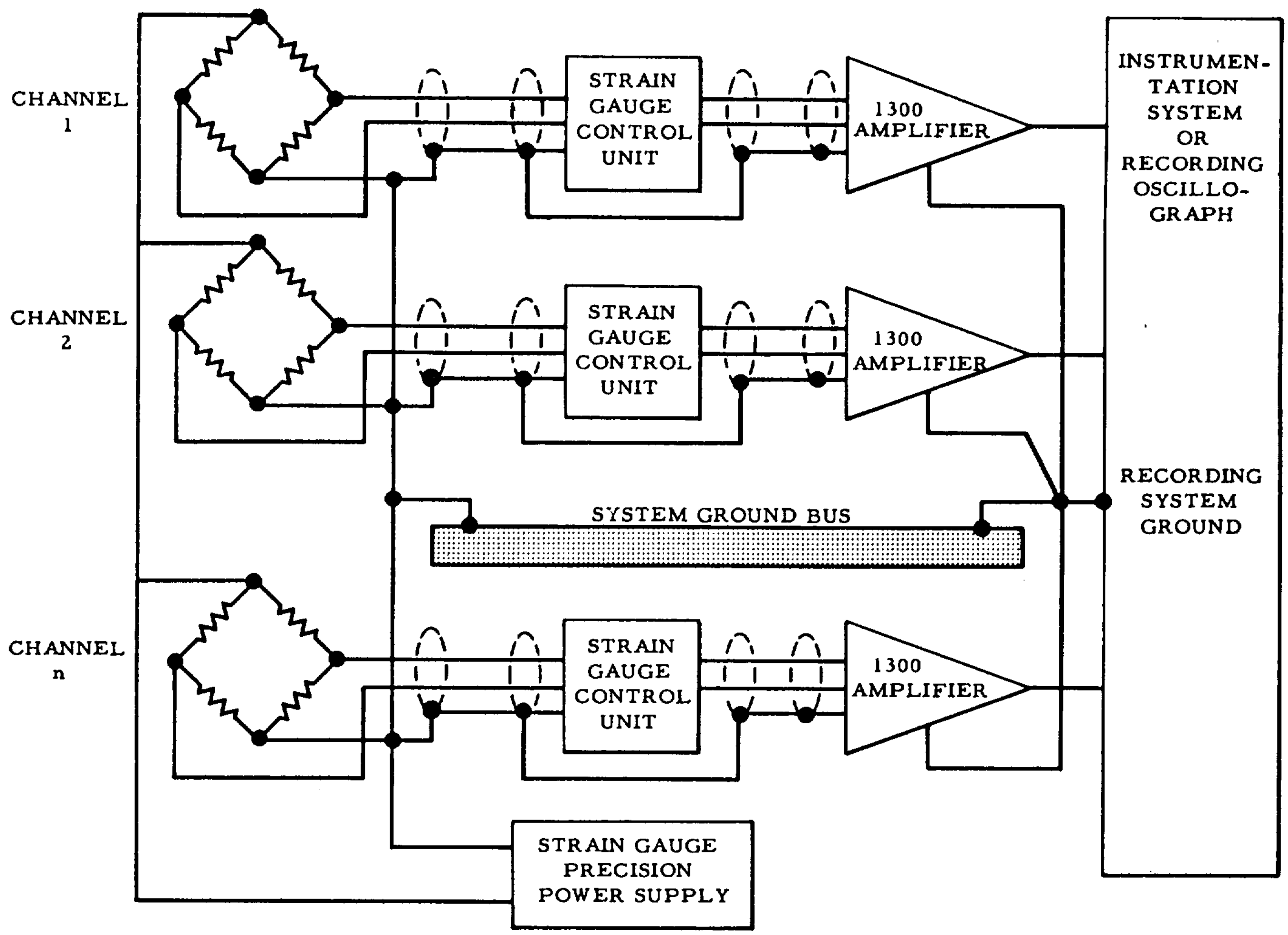


Figure 6. Application for Cubic Model 1300 Differential DC Amplifiers

2.7.1 The differential input terminals of the amplifier are electronically isolated from the output terminals of the amplifier in such a manner that the common-mode input impedance is greater than 1000 megohms for frequencies up to 60 cps, provided that the common-mode voltage does not exceed ±10V dc or peak ac. This high impedance results in negligible current flow in the input circuit leads due to common-mode voltage, therefore line imbalance produces very little common-mode to normal-mode conversion.

2.7.2 Since the model 1300 amplifier contains a differential input, a system such as that shown in figure 6 does not require an individual precision power supply for each strain gauge channel, thus resulting in an appreciable cost saving for the user. The system ground bus should be such that the voltage drop across its length does not exceed a few (2 to 5) volts. This low voltage drop is required by the ±10V common-mode limitation on the amplifier. It should be noted that one-half the bridge excitation appears as a common-mode input to the amplifier.

NOTE

Care should be taken to prevent large radio frequency signals from appearing at the amplifier input terminals and possibly overloading the amplifier.

SECTION III
THEORY OF OPERATION

3.1 General. This section discusses the basic principles of operation and describes the functional operation of the major assemblies of the Cubic Model 1300 Differential DC Amplifier. Figure 12 presents the over-all schematic diagram of the amplifier circuitry.

3.2 Basic Principles of Operation. Essentially, the model 1300 amplifier (figure 7) consists of three principal circuit sections: (1) floating input amplifier A1, a multistage amplifier that is stabilized by a closed-loop potentiometric feedback circuit; (2) output amplifier A2, a differential operational amplifier that is stabilized by a differential feedback loop; and (3) a floating power supply that is completely isolated from the ac line. Selectable precision resistors inserted in the feedback loops vary the gain product of the two amplifiers from 10 to 1000 in fixed steps. A continuously variable vernier control may be switched in to vary the amount of feedback, thus permitting the gain to be set against a calibrated input to any desired gain factor between 10 and 2500.

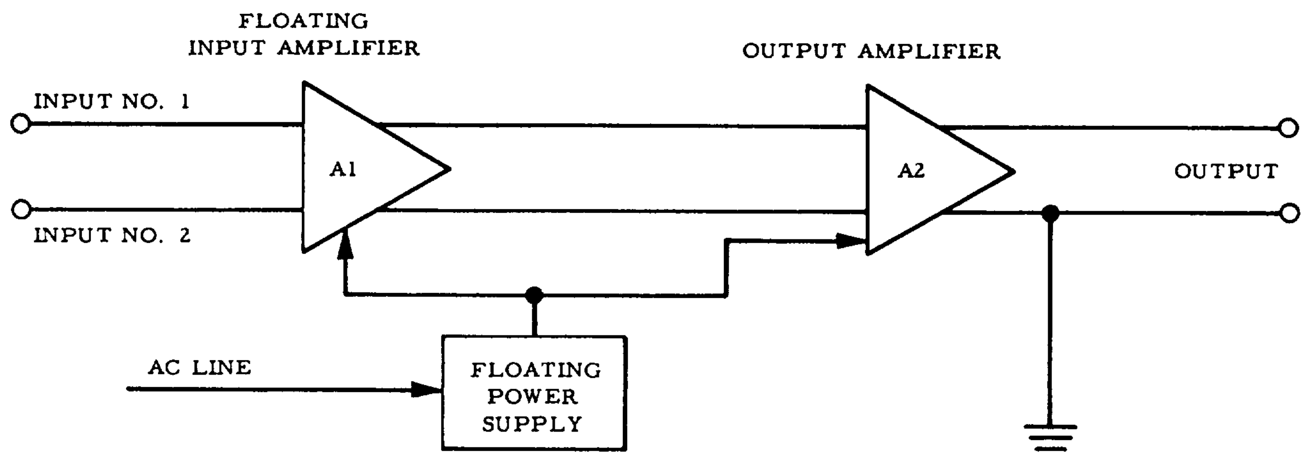


Figure 7. Simplified Block Diagram of Model 1300 Differential DC Amplifier

3.2.1 The input amplifier provides high gain for normal-mode signals, and passes common-mode* signals without either amplification or attenuation. These common-mode signals ultimately are rejected by the output amplifier. Although the input amplifier does not actively reject these undesired signals, it enhances the over-all common-mode rejection in the following ways:

(1) Common-mode rejection is improved by the closed-loop gain of the input amplifier, i.e., a closed-loop gain of 100 provides a 40-db improvement in the normal-mode to common-mode signal ratio.

(2) The high input impedance (greater than 1000 megohms) of the input amplifier limits current flow through the source impedance. For example, the common-mode to normal-mode conversion resulting from a source impedance imbalance in the order of 1K ohms will be limited to a few microvolts.

(3) The input amplifier includes a +30V tracking power supply circuit which automatically compensates for common-mode signal levels. For a common-mode voltage level of +5V, for example, the tracking power supply voltage increases to +35V. Constant-current power supply sinks prevent the operating points of the amplifier stages from varying in response to changes in the tracking supply output.

(4) Since the common-mode rejection of the output amplifier is degraded by any imbalance in its differential input source impedance, the input amplifier provides the required balanced source impedance and thus avoids such degradation.

* A common-mode signal is a signal or voltage applied in-phase or equally to both inputs of an amplifier or other device. The common-mode input is the average of the voltages on the two inputs with respect to ground.

3.2.2 The output amplifier is a differential operational amplifier with relatively low gain (2 to 10) and a single-ended output that may be grounded as desired. The output amplifier offers 80 db of common-mode rejection, resulting in 120 db rejection over-all. The power supply furnishes the regulated dc potentials and provides the constant current sources required for stable operation of the amplifier circuits.

3.2.3 The excellent stability, low drift, and low temperature coefficient characteristics as exhibited by the specifications have been achieved by means of unique circuit designs incorporating state-of-the-art semiconductor devices.

3.3 Functional Operation of Major Assemblies (Figure 12). Most of the circuitry for the model 1300 amplifier is mounted on two etched circuit boards designated as the amplifier board and power supply board, respectively. (See figure 9.)

3.3.1 Amplifier Board. The amplifier board (figure 8) contains both floating input amplifier A1 and differential operational amplifier A2. The floating input amplifier circuitry is located on the front portion of the amplifier board, and the differential operational amplifier circuitry is located near the rear of the board.

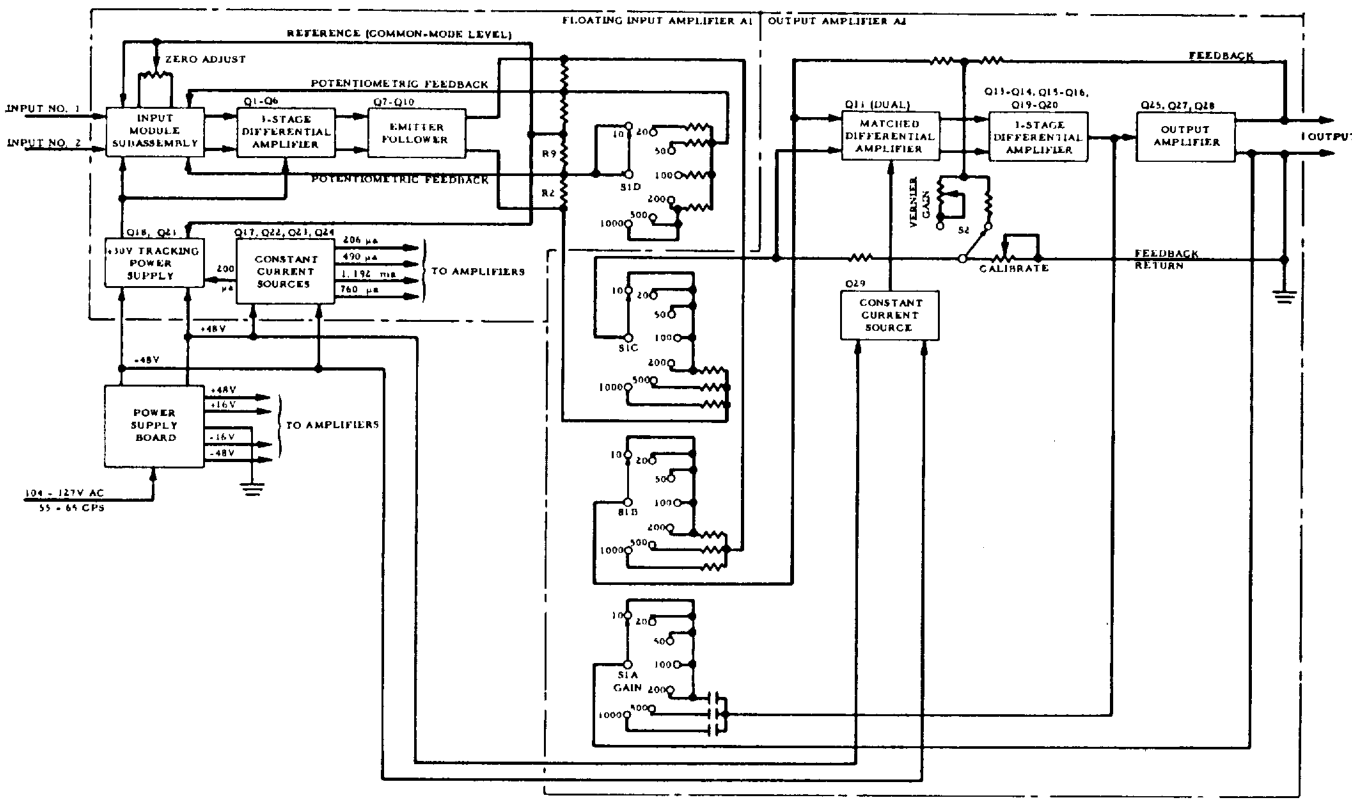


Figure 8. Functional Block Diagram of Model 1300 Differential DC Amplifier

3.3.1.1 Floating Input Amplifier A1. This circuit section contains a plug-in input module that contains a unique differential amplifier configuration, a three-stage differential amplifier (Q1 through Q6), a cascade emitter follower (Q7 through Q10), a +30V tracking power supply (Q18 and Q19), four constant current sources (Q17, Q22, Q23, and Q24), and an over-all potentiometric-type feedback loop. This feedback loop stabilizes the input amplifier gain with time and temperature and helps to provide a high input impedance. The closed-loop gain of this amplifier section is switchable in fixed steps from 5 to 100 by switching precision resistors (R5 through R8) into the feedback circuit by means of GAIN switch section S1D. The selected resistor shunts resistors R2 and R9, thus affecting the amount of feedback voltage.

3.3.1.1.1 Input signals are applied through amplifier board pins 1 and 2 to the input module subassembly. Resistors R95 through R104 in the input circuit prevent the base current of the input transistor from flowing back through the source resistance and producing a false input signal. The inputs first are amplified by a special circuit configuration in the input module. At constant temperature, this circuit holds the dc drift of the input amplifier to less than ±2 microvolts. The input module outputs are applied to transistors Q1 (signal No. 1) and Q2 (signal No. 2) which comprise the first stage of a three-stage differential amplifier.

3.3.1.1.2 The input module subassembly and the three-stage differential amplifier are powered by the tracking power supply. This supply furnishes +30V plus the common-mode voltage level so that this power supply, and consequently the input amplifier circuits, will track a varying common-mode voltage. Under no input conditions (inputs shorted to ground), the +30V is adjusted by means of the zero-adjust potentiometer to eliminate any dc offset.

3.3.1.1.3 Despite the varying voltages encountered when the +30V supply is tracking a common-mode signal, constant current sources Q22, Q23, and Q24 hold the current through the differential amplifier constant. Thus the common-mode signals do not affect the operating points (collector currents and collector-to-emitter voltages) of the transistors contained in the floating input amplifier.

3.3.1.1.4 The amplified signals are coupled to differential operational amplifier A2 through cascaded differential emitter followers Q7 through Q10. Precision resistors R31 through R36 are selectable by means of switch sections S1B and S1C to control the gain of differential operational amplifier A2. The emitter follower stage provides isolation between the two amplifiers. This isolation prevents any change in current through gain-controlling resistors R31 through R36 resulting from a changing common-mode level from feeding back and significantly affecting the operating point of the floating input amplifier section.

3.3.1.1.5 The +30V floating power supply which tracks the common-mode voltage consists of transistor Q21, constant current source Q18, Zener diode CR5, and associated circuitry. The common-mode voltage from the input module is applied to the junction of resistors R2 and R9 in the potentiometric feedback network and through resistor R60 to 33V Zener diode CR5. With no common-mode voltage present this junction is at -1.3V. The voltage drop across CR5 holds the Q21 base at about +31V, and the Q21 emitter is approximately +30V. This is the voltage applied to the floating input amplifier. Transistor Q21 is in effect an emitter follower where the emitter load resistor is the resistance of the floating input amplifier.

3.3.1.2 Differential Operational Amplifier A2. This amplifier section provides a small closed-loop gain for normal-mode signals and effectively rejects common-mode signals. This amplifier section contains an input differential amplifier using matched-transistor pair Q11 and emitter degeneration; a three-stage differential amplifier composed of Q13-Q14, Q15-Q16, and Q19-Q20, employing local feedback; an output amplifier composed of Q25 through Q28, employing local high-frequency rolloff feedback; and an over-all, operational-type feedback loop. Differential matched-transistor pair Q11 was designed to hold the dc drift of A2 to a negligible value. Q11 is supplied a constant current by Q29.

3.3.1.2.1 The gain of output amplifier A2 is switchable in fixed steps from 2 to 10 by selecting different values of input resistance by means of GAIN switch S1. Switch S2 inserts vernier GAIN control R105 into the over-all feedback circuit to provide an adjustment for varying the gain values between the fixed steps. Potentiometer R105 permits the gain to be increased approximately two and one-half times the selected fixed value.

3.3.1.2.2 The three-stage differential amplifier applies a single-ended output from the Q20 collector to the base of Q25. A differential step roll feedback loop is coupled from the Q19 and Q20 emitters to the input of the three-stage differential amplifier. Potentiometer R90 is ganged with vernier GAIN control R105 and controls the forward gain of A2, thus the gain-beta product and consequently the closed-loop frequency response is independent of the vernier GAIN control setting.

3.3.1.2.3 The power output section of the output amplifier consists of Q25, Q26, Q27, Q28 and associated circuitry. This output section is capable of supplying ±10V dc or peak ac at currents up to 120 ma. Emitter follower Q25 couples the output of the three-stage differential amplifier to the base of Q27. The amplified output at the collector of Q27 drives Q28 through diode CR9. The power amplifier output is taken off at the junction of resistors R84 and R85.

3.3.1.2.4 The Q26 circuit appears as a constant current source and maintains the current through CR9 independent of the output level. This tends to improve the efficiency of amplifier Q28. A high-frequency rolloff circuit composed of resistor R93 and selectable capacitors C15, C16, and C17 is used to roll off the high-frequency open-loop gain of differential operational amplifier A2. This ensures high-frequency stability for this output amplifier for all gain ranges and load conditions.

3.3.1.3 Selectable Fixed Gain Values. Table I lists the selectable fixed gain provided by each amplifier section and shows the total closed-loop gain of the model 1300 amplifier for each setting of the GAIN switch (GAIN vernier not in circuit).

TABLE I
SELECTABLE FIXED GAIN VALUES*

Input Amplifier Gain	Output Amplifier Gain	Total Closed-Loop Gain (GAIN Switch Setting)
5	2	10
10	2	20
25	2	50
50	2	100
100	2	200
100	5	500
100	10	1000

*Vernier GAIN control out of circuit (fully counterclockwise).

3.3.2 Power Supply Board. The power supply board contains power transformer T1 and the following series-regulated power supply circuits:

(1) The circuit consisting of series regulator Q1, sensing amplifier Q2, and associated circuitry supplies -48V to all the amplifiers, to the +30V floating supply, and to the constant current sources on the amplifier board.

(2) The circuit consisting of series regulator Q4, sensing amplifier Q3, reference diodes CR18 through CR23, and associated circuitry furnishes -16V to the input module and the output section of differential operational amplifier A2.

(3) The circuit consisting of series regulator Q5, sensing amplifier Q6, and associated circuitry furnishes +16V to the power output section of differential operational amplifier A2.

(4) The circuit consisting of series regulator Q7, sensing amplifier Q8, and associated circuitry furnishes +48V to the differential operational amplifier, to the +30V floating power supply, and to the various constant current sources.

3.3.2.1 The -16V supply regulates the outputs of the other three supplies. This results in very close control of the ratio between the various power supply outputs, since the +16V, +48V, and -48V supplies operate as operational amplifiers controlled by the -16V supply. The temperature coefficient of the -16V supply is reduced significantly by connecting diodes CR19 through CR23 in series with Zener diode CR18. This reduced temperature coefficient then controls the temperature coefficient of the other power supplies. For the +48V supply, for example, the temperature coefficient is reduced to approximately 1 mv/°C. Thus all power supply voltages are well regulated, and preregulator Zener diode CR17 further reduces power supply output variations caused by line voltage changes.

SECTION IV
MAINTENANCE

4.1 Introduction. This section contains the maintenance instructions for the Cubic Model 1300 Differential DC Amplifier.

4.2 General. The model 1300 amplifier employs very complex circuitry involving multiple feedback, with critical circuits housed in the input module. Repair, therefore, should be performed only by well-qualified technicians experienced in the maintenance of precision instrumentation. The following information is presented to aid in field servicing this instrument.

4.3 Adjustment Procedures.

4.3.1 Input Section Zero Adjustment. This procedure can be performed with the amplifier either plugged into a single unit adapter or installed in a 1390 rack mount assembly.

(1) Apply primary power and allow a 30-minute warmup period.

(2) Short together and ground the two differential input leads.

(3) Connect the amplifier output to a digital voltmeter (Cubic Model V71 or equivalent).

(4) Set the GAIN selector to 1000 and rotate the vernier GAIN control fully counterclockwise until a click is heard.

(5) If the dc offset measured by digital voltmeter exceeds 10 mv, adjust the zero adjust potentiometer as required. This adjustment is accessible through the lower ventilation slot in the front panel.

(6) Set the GAIN selector to each position in turn and check that the dc offset for each position is less than 5 mv.

(7) If the instrument can not be adjusted to zero by means of the zero adjust potentiometer, check for +30V at the Q21 emitter in the tracking power supply. If this power supply output is normal, check the outputs of the power supply board (paragraph 4.4). If these outputs are correct, trouble in the floating input amplifier is indicated and the instrument should be returned to the factory for repair.

(8) Disassemble the test setup.

4.3.2 Output Section Zero Adjust. This adjustment rarely needs to be reset, and can be performed only with the amplifier plugged into a single-unit adapter.

(1) Place the amplifier on the bench and remove the case from the unit.

(2) Short together the emitters of Q9 and Q10. (See figure 10.)

(3) Plug the amplifier into a single unit adapter, apply primary power and allow a 30-minute warmup period.

(4) Connect the amplifier output to a digital voltmeter (Cubic Model V71 or equivalent) and check that the amplifier output is within ±2 mv of ground for each position of GAIN selector switch S1.

(5) If the output exceeds ±2 mv, adjust potentiometer R46 (figure 9) as required. If the amplifier output cannot be adjusted to within ±2 mv by means of R46, the amplifier should be returned to the factory for maintenance.

(6) Disassemble the test setup.

4.3.3 Fixed Gain Calibration.

NOTE

In the following adjustment procedure, be sure that the amplifier output is within ±1 mv with no input (differential input leads shorted together) each time the gain setting is changed. Otherwise, the gain adjustment obtained may be inaccurate.

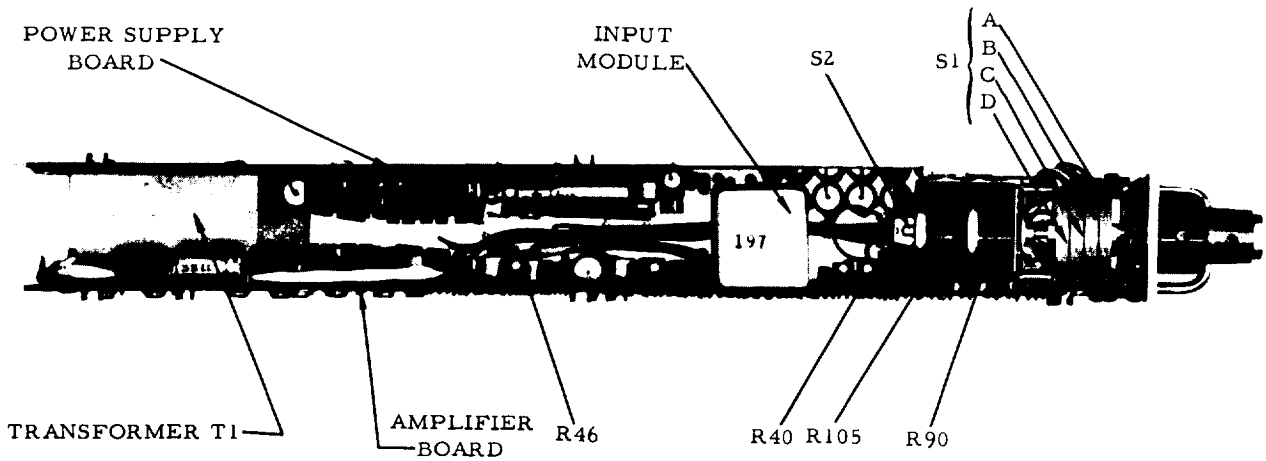


Figure 9. Top View of Model 1300 Differential DC Amplifier (Case Removed)

4.3.3.1 Test Equipment Required.

(1) Oscilloscope (Tektronix Model 531 or equivalent).

(2) Voltage Standard (Kintel Model 301 or equivalent).

(3) 1K Dekavider (Electro Scientific Industries DV-411 or equivalent).

4.3.3.2 Calibration Procedure.

(1) Connect the Voltage Standard output to the Dekavider input, connect the Dekavider output to the amplifier input, and connect the amplifier output to the oscilloscope. Apply power and allow 30 minutes or more for warmup.

(2) Set the Voltage Standard output to 9.900V and set the Dekavider dials to 0.00100.

(3) Set the amplifier GAIN switch to 1000.

(4) Rotate the vernier GAIN control fully counterclockwise so that this control is switched out of the circuit.

(5) Check that the amplifier outout is 9.9V ±1 mv; adjust calibration potentiometer R40 if necessary to obtain an output within this tolerance. The potentiometer is accessible through a hole in the top of the amplifier case.

(6) Reset the GAIN switch and the Dekavider output as follows and check for an output of 9.9V ±2 mv for each GAIN switch and Dekavider dial setting:

GAIN Switch	Dekavider Dial
500	0.00200
200	0.00500
100	0.0100
50	0.0200
20	0.0500
10	0.100

It may be necessary to slightly readjust the zero adjust potentiometer as the amplifier gain is changed in order to maintain the output within ±1 mv when the differential input leads are shorted together.

(7) Disassemble the test setup.

NOTE

Potentiometer R92 is a factory adjustment that controls the temperature coefficient of the amplifier drift. This adjustment should not be disturbed.

NOTE

Potentiometer R76 is a factory adjustment that controls the current through transistor Q24, and may be adjusted if necessary to produce a voltage level at the emitter of Q9 that is equal to the voltage at the junction of resistors R2 and R9.

4.4 Localization of Troubles. If the amplifier fails to function properly, the major circuit section at fault (power supply, floating input amplifier, or output amplifier) must first be isolated. Check that the power supply board outputs are correct in accordance with the values given in table II. Isolate trouble in the amplifier to the malfunctioning section by means of conventional signal tracing techniques. Since differential amplifier Q11 is a selected matched pair, replacements must be obtained from the factory. If trouble is isolated to the floating input amplifier section, the instrument must be returned to the factory for repair.

TABLE II
POWER SUPPLY OUTPUT VOLTAGES

DC Voltage	Power Supply Board Test Point	Amplifier Board Test Point	Tolerance On DC Output	Ripple (Peak-to-Peak)	
				Typical	Maximum Acceptable
-16V	Pin 2	Pin 10	-15V to -16V	5 mv	10 mv
+48V	Pin 1	Pin 11	+46V to +50V	120 mv	200 mv
-48V	Pin 13	Pin 12	-46V to -50V	120 mv	200 mv
+16V	Pin 14	Pin 13	+15V to +16V	16 mv	25 mv
Ground	Pin 15	Pin 4			

4.4.1 Voltage Check Charts. Tables III, IV, and V list accessible points at which voltage and current levels of the amplifier circuitry may be measured. For these measurements set the GAIN switch to 1000 and short together and ground the input leads, and use a Cubic Model V-71 Digital Voltmeter or equivalent.

TABLE III
INPUT AMPLIFIER VOLTAGE CHECK CHART

Test Point	DC Level	Tolerance
R2-R9 junction	-1.1V	±0.2V
C of Q1 and Q2	+12.8V	±1.0V
E of Q1 and Q2	+7.9V	±0.5V
C of Q3 and Q4	+20.6V	±1.5V
E of Q5 and Q6	+20V	±1.5V
E of Q7 and Q8	+19.4V	±1.5V
E of Q9 and Q10	Set equal to junction of R2 and R9 with potentiometer R76.	

TABLE IV
OUTPUT AMPLIFIER VOLTAGE CHECK CHART

Test Point	DC Level	Tolerance
E of Q9 and Q10	-1.2V	±0.05V
B of Q11	-0.9V	±0.1V
E of Q11	-1.2V	±0.1V
C of Q11	+22V	±3V
E of Q13 and Q14	+21.5V	±3V
E of Q15 and Q16	+22V	±3V
B of Q19 and Q20	+6.4V	±1V
C of Q20	+14V	±1V
E of Q25	+13.5V	±1V
E of Q27	+13.8V	±1V
C of Q27	+0.25V	±0.1V
E of Q28	+0.25V	±0.1V
B of Q28	-0.5V	±0.1V
C of Q28	-15V	±1V
B of Q26	-1.2V	±0.2V
E = emitter, B = base, C = collector		

TABLE V
CONSTANT CURRENT SOURCE VOLTAGE CHECK CHART

Test Point	DC Level	Tolerance
voltage across R56	0.96V	±0.1V
voltage across R60	0.2V	±0.02V
voltage across R69	0.206V	±0.02V
voltage across R71	0.49V	±0.05V
voltage across R74	1.19V	±0.05V
voltage across R87	1.25V	±0.2V

4.5 Replaceable Parts List and Wiring Diagrams. In addition to the schematic diagram of the amplifier (figure 12), section V contains a list of replaceable parts and the wiring diagrams for the Model 1390 Rack Mount Assembly and the signal unit adapter.

SECTION V

PARTS LIST

AND

SCHEMATIC DIAGRAMS

PARTS LIST

Symbol	Material Description	Manufacturer	Manufacturer's Part Number	Quantity Required
	MODEL 1300 AMPLIFIER			
	Input assembly	Cubic	87-1015-1	1
S1	Switch assembly	Cubic	87-0003	1
	Knob, concentric type	Buckeye Stamping Co.	PS-70D-1/ 95CL-2	1
T1	Transformer assembly	Cubic	87-0001	1
	AMPLIFIER BOARD ASSEMBLY	Cubic	87-7001-1	1
C1	Capacitor, 0.0022 μf		CM06F222J03	2
C2, C3	Capacitor, 47 μf		CM05E470J03	2
C4	Same as C1			
C5	Capacitor, 0.047 μf	Elpac	ZX1A473	1
C6	Capacitor, 56 μμf		CM05E560J03	2
C7, C8	Capacitor, 390 μμf		CM05F391J03	2
C9	Same as C6			
C10, C11	Capacitor, 25 μf, 25V	Sprague	TE-1207	3
C12, C13	Capacitor, 0.015 μf, 200V	Sprague	192P15392	2
C14	Capacitor, 50 μf, 50V	Sprague	TE-1307	1
C15	Capacitor, 330 μμf		CM05F331J03	1
C16	Capacitor, 470 μμf		CM06F471J03	1
C17	Capacitor, 680 μμf		CM06F222J03	1
C18	Capacitor, 0.01 μf		1DP-1-103	2
C19	Same as C10			
C20	Capacitor, TBD			3
C21	Capacitor, TBD			
C22	Same as C18			
C23, C24	Capacitor, 100 μμf		CM05F101J03	2
C25	Capacitor, TBD			
CR1, CR2	Diode (Zener), 20V		1N968B	2
CR3	Not used			
CR4	Diode (Zener), 5.2V	Texas Instruments	651C7	2
CR5	Diode (Zener), 33V		1N973B	1
CR6 through CR11	Diode	Zytan	1041	6
CR12	Same as CR4			
Q1, Q2	Transistor		2N2716	5
Q3, Q4	Transistor	RCA	40053	9
Q5, Q6	Same as Q1			
Q7, Q8	Same as Q3			
Q9, Q10	Transistor		2N699	7
Q11	Transistor, dual pair "D"	Cubic	87-0002-B	1
Q12	Not used			
Q13, Q14	Same as Q3			
Q15, Q16	Transistor	Sperry	455-S-2	3
Q17	Same as Q9			
Q18	Same as Q15			
Q19, Q20	Same as Q3			
Q21	Same as Q3			
Q22, Q23	Same as Q9			
Q24	Same as Q9			
Q25	Same as Q1			
Q26	Transistor		2N1305	1

PARTS LIST (Cont)

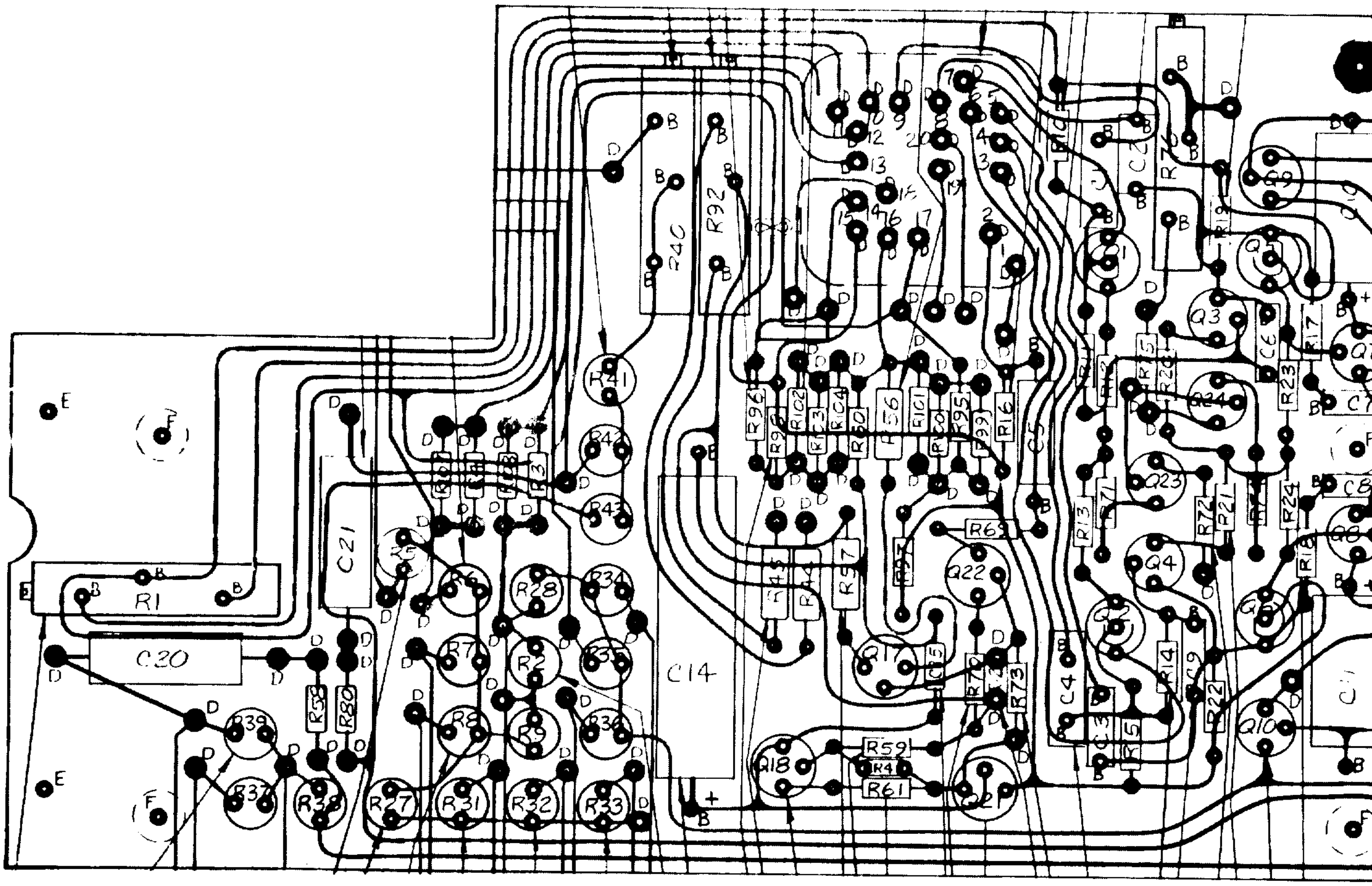
Symbol	Material Description	Manufacturer	Manufacturer's Part Number	Quantity Required
	AMPLIFIER BOARD ASSEMBLY (Cont)			
Q27, Q28	Transistor		2N1905	2
Q29	Same as Q9			
R1	Potentiometer, 2K	Bourns	275-1-202	1
R2	Resistor, 2.5K ±0.1%, 2 ppm/°C	Riedon	101-PC	2
R3	Resistor, TBD			
R4	Resistor, TBD			
R5	Resistor, 210.53Ω ±0.01%, 2 ppm/°C	Riedon	101-PC	1
R6	Resistor, 444.44Ω ±0.01%, 2 ppm/°C	Riedon	101-PC	1
R7	Resistor, 1K ±0.01%, 2 ppm/°C	Riedon	101-PC	7
R8	Resistor, 4K ±0.01%, 2 ppm/°C	Riedon	101-PC	1
R9	Same as R2			
R10	Resistor, 68K ±5%, 1/4W	MIL-R-11	RC07GF683J	4
R11 through R14	Resistor, 2K ±5%, 1/4W	MIL-R-11	RC07GF202J	4
R15	Same as R10			
R16	Resistor, 62K ±5%, 1/4W	MIL-R-11	RC07GF623J	1
R17, R18	Resistor, 10K ±5%, 1/4W	MIL-R-11	RC07GF103J	4
R19	Resistor, 20K ±5%, 1/4W	MIL-R-11	RC07GF203J	4
R20, R21	Resistor, 47Ω ±5%, 1/4W	MIL-R-11	RC07GF470J	2
R22	Same as R19			
R23, R24	Same as R10			
R25, R26	Resistor, 220K ±5%, 1/4W	MIL-R-11	RC07GF224J	2
R27, R28	Resistor, 10K ±0.01%, 2 ppm/°C	Riedon	101-PC	2
R29, R30	Same as R17			
R31	Same as R7			
R32	Resistor, 2K ±0.01%, 2 ppm/°C	Riedon	101-PC	2
R33	Resistor, 5K ±0.01%, 2 ppm/°C	Riedon	101-PC	3
R34	Same as R7			
R35	Same as R32			
R36, R37	Same as R33			
R38, R39	Resistor, 3.25K ±0.01%, 2 ppm/°C	Riedon	101-PC	4
R40	Potentiometer, 50 ohms	Bourns	200P-1-500	1
R41	Resistor, 1K ±0.1%, 10 ppm/°C	Riedon	101-PC	1
R42, R43	Same as R38			
R44, R45	Resistor, 374K ±1%, 1/8W	MIL-R-10509	RN60C3743F	2
R46	Potentiometer, 1K	Bourns	275-1-102	1
R47	Resistor, 39.2K ±1%	IRC	RN20X	2
R48, R49	Resistor, 562Ω ±1%	IRC	RN20X	2
R50	Same as R47			
R51	Resistor, 1.5K ±5%, 1/4W	MIL-R-11	RC07GF152J	2
R52, R53	Same as R19			
R54	Same as R51			
R55	Resistor, 470K ±5%, 1/4W		RC07GF474J	1
R56	Resistor, 1K ±1%, 1/8W	MIL-R-10509	RN60C1001F	1
R57	Resistor, 4.02K ±1%, 1/8W	MIL-R-10509	RN60C4021F	1
R58	Resistor, TBD			
R59	Resistor, 270K ±5%, 1/4W	MIL-R-11	RC07GF274J	1
R60	Resistor, 1K ±5%, 1/4W	MIL-R-11	RC07GF102J	6
R61	Resistor, 15K ±5%, 1/4W	MIL-R-11	RC07GF153J	1
R62, R63	Resistor, 22K ±5%, 1/4W	MIL-R-11	RC07GF223J	4
R64	Resistor, 39K ±5%, 1/4W	MIL-R-11	RC07GF393J	1
R65	Same as R62			
R66, R67	Resistor, 1.2K ±5%, 1/4W	MIL-R-11	RC07GF122J	3
R68	Same as R62			
R69	Same as R60			

PARTS LIST (Cont)

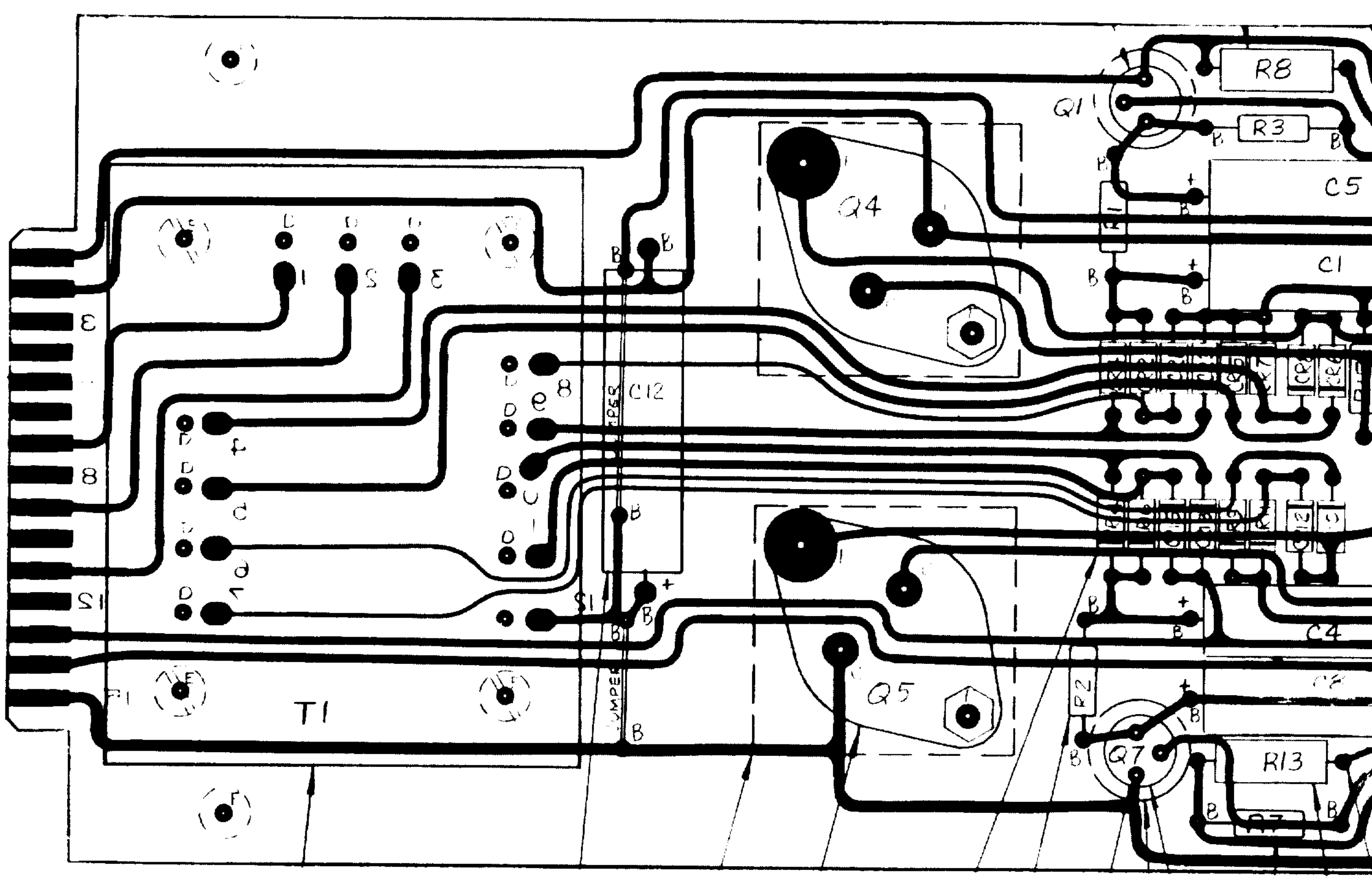
Symbol	Material Description	Manufacturer	Manufacturer's Part Number	Quantity Required
	AMPLIFIER BOARD ASSEMBLY (Cont)			
R70	Resistor, 18K ±5%, 1/4W	MIL-R-11	RC07GF183J	1
R71	Same as R60			
R72	Resistor, 7.5K ±5%, 1/4W	MIL-R-11	RC07GF752J	1
R73	Resistor, 100K ±5%, 1/4W	MIL-R-11	RC07GF104J	1
R74	Same as R60			
R75	Resistor, 2.7K ±5%, 1/4W	MIL-R-11	RC07GF272J	2
R76	Potentiometer, 500 ohms	Bourns	275-1-501	1
R77, R78	Resistor, 6.2K ±5%, 1/4W	MIL-R-11	RC07GF622J	2
R79	Resistor, 470Ω ±5%, 1/4W	MIL-R-11	RC07GF471J	1
R80	Resistor, TBD			
R81	Resistor, 27Ω ±5%, 1/4W	MIL-R-11	RC07GF470J	1
R82	Same as R66			
R83	Resistor, 10Ω ±5%, 1/2W	MIL-R-11	RC20GF100J	1
R84, R85	Resistor, 3.9Ω ±5%, 1/2W	MIL-R-11	RC20GF3R9J	2
R86	Resistor, 22Ω ±5%, 1/2W	MIL-R-11	RC20GF220J	1
R87	Same as R60			
R88	Same as R75			
R89	Resistor, 16.9K ±1%, 1/4W	MIL-R-10509	RN65C1692F	1
R91	Same as R60			
R92	Potentiometer, 50K	Bourns	200P-1-503	1
R93	Resistor, 120K ±5%, 1/4W	MIL-R-11	RC07GF124J	1
R94	Resistor, TBD			
R95, R96	Resistor, 22 meg ±5%, 1/4W	MIL-R-11	RC07GF226J	2
R97, R98	Resistor, 1 meg ±5%, 1/4W	MIL-R-11	RC07GF105J	2
R99	Resistor, TBD			
R100	Resistor, TBD			
R101	Resistor, TBD			
R102	Resistor, TBD			
R103	Resistor, TBD			
R104	Resistor, TBD			
R106	Resistor, TBD			
R107	Resistor, TBD			
R108	Resistor, TBD			
	NOTE: Switch S1 and potentiometers R90 and R105 are integral parts of the S1 Switch Assembly, Cubic Part No. 87-0003			
	POWER SUPPLY BOARD ASSEMBLY	Cubic	87-7002	1
C1	Capacitor, 20 µf, 100V	Sprague	TE-1409	4
C2, C3	Capacitor, 50 µf, 50V	Sprague	TE-1307	7
C4, C5	Same as C1			
C6, C7	Same as C2			
C8	Same as C1			
C9, C10	Same as C2			
C11	Capacitor, 100 µf, 25V	Sprague	TE-1211	1
C12	Same as C2			
CR1 through CR16	Diode		SC-1	16
CR17	Diode (Zener), 30V		1N972B	1
CR18	Diode (Zener), 13V		1N717A	1
CR19 through CR23	Diode	Zytan	1041	5

PARTS LIST (Cont)

Symbol	Material Description	Manufacturer	Manufacturer's Part Number	Quantity Required
	POWER SUPPLY BOARD ASSEMBLY (Cont)			
Q1, Q2	Transistor	RCA	40053	4
Q3	Transistor		2N1305	2
Q4, Q5	Transistor		2N457A	2
Q6	Same as Q3			
Q7, Q8	Same as Q1			
R1, R2	Resistor, 10Ω ±5%, 1/2W	MIL-R-11	RC20GF100J	2
R3	Resistor, 5.1K ±5%, 1/2W	MIL-R-11	RC20GF512J	2
R4	Resistor, 10K ±5%, 1/2W	MIL-R-11	RC20GF103J	1
R5	Resistor, 11K ±5%, 1/2W	MIL-R-11	RC20GF113J	1
R6	Same as R3			
R7	Resistor, 47K ±5%, 1/2W	MIL-R-11	RC20GF473J	1
R8	Resistor 15K ±1%, 1/4W	MIL-R-10509	RN65C1502F	1
R9	Resistor, 5.11K ±1%, 1/4W	MIL-R-10509	RN65C5111F	1
R10	Resistor, 1.4K ±1%, 1/2W	MIL-R-10509	RN70C1401F	1
R11	Resistor, 1.47K ±1%, 1/2W	MIL-R-10509	RN70C1471F	1
R12	Resistor, 22.1K ±1%, 1/4W	MIL-R-10509	RN65C2212F	1
R13	Resistor, 23.7K ±1%, 1/4W	MIL-R-10509	RN65C2372F	1
R14	Resistor, 100Ω ±5%, 1/2W	MIL-R-11	RC20GF101J	1



Assembly Drawing 87-7001



Assembly Drawing 87-7002

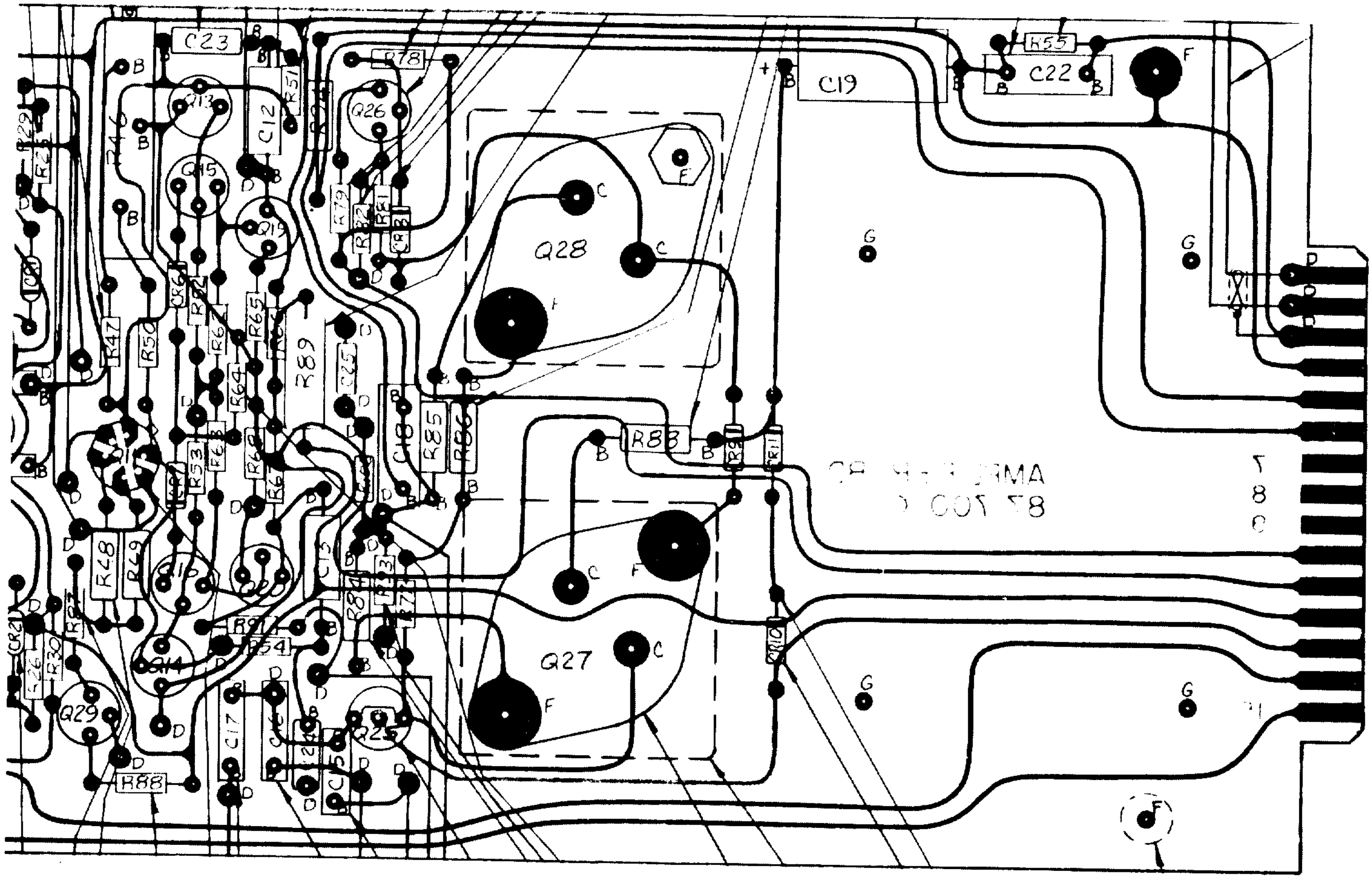


Figure 10. Amplifier Circuit Board Assembly

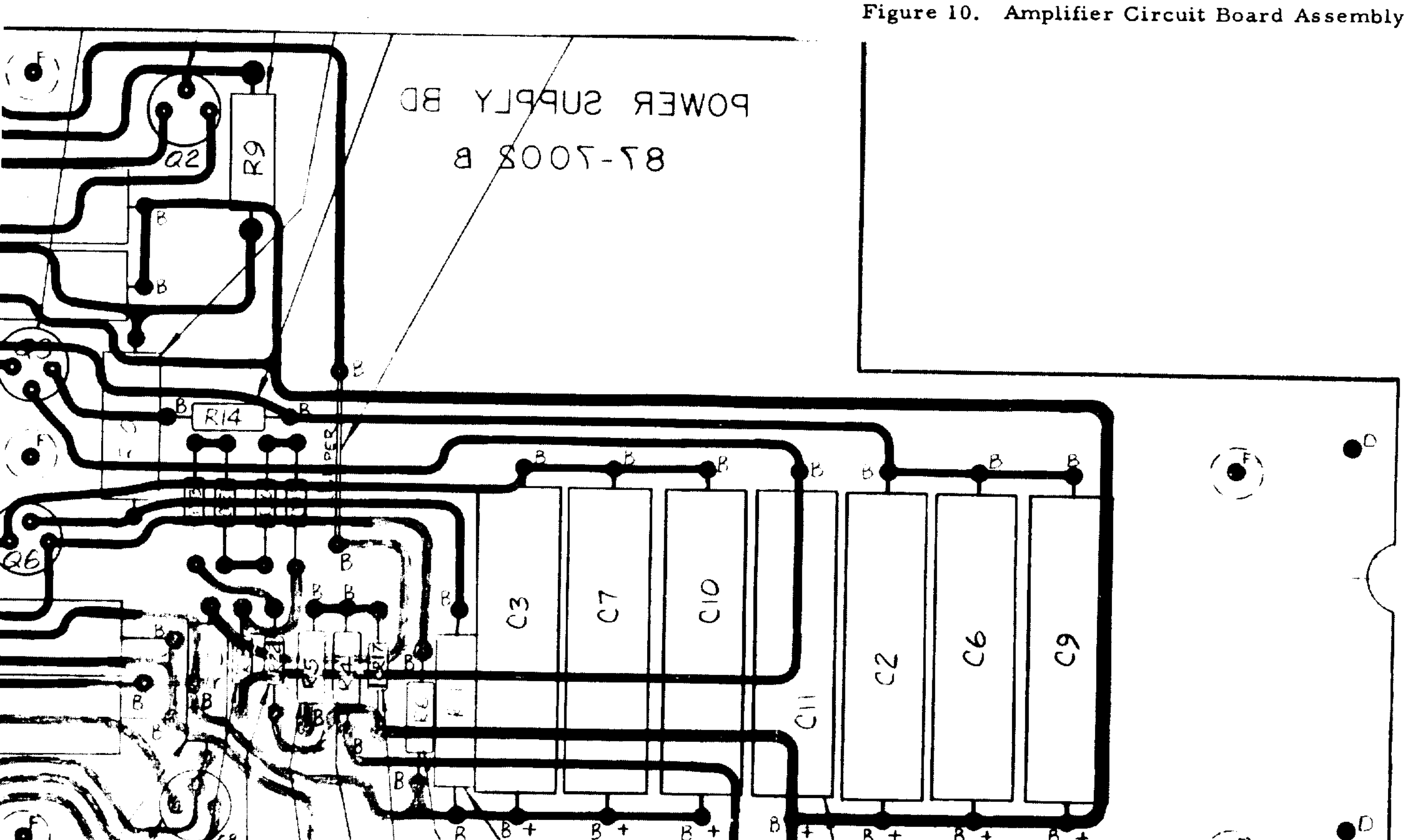
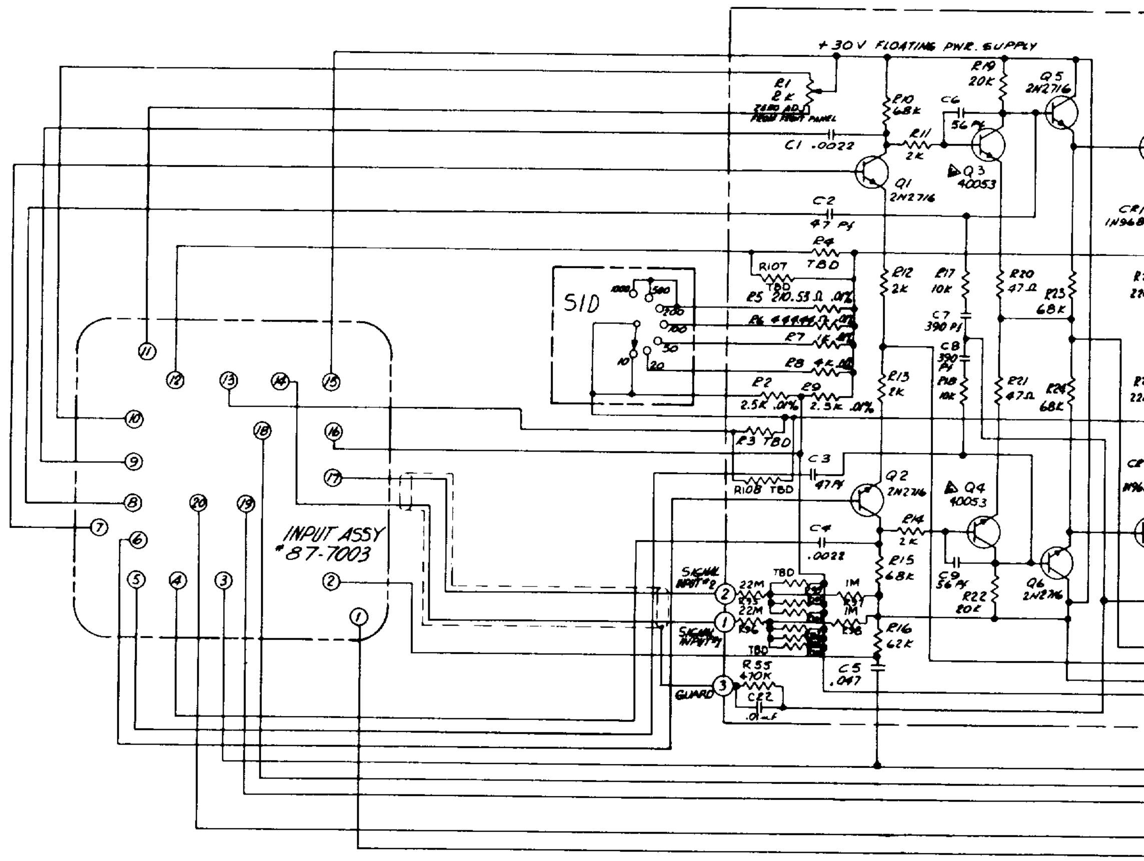
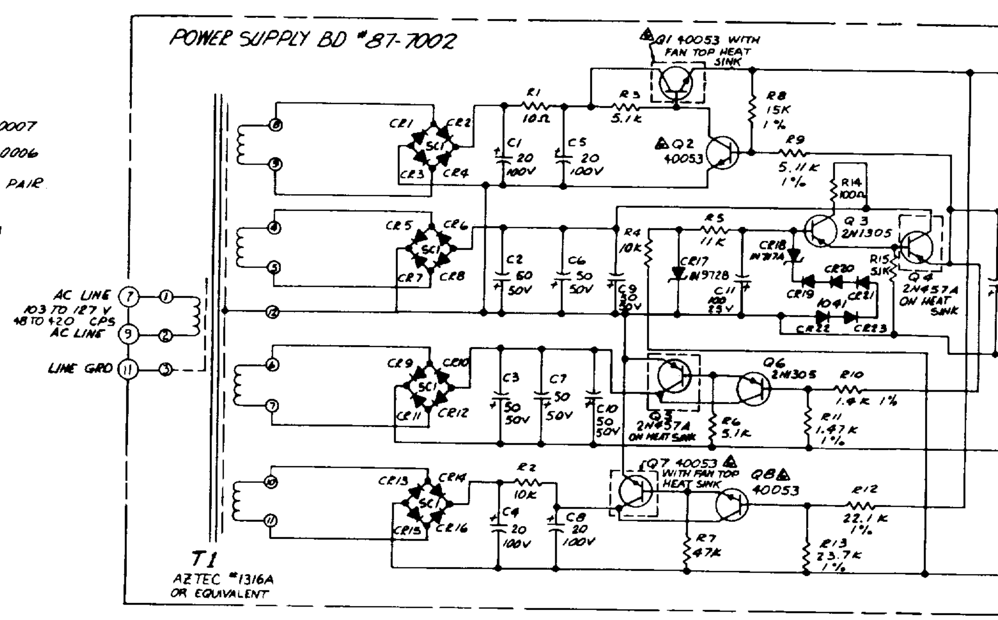


Figure 11. Power Supply Circuit Board Assembly





6. FOR 40053 TRANSISTOR CHECK SPEC. SEE 87-0007

5. FOR 56652 TRANSISTOR CHECK SPEC. SEE 87-0006

4. Q11 ON BD #87-7001 IS A SELECTED MATCHED PAIR.

3. REF. IDENTIFICATION FOR PIN 1 THRU PIN 20 ON INPUT ASSY #87-7003

PIN 1 -16 VOLTS POWER SUPPLY INPUT.
2 BIAS CURRENT INPUT
3 200 μA CONSTANT CURRENT INPUT
4 INNER-LOCAL FEEDBACK #2
5 OUTER-LOCAL FEEDBACK #2
6 OUTPUT #2
7 OUTPUT #1
8 OUTER-LOCAL FEEDBACK #1
9 INNER-LOCAL FEEDBACK #1
10 TO ZERO POTENTIOMETER.
11 TO ZERO POTENTIOMETER.
12 OVERALL FEEDBACK #1
13 OVERALL FEEDBACK #2
14 SIGNAL INPUT #1
15 +30 VOLTS FLOATING POWER SUPPLY.
16 COMMON LEVEL OUTPUT.
17 SIGNAL INPUT #2
18 REFERENCE INPUT
19 BIAS INPUT.
PIN 20 BIAS INPUT.

2. ALL RESISTANCE ARE 5%.

1. ALL CAPACITANCE ARE IN MICROFARADS.

NOTES: UNLESS OTHERWISE SPECIFIED.

Drawing No. 87-0500

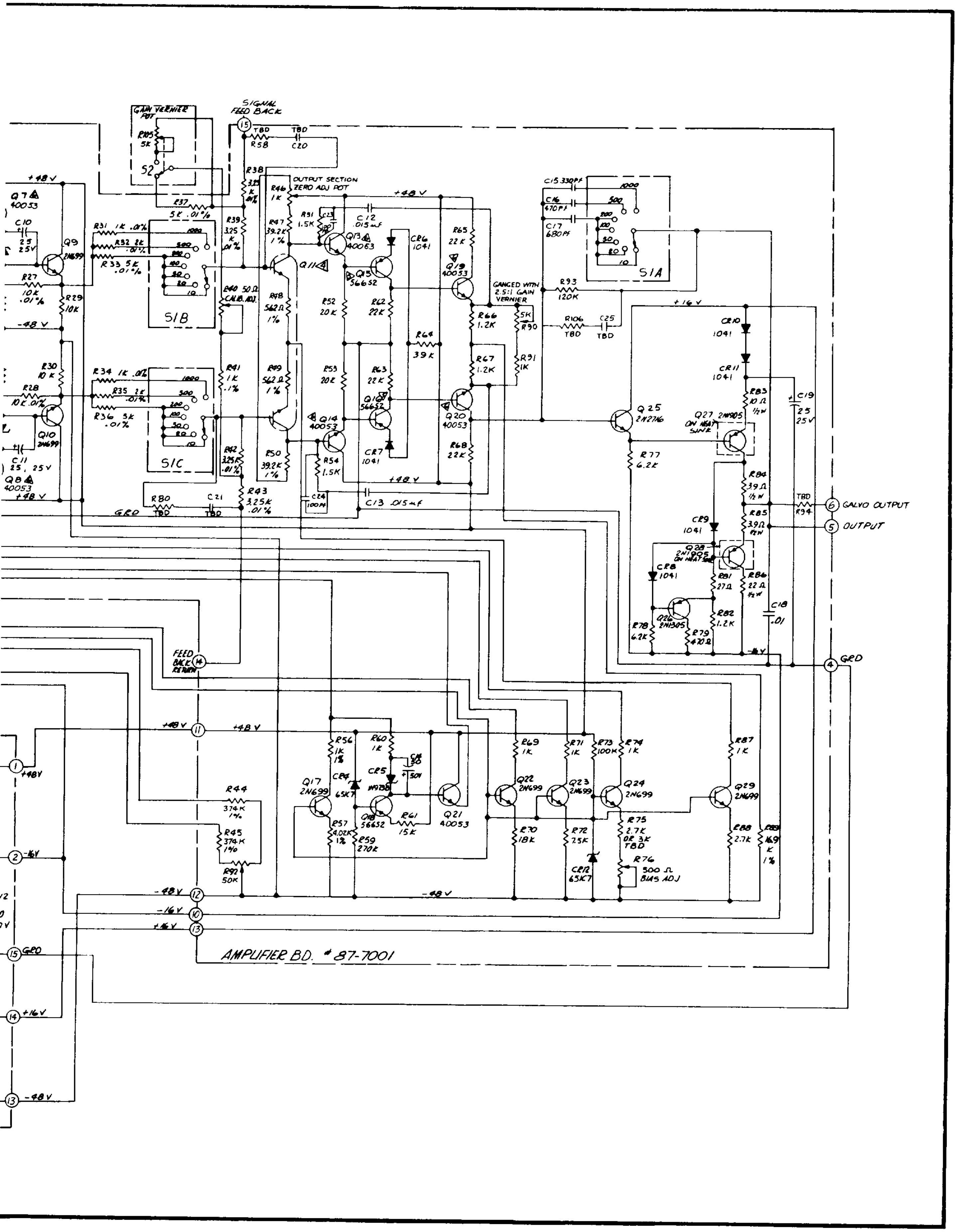
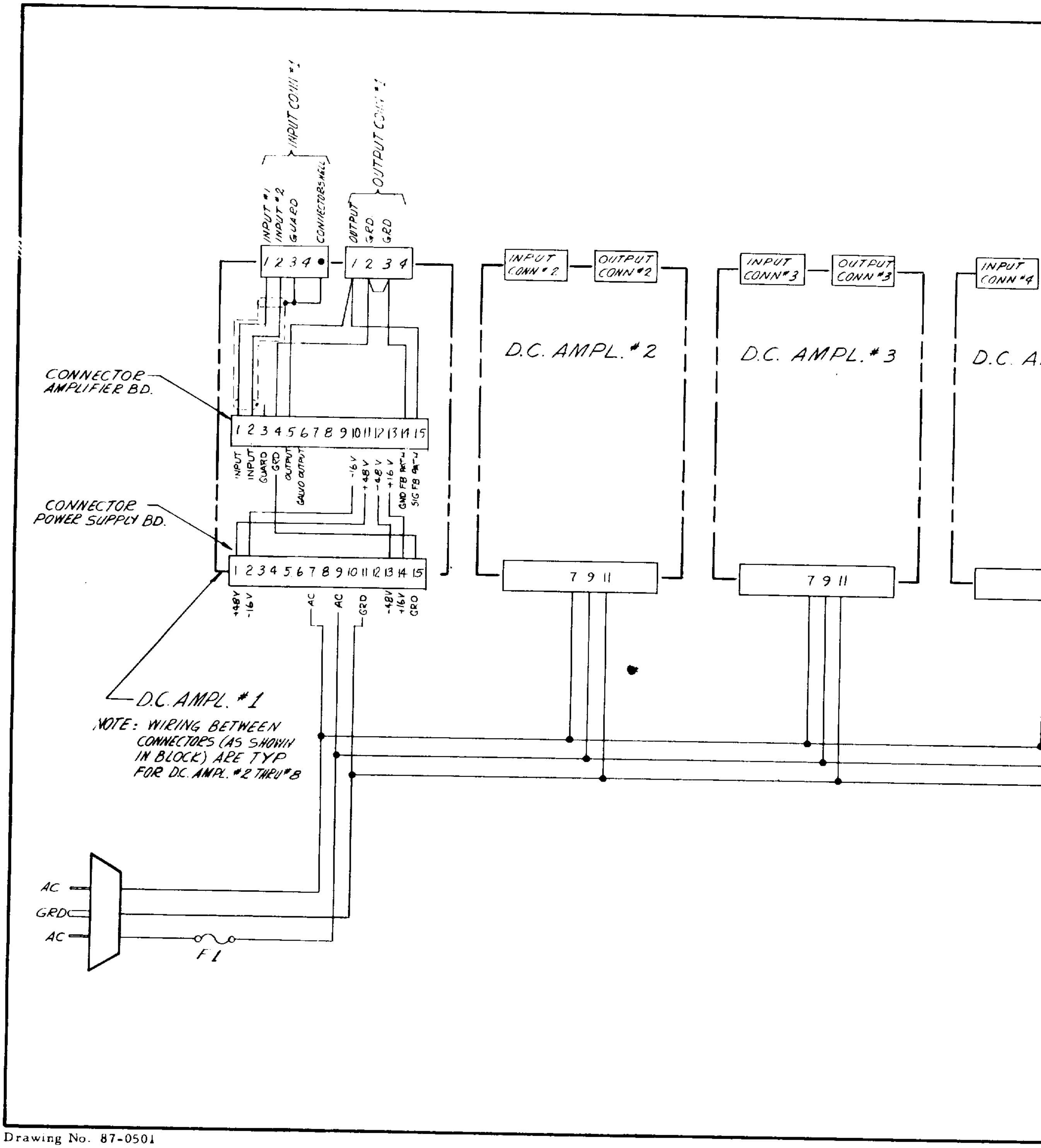


Figure 12. Schematic Diagram of Cubic Model 1300 Differential DC Amplifier

2



Drawing No. 87-0501

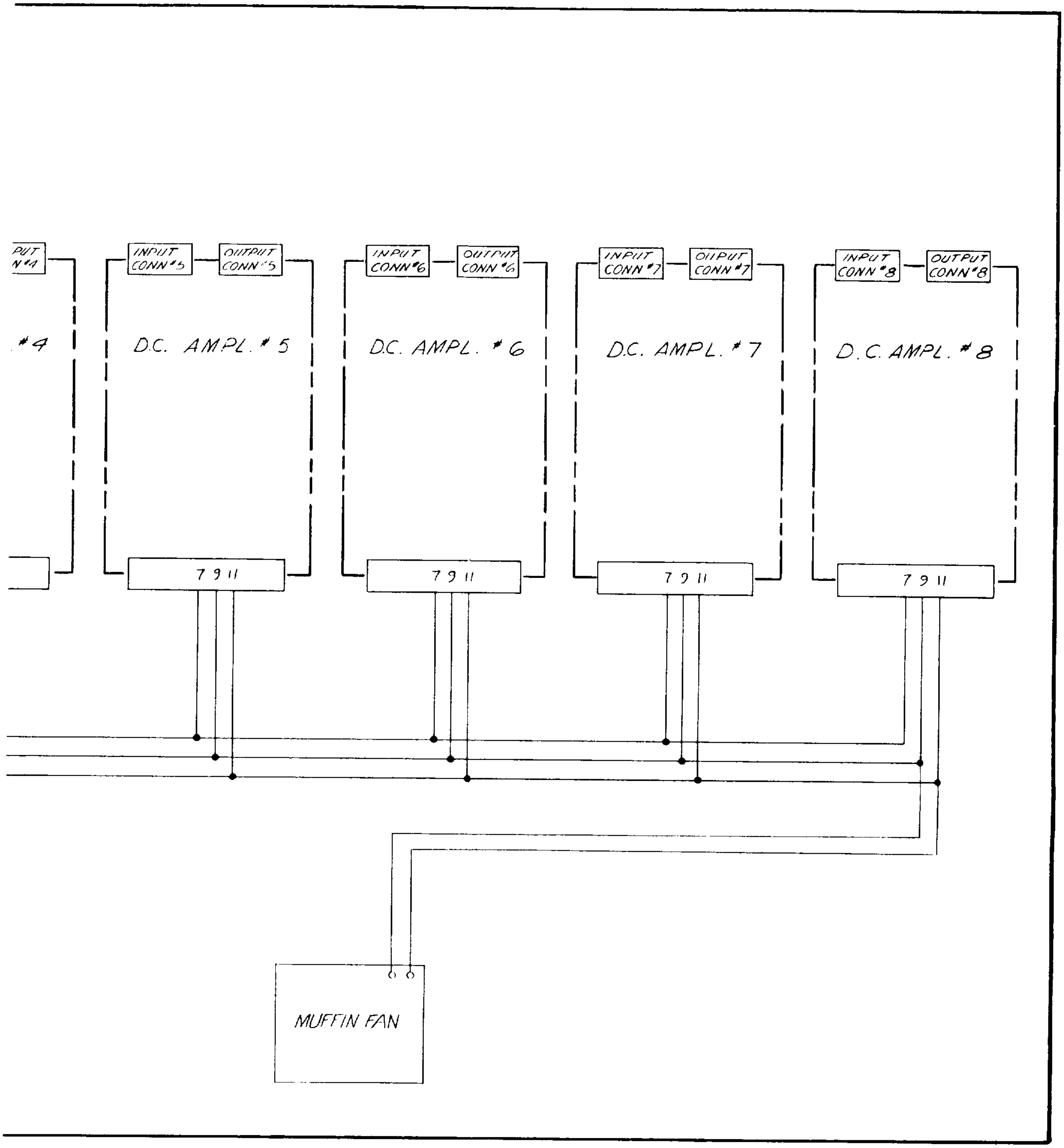


Figure 13. Wiring Diagram of Model 1390 Rack Mount Assembly

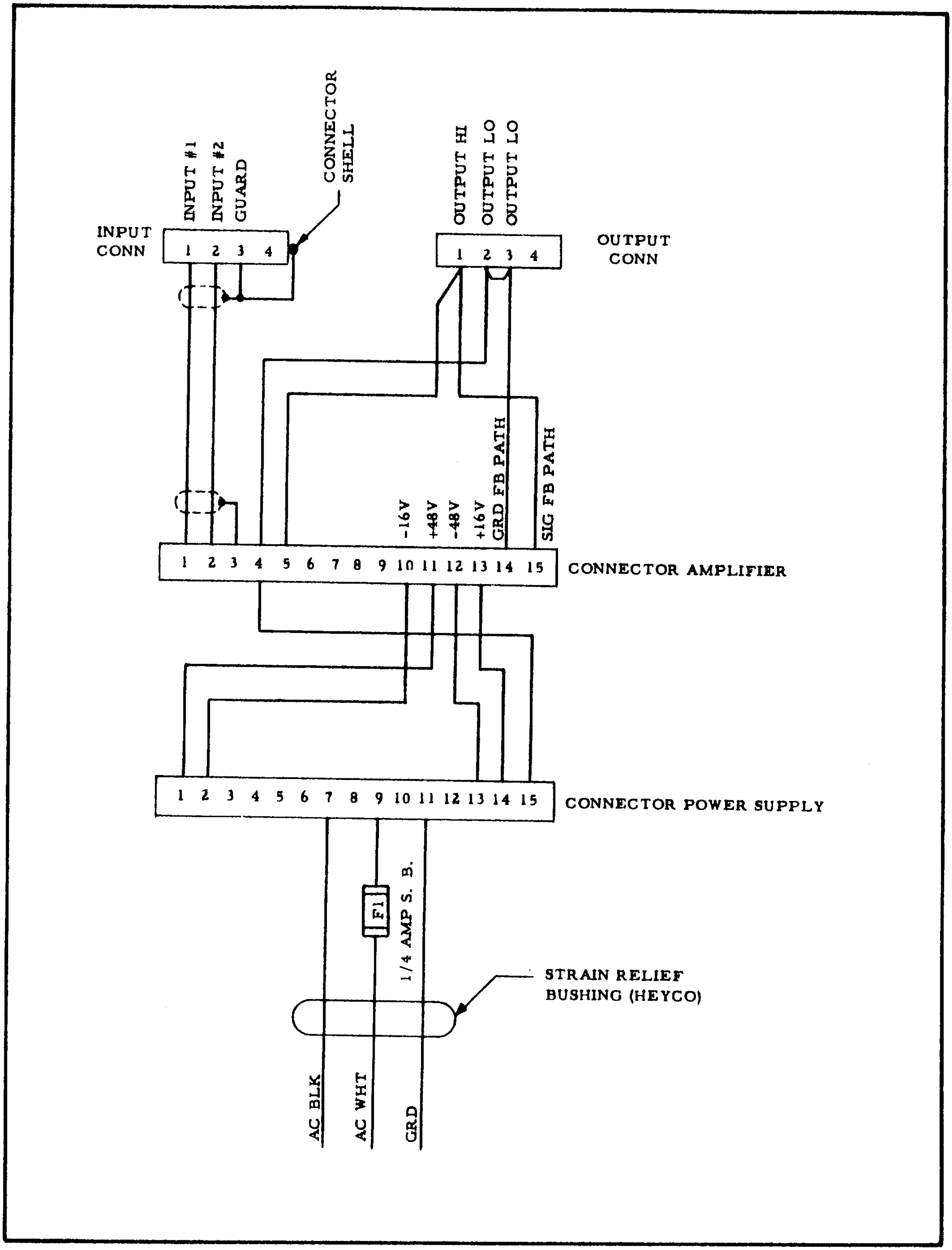


Figure 14. Wiring Diagram of Single Unit Adapter

ADDENDUM TO

Technical Manual 757225

INSTRUCTIONS FOR DIFFERENTIAL PREAMPLIFIER

This amplifier is now called the Honeywell Accudata 103.

I. CORRECTIONS:

Page 2-2, Figure 2-1 - Connectors J1 thru J8 should read:

Pin	Function
1	Ground
2	Input (Low)
3	Input (High)

Page 6-6 - DS7 should be DS1

II. 230 VOLT MODELS:

A 230 volt, 50 to 60 cps version of the Accudata 103 is now available. The manual requires the following changes to describe the 230 volt model:

Para. 1-3. SPECIFICATIONS

Power Requirements - Add: 230 volt; 50 to 60 cps.

Page 4-1, para 4-2. D. - Add to last sentence "or 230V; 50 to 60 cps."

Page 4-3, para 4-3. D. - Delete "105 to 129 vac."

PARTS LIST

Page 6-4 - Change to:

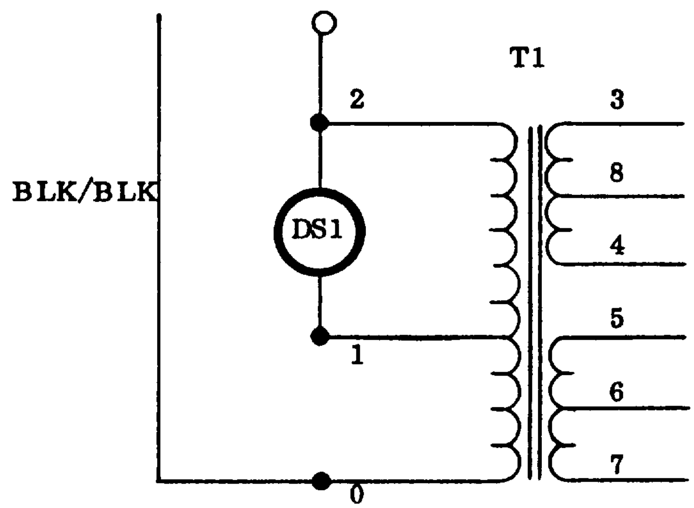
Differential Preamp Assy (120V)	790714-001
Differential Preamp Assy (230V)	790714-002

Page 6-5 - Change to:

A11 .	Power Supply Assy (120V)	756769-001	1
A11 .	Power Supply Assy (230V)	756769 002	1
T1 ..	Transformer, Power (120V)	756803-001	1
T1 ..	Transformer, Power (230V)	756803-002	1

SCHEMATIC

Add the following circuit diagram to show connections to the primary of the 230 volt transformer (T1):



TECHNICAL MANUAL

INSTRUCTIONS FOR

DIFFERENTIAL PREAMPLIFIER

AUGUST 1964

HONEYWELL - Denver Division - 4800 East Dry Creek Road - Denver, Colorado - 80217

757225

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LIST OF ILLUSTRATIONS

LIST OF TABLES

SECTION I

GENERAL DESCRIPTION

1-1. INTRODUCTION

This manual provides operation and maintenance information for the Honeywell Eight Channel Differential Preamplifier. The manual is divided into six sections. Section I, General Description, and Section III, Operation, provide pertinent procedures and information for both the operator and the maintenance man. Section II, Unpacking and Installation, contains special instructions for unpacking, installation, and repackaging the preamplifier. Components most likely to be damaged in shipment are indicated in this section.

Section IV, Theory of Operation, provides information essential to maintenance personnel to understand circuit functions; and is also of value to the operator seeking further knowledge of his equipment. Use the preamplifier schematic, located at the rear of the manual, as an aid when following circuit function discussions in Section IV.

Section V outlines routine inspection and maintenance procedures required to prolong the instrument life and to insure safe instrument operation. Section V also includes step-by-step trouble shooting procedures to be used for isolation of a defective component. Section VI contains the preamplifier detailed parts list.

1-2. DESCRIPTION

The Honeywell Eight Channel Differential Preamplifier provides eight separate transistorized preamplifier channels in a single chassis. Each amplifier couples a differential source to instruments requiring a single-ended input. Refer to Figure 1-1 for an outline and dimension drawing. The unit is ideally suited for use with Honeywell 8100 Portable Magnetic Tape Recorder/Reproducer, or any other magnetic tape system requiring a single-ended input and having input voltage limits matching the output of the preamplifier.

The instrument may also be used with unity voltage gain amplifiers such as the Honeywell Model T6GA Galvanometer Amplifier for driving oscillographic galvanometers.

Each channel of the Differential Preamplifier has a six position selector switch to provide an input and output shorting facility, and four gain positions. Two screwdriver adjust potentiometers provide each channel with adjustments for rejection of common-mode voltages, and setting the d-c level of the output. The front panel of the instrument also includes a power ON-OFF switch and a pilot lamp.

The Differential Preamplifier is suitable for either rack mounting or bench use. The instrument occupies 3-1/2 inches of panel space in a standard 19-inch relay rack. Rubber feet are provided for bench use.

The instrument employs the highest quality transistors and electronic components mounted on carefully designed circuit cards to provide clean, open construction. Corrosion resistant parts and quality workmanship throughout ensure a long instrument life with optimum performance. Each instrument is adjusted, tested, and inspected before leaving the factory. Only a reasonable amount of care and attention is required to maintain proper operation.

1-3. SPECIFICATIONS

Input Differential

Maximum voltage peak-to-peak: $\frac{20\ \text{v}}{\text{gain setting}}$ (Overloads of 500% will not damage the instrument.) To meet output specifications.

Common Mode Voltage

Inputs to ground: $\frac{150\ \text{v peak}}{\text{gain setting}}$ maximum.

Rear Panel Connectors

Eight input connectors (3-pin male) and one output connector (17-pin female); mating connectors are provided.

Power Requirements

105-129 v; 50 to 60 cps

Input Impedance

10K ohm minimum (X40 gain)
60K ohm minimum (other gain positions)

Frequency Response

DC to 40 kc with output amplitude constant ± 1 db.

Noise Referred to Output--DC to 10 kc Bandpass (Noise measured with shorted input)

1.0 mv p-p in X40 gain position
6 mv p-p in X10 gain position
3 mv p-p in X2 gain position
1.5 mv p-p in X1/2 gain position

Output Voltage

$\pm$10 v peak into 10K load; 2% maximum total distortion; output is single-ended with zero volts $\pm$50 mv offset; output may be shorted to ground without damage to the preamplifier.

Voltage Gain ($\pm$10%)

1/2, 2, 10, and 40 depending upon selector switch setting

Common Mode Rejection (Shorted Input)

60 db minimum at 60 cps
$\pm$5 v peak for X40 gain
$\pm$20 v peak for X10 gain
$\pm$75 v peak for X2 gain
$\pm$300 v peak for X1/2 gain

Gain Stability

Gain changes less than $\pm$2% with line voltage change of $\pm$10% at constant temperature.

Linearity

$\pm$2% maximum error; best straight line through zero (defining -2 v to +2 v as full scales).

Drift (Input shorted and constant line voltage)

Less than 6 mv/^{o}C at output

Crosstalk

20 mv rms output maximum with adjacent channel output of 10 volts p-p at 10 kc and measured channel with shorted input.

Environmental

Temperature: Operating 35^{o}F to 120^{o}F
Storage -30^{o}F to 185^{o}F
Humidity (operating): 90% relative humidity maximum

Dimensions (Refer to Figure 1-1)

Height: 3-1/2 inches
Width: 19 inches

Depth: 14-3/4 inches

Weight

11 pounds maximum

Case

Sheet metal; slotted screw holes provided for mounting in standard relay rack; top and bottom covers removable; rubber feet provided for bench use.

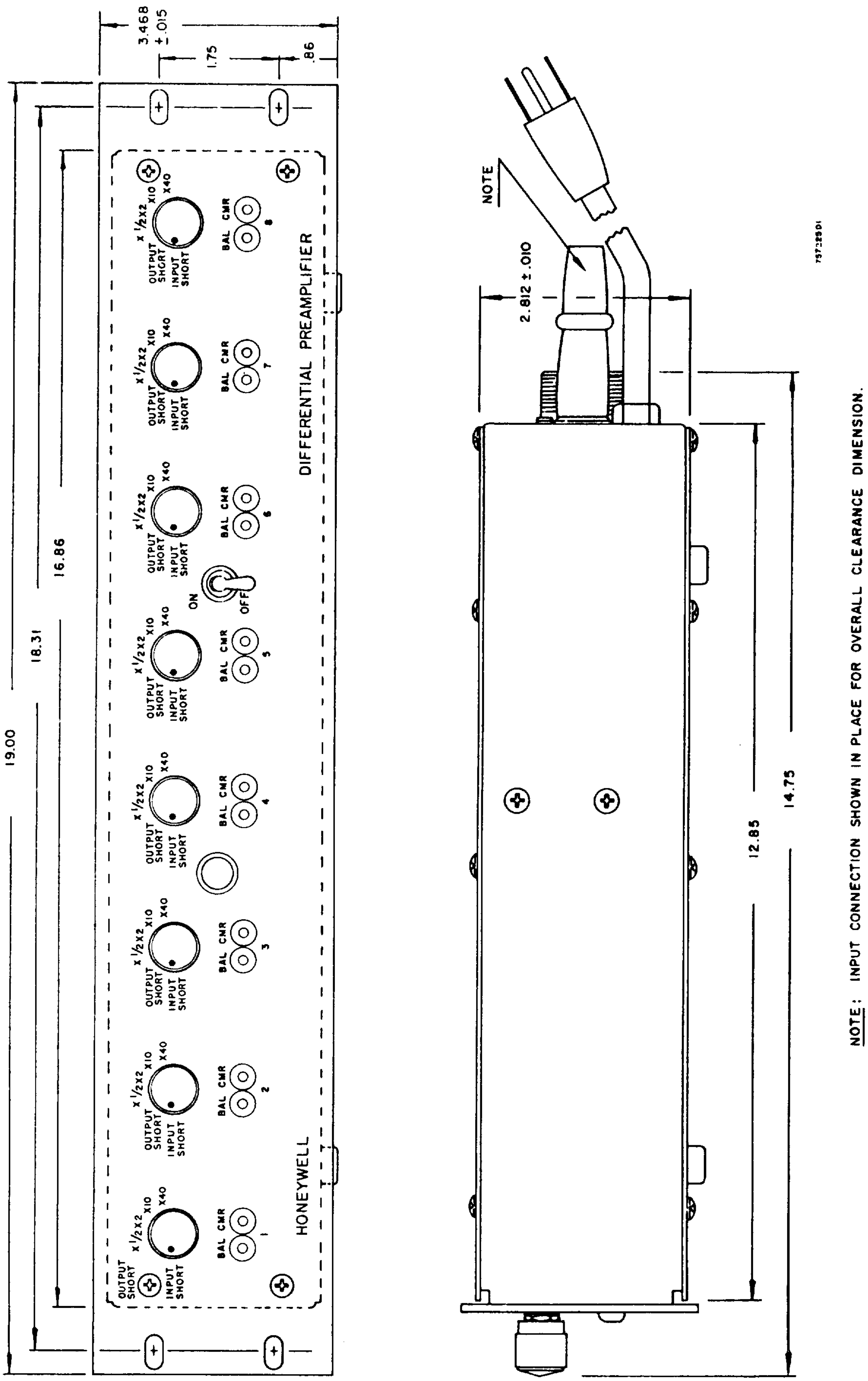


Figure 1-1. Outline and Dimension Drawing

SECTION II

UNPACKING AND INSTALLATION

2-1. UNPACKING

The Honeywell Differential Preamplifier is shipped in a single carton, wrapped and enclosed in padding if ordered above, or shipped in a relay rack if it is a component part of a system. Exercise care when unpacking the unit. After unpacking, examine the outside of the preamplifier for evidence of damage incurred during shipment. If there is no obvious external damage, remove the enclosure and check the physical condition of the circuit cards and components. If damage is found during this inspection, immediately file a claim with the carrier agency, stating the extent of damage.

2-2. INSTALLATION

The Differential Preamplifier operates on a bench or mounted in a standard 19-inch relay rack. If operated from a bench, place the amplifier on a firm level surface with adequate space for any associated equipment. Fabricate cables using the connectors supplied with the unit. All electrical connections are made to the amplifier on the rear panel.

To install the amplifier in a relay rack, slide the unit into the rack, placing the front panel flush with the rack. Use four mounting bolts to fasten the preamplifier to the rack. Make power and signal connections to the rear panel connectors.

2-3. SIGNAL CONNECTIONS

Separate input connectors (J1 through J8) are provided on the rear panel for the eight preamplifier channels. Output signals for all channels are taken from the OUTPUT connector J9. The front panel controls provide for shorting any input or output signal. Power is applied to the unit through a three-prong power plug and cable extending from the rear panel. Refer to Table 2-1 for connector pin identification.

2-4. OPERATIONAL CHECKOUT

To perform an operational checkout of the Differential Preamplifier, refer to Section III, paragraph 3-3 for proper test procedure.

2-5. REPACKAGING

Should it become necessary to ship the instrument to another destination or to return it to the factory, package the instrument according to the following instructions:

1. Place the preamplifier in a heavy corrugated cardboard inner carton having approximately the same inside dimensions as the outside instrument dimensions.

2. Pack dunnage on all sides of the instrument, filling and tightly packing all open areas.

3. Seal the inner carton and place it in a heavy corrugated outer carton. The outer carton should be large enough to allow a minimum of two inches for dunnage on all sides of the inner package.

4. Tightly pack dunnage between the inner and outer cartons, making certain that no voids remain.

5. Seal the package and mark FRAGILE. Check with the carrier agency to insure the above packaging procedure meets regulations and packaging specifications.

CONNECTORS J1 THRU J8		CONNECTOR J9	
Pin	Function	Pin	Function
1	Input	A	Channel 1 Output
2	Input	B	Channel 1 Ground
3	Ground	C	Channel 2 Output
		D	Channel 2 Ground
		E	Channel 3 Output
		F	Channel 3 Ground
		G	Channel 4 Output
		H	Channel 4 Ground
		J	Channel 5 Output
		K	Channel 5 Ground
		L	Channel 6 Output
		M	Channel 6 Ground
		N	Channel 7 Output
		P	Channel 7 Ground
		R	Channel 8 Output
		S	Channel 8 Ground

Table 2-1. Connector Pin Identification

SECTION III

OPERATION

3-1. GENERAL

This section describes controls, connectors, and operating procedures, including adjustment and operational checkout information. The user should be thoroughly acquainted with these procedures before operating the preamplifier.

3-2. DESCRIPTION OF CONTROLS AND CONNECTORS

A. FRONT PANEL CONTROLS. Refer to Figure 3-1. The following controls are located on the front panel of the Differential Preamplifier and perform the functions listed. Paragraph numbers coincide with index numbers of Figure 3-1.

1. Operation Selector Switch. One for each preamplifier channel. A six position rotary switch that selects four gain positions (X1/2, X2, X10, and X40) plus INPUT SHORT and OUTPUT SHORT. INPUT SHORT is used during balance adjustment, and OUTPUT SHORT is used to ensure zero volts input at the unit following the preamplifier during calibration.

2. BAL (Balance) Screwdriver Adjustment. One for each preamplifier channel. Sets the d-c level of the channel output to zero volts with no input.

3. CMR (Common Mode Rejection) Screwdriver Adjustment. One for each preamplifier channel. Balances out any unbalanced input source resistance.

4. Power ON-OFF Switch. A two position switch that applies 105 to 129 volts ac to the preamplifier power supply. The front panel power lamp lights when power is applied to the preamplifier.

B. REAR PANEL CONNECTIONS. All input and output signal connections and the power input are located on the rear panel of the Differential Preamplifier. Refer to paragraph 2-3 for pin connections.

3-3. OPERATING PROCEDURE

Place the desired preamplifier channels into operation according to the following procedure:

A. SET CONTROLS

1. Power Switch to OFF

2. Operation Selector Switch to INPUT SHORT

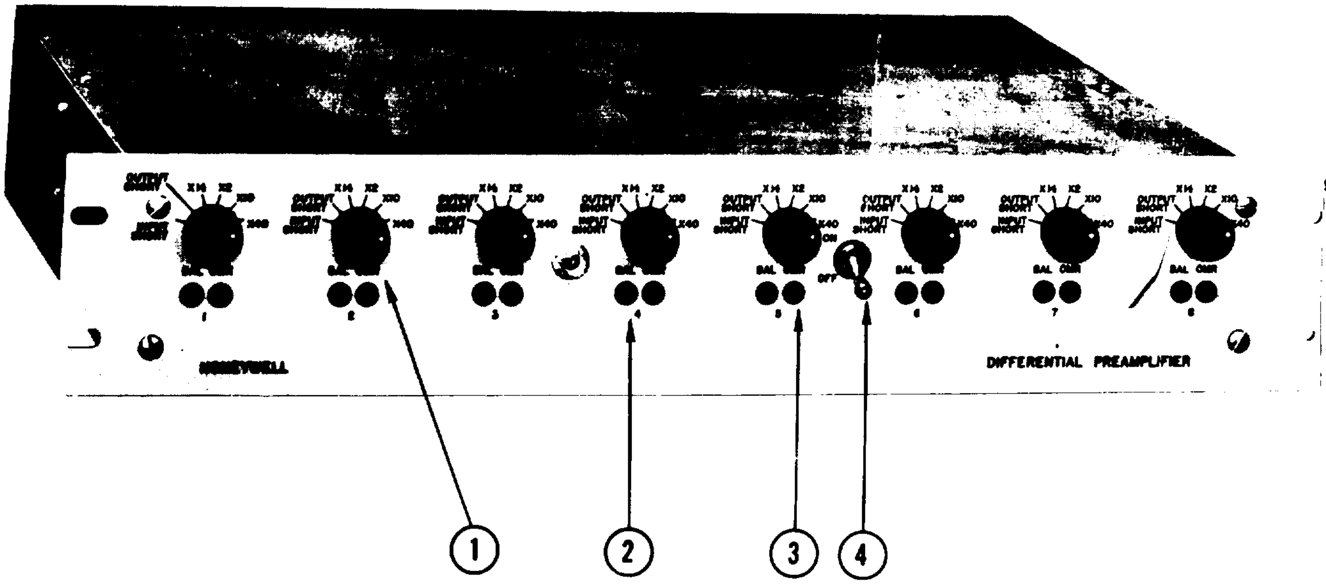


Figure 3-1. Differential Preamplifier Controls

B. AMPLIFIER OUTPUT CONNECTIONS. Make the necessary output connections to preamplifier output connector J9. Refer to Table 2-1 for J9 connector pin identification. If using the unit to drive galvanometers in a Visicorder oscillograph, refer to the associated amplifier manual for input connections to that unit. When used with the Honeywell 8100 Portable Magnetic Tape Recorder/Reproducer, or any other magnetic tape system, refer to the associated tape recorder manual for input connection informat on. If cable fabrication is necessary, use mating connector AN3106A-20-29 P (Honeywell part number 100581).

C. AMPLIFIER INPUT CONNECTIONS. Connect the differential source to the desired preamplifier channel input connector (J1 through J8) on the rear panel of the unit. Signal connections are made to pins 2 and 3 with pin 1 grounded. If fabricating an input cable, use the three socket receptacle (Honeywell part number 200413) supplied with the preamplifier.

D. POWER INPUT CONNECTIONS. The power cable plugs into a 105-129 volt rms; 50 to 60 cps outlet designed to accommodate a standard three prong grounding-type plug. The cable may also be used with an adapter to fit standard two terminal outlets by connecting the adapter pigtail lead to ground. When used as a component part of a Honeywell system, power may be supplied by a Main Power Panel.

E. WARMUP AND BALANCE. For maximum stability and accuracy, energize the preamplifier one-half hour before operation. At the end of the warmup period, perform the following preamplifier balance procedure:

1. With the differential input signal source connected, attach a d-c voltmeter capable of indicating 10 volts to the proper channel output pins of connector J9.

2. Set the Operation Selector Switch to INPUT SHORT.

3. Using a screwdriver, adjust the BAL control for a voltage indication of zero (± 50) mv.

F. COMMON-MODE REJECTION. Common-Mode Rejection in db equals 20 $\log_{10}$ of $\frac{CMV_{in} \times Gain}{CMV_{out}}$. To adjust rejection of common-mode voltages, perform the following:

NOTE

Re-adjust balance (paragraph E) after performing common-mode rejection adjustment.

1. Refer to Figure 3-2. Short pins 3 and 2 of the desired channel input connector, and attach an a-c signal generator as shown.

2. Connect an oscilloscope to the channel output. Refer to Table 2-1 for proper pin connections.

3. Set the Operation Selector Switch to the desired gain position and adjust the signal generator to provide the desired trace amplitude on the oscilloscope.

4. Using a screwdriver or alignment tool, adjust the CMR control for maximum rejection (minimum voltage level on the oscilloscope).

5. Remove short from pin 2 and 3, and disconnect test equipment.

NOTE

Source impedance changes may affect both the CMR and BAL adjustments. Both should be reset whenever changing differential signal sources.

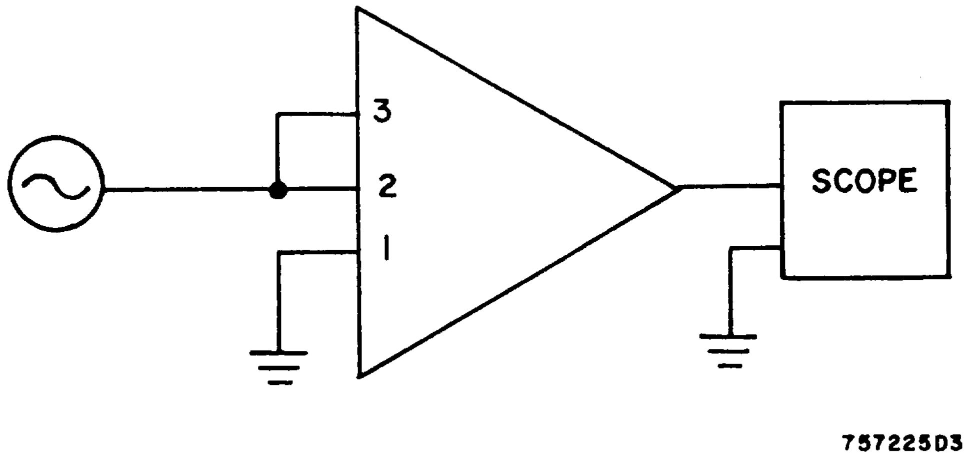


Figure 3-2. CMR Adjustment Circuit

G. GAIN SETTING. Before placing the amplifier in operation, select the gain setting with the Operation Selector Switch according to the peak-to-peak level of the input signal. Determine the proper gain setting using Table 3-1.

Gain Setting	Max. P-P Input Signal
40	0.5 volts
10	2 volts
2	10 volts
1/2	40 volts

Table 3-1. Gain Settings

H. POWER SUPPLY. Adjust the power supply voltage as follows:

1. Connect a d-c voltmeter to power supply circuit card eyelets 8 and 16, and adjust R2 for negative 20(±0.5) vdc reading.

2. Remove voltmeter lead from eyelet 8 and connect it to eyelet 7. Adjust R9 for positive 20(±0.5) vdc reading.

SECTION IV

THEORY OF OPERATION

4-1. GENERAL

This section describes the Differential Preamplifier theory of operation, both for Basic Operational Description, and Detailed Operational Theory. The Basic Operational Description discusses the overall function of the three basic stages within each preamplifier channel, while the Detailed Operational Theory describes component functions within the stages.

4-2. BASIC OPERATIONAL DESCRIPTION

A. GENERAL. The Differential Preamplifier is a signal conditioning device which couples or matches a differential output signal source to a unit requiring a single-ended input. The preamplifier consists of eight identical channels, and serves primarily to couple the output of Honeywell medical amplifiers to the input of a tape recorder, while providing a voltage gain. Each preamplifier channel consists of two functional sections: (1) Input Attenuator, (2) Amplifier. The single Power Supply is common to all eight channels. Refer to the schematic diagram at the rear of this manual.

B. INPUT ATTENTUATOR. The Input Attenuator (A1 through A8) provides attentuation of the input signal by use of a four-position resistance voltage divider mounted on a six-position rotary switch (S1 through S8). Two additional switch positions shunt the amplifier input and output to ground for calibration purposes.

C. AMPLIFIER. The amplifier is a direct-coupled d-c differential amplifier with high common-mode rejection and single-ended output. The output capability of the amplifier is ± 10 volts with a frequency response from dc to 40 kc at a fixed voltage gain of 40. Two amplifier controls are located on the preamplifier front panel: A BAL (Balance) control and a CMR (Common-Mode Rejection) control. Both controls are screwdriver adjustments to set the d-c level of the amplifier output and to provide maximum common-mode rejection. The eight amplifiers mount on two circuit cards (A9 and A10).

D. POWER SUPPLY. The Power Supply (All) is a separate sub-assembly supplying regulated positive and negative 20 vdc to all eight amplifiers. The line voltage input to the power supply is 105 to 129 v, 50 to 60 cps.

4-3. DETAILED OPERATIONAL THEORY (Refer to the schematic diagram at the rear of this manual.)

A. INPUT ATTENUATOR. The input attenuator is a four-position resistive voltage divider providing gain divisions of X1/2, X2, X10, and X40. The differential input is applied across pins 2 and 3 of each channel input connector (J1 through J8). Pin 1 is grounded. The d-c input signal passes through this symmetrical voltage divider, dividing both differential input leads. With the Operation Selector Switch (S1 through S8) set for a gain of X40, the differential input passes directly to the amplifier input through resistors R1 and R2 with no attenuation. R7 and R3 are added to the circuit in the X10 position; R8 and R4 are added in X2 position; and R9 and R5 are added in X1/2 position of S1 through S8. The maximum peak-to peak input differential equals 20 v divided by the gain position used.

B. AMPLIFIER. The amplifier assembly is a two-stage, transistorized differential amplifier followed by a single-ended power stage. Overall feedback is applied to the amplifier, stabilizing the gain and drift characteristics, and improving the gain linearity. Because all channel amplifiers are identical, only one channel will be discussed.

The input signal is applied to the amplifier through the following eyelets on the circuit cards (A9 and A10):

AMPLIFIER	EYELETS
1	1 and 2
2	41 and 10
3	12 and 11
4	17 and 18

The signal is direct-coupled from the input coupler circuit to the base of transistors Q1 and Q2. Q1 and Q2 are a matched pair of NPN silicon planar transistors, potted in an aluminum heatsink. The H_{fe} and V_{BE} are matched, with the heatsink and potting material minimizing the thermal gradients between the transistors, so that H_{fe} and V_{BE} remain matched as temperature varies. The matched transistor parameters and design of the heatsink provide the low drift characteristics of the overall amplifier. CMR potentiometer R1 balances out any unbalanced source resistance, providing equal common-mode voltages at the bases of Q1 and Q2.

Transistor Q3 serves as a controlled current source to stabilize the emitters of the first stage transistors Q1 and Q2. Q3 offers a high impedance to the first stage, thereby providing optimum common mode rejection. BAL control R4 compensates for the effect of small differences through the amplifier. The BAL control is normally adjusted with the selector switch in the INPUT SHORT position. It may be used to set zero volts output for zero volts input, or to balance out the effect of a small d-c differential signal present at the input terminals. Resistors R8, R9, and R10 provide fixed bias for Q3.

The first stage signal is direct-coupled to the bases of second stage transistors Q4 and Q5, with Q6 serving as the controlled current source. The output feeds directly to the base of transistor Q7. Resistor R18 serves as a short circuit protector, allowing a maximum of 20 ma to pass through Q7, with the emitter shorted to ground. Feedback resistor R7, and balance resistor R11 provide gain stability with minimum d-c drift.

The combined use of NPN and PNP transistors provides a voltage translation, maintaining a zero output with zero volts applied to the first stage. The output capability of the amplifier is positive and negative 10 volts, and has a frequency response from dc to 40 kc with a fixed voltage gain of 40.

The amplifier output is taken from the following circuit card eyelets:

AMPLIFIER	EYELET
1	5
2	7
3	14
4	18

C. POWER SUPPLY. The 105 to 129 vac line voltage is applied to transformer T1 from three prong a-c power connector P1. The transformer secondary voltage enters the rectifier-filter-regulator circuitry on the circuit card (A11) through eyelets 2 and 3 for the negative supply, and 10 and 11 for the positive supply. As both supplies are identical, only the negative supply is discussed.

Diodes CR1 and CR2 provide full-wave rectification, placing unregulated d-c voltage (approximately 35 vdc) across filter capacitor C3. Resistor R7 and zener diode VR2 provide a constant 24 volts dc to the regulator circuitry. Resistor R6 is a load resistor for common emitter transistor Q3. Capacitor C1 ties across the base-to-collector of Q3 to reduce possible high frequency oscillations. VR1 provides a regulated reference voltage of 6.2 vdc at the emitter of Q3. Changes in output voltages across the voltage divider, consisting of R1, R2, and R3, affect the collector current of transistor Q3. The change in collector current regulates series-pass transistor Q1, which compensates for the output voltage change. This provides a regulated negative 20 vdc at eyelets 8 and 9 of the circuit card.

Resistor R5 provides a leakage path for Q2 and Q1 as their temperature increases. The positive output is at eyelets 6 and 7.

SECTION V

MAINTENANCE

5-1. GENERAL

This section contains procedures necessary for the technician to maintain the Differential Preamplifier in an operating condition. These procedures include inspection and cleaning of the preamplifier for preventative maintenance, corrective maintenance for component malfunction isolation, repair and replacement for malfunction correction after trouble shooting, and testing after repair.

This information aids the technician in determining the locality of a malfunction, but does not go into lengthy detail explaining corrective action to be taken upon localizing the defect. Using the schematic at the rear of this manual, the technician should utilize his training and experience to determine the best method for correcting the malfunction.

5-2. INSPECTION

The preamplifier incorporates all solid state circuitry and requires little or no routine maintenance; however, visual inspection of the following components during corrective maintenance or initial installation may lead to longer operating life with less discrepancies. Perform repair and replacement procedures (paragraph 5-5) as required from visual inspection.

A. CONNECTORS. Inspect all connectors and plugs for broken or bent pins, cracked insulation, and loose or broken leads.

B. SWITCHES. Inspect all switches for binding, contact corrosion or burnishing, and bent or broken leads.

C. CIRCUIT CARDS. Inspect circuit cards for proper solder connections, burned components, and loose or broken copper clad. Inspect the power supply for evidence of arcing, indicating transformer or capacitor breakdown.

5-3. CLEANING

Remove dust and loose dirt from the unit with a brush and a vacuum hose. Remove any dirt deposits, grease, or oil with a cloth moistened with any commercial dry cleaning solvent (petroleum solvent). Clean all other metal parts with trichlorethylene. Clean non-metallic parts with a lint-free cloth moistened with plain water.

5-4. CORRECTIVE MAINTENANCE

GENERAL. Malfunctions within the preamplifier are normally indicated by no output, or improper gain. Refer to preamplifier specifications in paragraph 1-3. Whenever a malfunction is noted for a channel within the preamplifier, remove the unit from the Rack Assembly and perform a visual inspection (paragraph 5-2). If visual inspection fails to pinpoint the defect, proceed with the applicable trouble shooting procedures listed in this paragraph.

NOTE

If proper test facilities and equipment are not available to thoroughly trouble shoot and repair the preamplifier, contact your local Honeywell Sales and Service representative. Honeywell branch offices are staffed with factory trained engineers, equipped to make effective repairs in the minimum amount of time.

A. TEST EQUIPMENT. The tools and test equipment recommended for trouble shooting the preamplifier are listed in Table 5-1; however any equivalent test equipment that will indicate within component and specification tolerances will suffice.

MANUFACTURER	MODEL NO.	DESCRIPTION
Hewlett-Packard	202A	AC Source
John Fluke	803	AC-DC Differential Voltmeter
Tektronix	531	Oscilloscope
Triplett	630-NA	Multimeter
Unger	30-Watt	Soldering Iron Bench Test Adapter Cable Standard Shop Tools

Table 5-1. Recommended Tools and Test Equipment

B. TROUBLE SHOOTING. The following paragraphs and tables list trouble shooting procedures for the preamplifier power supply and the attenuator and amplifier within each preamplifier channel. Each channel is identical, therefore trouble shooting procedures for one channel will be the same for channels.

Before trouble shooting the preamplifier, the maintenance man should thoroughly acquaint himself with the theory of operation by reviewing Section IV. Use the schematic at the rear of this manual and the wiring diagram in Section VI as an aid for trouble shooting. When locating a defect, refer to paragraph 5-5 for proper repair and replacement procedures.

1. Power Supply. The single power supply (A11) is common to all preamplifier channels; therefore, a power supply malfunction should affect all channels. Refer to Table 5-2 for possible causes of power supply malfunctions. Because of negative supply and positive supply similarity, the table only covers the negative supply.

SYMPTON	POSSIBLE CAUSE	REMEDY
No power supply output and power lamp DS1 not lighted.	No input power from Rack Assembly; open plug P1; defective switch S9.	Repair defective wiring; repair or replace Pl; replace S9.
Excessive a-c ripple at eyelet 8.	Open C3 or VR2. Shorted CR1 or CR2.	Replace Cl or VR2. Replace CR1 or CR2.
High frequency oscillations at eyelet 8.	Open C1.	Replace C1.
Zero vdc at eyelet 8.	Open T1; defective Q1, Q2, or Q3; shorted C3; open R7, R6, R1, R2, or R3.	Replace defective component.
No apparent d-c regulation.	C1 shorted.	Replace C1.
Voltage at eyelet 8 not within 20($\pm$0.5) vdc.	Misadjustment of R2. Open or shorted VR1 or R4.	Adjust R2. Replace VR1 or R4.

Table 5-2. Power Supply Trouble Shooting

2. Amplifier and Attenuator. A single channel malfunction indicates a defective amplifier or attenuator within that channel. To ensure that the fault lies within the channel rather than the input source, disconnect the input cable from the applicable channel connector (J1 through J8) and connect it to another channel, maintaining the same gain setting. If improper output still exists, the fault lies in the input source or input cabling. If the output is correct, reconnect cables to proper channel connections and proceed with defective channel as follows:

   a. Disconnect output cable from connector J9 and check for proper output signal on applicable pin of J9. Refer to Table 2-1 for channel output connections to J9. A proper output signal indicates a faulty output load. Correct the malfunction in accordance with instruction manual for that unit.

b. Reconnect output cable to J9. Perform CMR and BAL adjustments on a good channel. (Refer to paragraphs 3-3F and E.) Set Operation Selector Switches for the defective channel and the good channel to X1/2. Connect the a-c source to pins 2 and 3 of the two input connectors. Using an oscilloscope and voltmeter, trouble shoot the defective channel by comparing indications with those found at the identical locations of the good channel. Isolate defective component and replace. Refer to Table 5-3 for amplifier voltages at various locations with the Operation Selection Switch set to INPUT SHORT.

LOCATION	VOLTAGE (DC)
Q1 or Q2 - E	-0.6
- B	0
- C	12
Q3 - E	-9.4
- B	-10
Q4 or Q5 - E	12.6
- B	12
- C	-0.6
Q6 - B	4
Q7 - E	0
- C	20

Table 5-3. Amplifier Nominal Voltages

5-5. REPAIR AND REPLACEMENT.

A. GENERAL. TheDifferential Preamplifier contains no repairable components; therefore repair consists only of resoldering loose or broken connections and reconnecting loose wiring. Remove and replace defective components or those failing to meet inspection requirements.

Section VI contains a complete listing of replacement parts. To ensure safe, efficient preamplifier operation, use only parts that meet the electrical characteristics and tolerances listed.

B. SWITCHES. Remove and replace a switch assembly by first removing the preamplifier top cover and front panel. Unsolder and tag leads to assembly, and remove switch by disengaging knob socket head screws and unscrewing holding nut.

C. CIRCUIT CARDS. Exercise caution when removing or replacing components from the preamplifier circuit cards, especially where a component has multiple pins and each pin must be unsoldered individually to remove the component. Too much heat applied to a small area may scortch the copper clad and loosen it from the board. To remove or replace circuit card components, use an iron of the Unger type with no more than a 30-watt tip. Dip the end of a braided shield or ground type strap in solder flux, and place the flux end of the strap over the point where solder is to be removed. Then place the iron on the strap, directly over the terminal. Capillary action will draw the solder from the hole into the strap.

If necessary to remove a complete amplifier circuit card, first remove the preamplifier top and bottom covers and front panel. Then unsolder and tag all eyelet leads, and remove circuit card by unscrewing six screws.

5-6. TESTING.

After completion of corrective maintenance, check the preamplifier for proper operation in accordance with paragraphs 1-3 and 3-3.

SECTION VI

PARTS LIST

6-1. GENERAL

This section presents an electrical parts list by assembly sequence. Parts of a particular assembly are indented and listed directly below the assembly listing. The following listing explains the columns as used in the parts list.

A. Figure Number: The number refers to an illustration locating a particular item. All circuit card components are clearly marked on the card; therefore only the switch assembly diagram and wiring diagram are illustrated in Figures 6-1 and 6-2.

B. Index Number: Refers to the number on the associated illustration identifying the particular item.

C. Schematic Reference: Lists schematic reference designations of electrical components in alpha-numerical order by assembly.

D. Description: The name and description of the item appear in this column.

E. Manufacturer and Part Number: This column lists the suggested manufacturer and the manufacturer's part number of all items that can be purchased directly from the manufacturer. In some cases more than one manufacturer can supply the part, but only one is listed. If there are questions concerning alternate suppliers, please contact Honeywell-Denver Division.

F. Honeywell Part Number: This column lists the number under which an item or assembly may be ordered directly from Honeywell-Denver Division.

G. Quantity per Unit: This column reflects the total quantity of each item used in the instrument.

H. Spares: This column reflects the number of spares recommended to maintain the equipment.

6-2. LIST OF MANUFACTURERS.

Abbreviated manufacturers' names used in the parts list are listed below with complete name and address.

A-B	Allen-Bradley 136 W. Greenfield Ave. Milwaukee 4, Wisconsin
Ark-Les	Ark-Les Switch Corporation 51 Water Street Watertown, Massachusetts
Bourns	Bourns Labs Incorporated 6135 Magnolia Avenue Riverside, California
Cannon	Cannon Electric Company 3208 Humbolt Street Los Angeles 31, California
CTS	CTS Corporation 1142 W. Beardsley Elkhart, Indiana
Dial Light	Dial Light Corporation 60 Steward Avenue Brooklyn 37, New York
GE	General Electric Semiconductor Products Electronic Park Syracuse, New York
Good All	Good All Electric Co. 112 W. 1st Street Ogallalla, Nebraska
IRC	International Resistance Corp. Burlington, Iowa
Mallory	Mallory Capacitor Box 372 Indianapolis, Indiana
Motorola	Motorola Semiconductor P.O. Box 2929 Phoenix 2, Arizona
National	National Semiconductor Danbury, Connecticut

Ohmite	Ohmite Manufacturing Co. 3604 Howard Street Skokie, Illinois
TI	Texas Instruments P.O. Box 1964 Dallas 21, Texas

6-3. PARTS LIST

See the following pages

References			Description	Manufacturer and Part Number	Honeywell Part No.	Qty/ Unit	Spares
Fig.	Index	Schem.					
			DIFFERENTIAL PREAMPLIFIER ASSY		790714-001	1	
6-2		A1 thru A8	. Switch Assy		756805-001	8	
6-2		R1, R2	.. Resistor, Film, 499, 0.5W, 1%	IRC, Type CEC T-O	750093-052	2	
6-2		R3, R7	Resistor, Film, 43.2K, 0.5W, 1%	IRC, Type CEC T-O	750093-054	2	
6-2		R4, R8	Resistor, Film, 29.4K, 0.5W, 1%	IRC, Type CEC T-O	750093-055	2	
6-2		R5, R9	Resistor, Film, 3480, 0.5W, 1%	IRC, Type CEC T-O	750093-075	2	
6-2		R6, R10	Resistor, Film, 1000, 0.5W, 1%	IRC, Type CEC T-O	750193-026	2	
6-2		S1 thru S8	Switch, Rotary, 2P6P	CTS, 52455	756806-001	8	1

References			Description	Manufacturer and Part Number	Honeywell Part No.	Qty/ Unit	Spares
Fig.	Index	Schem.					
6-1		A9, A10	. Circuit Card Assy, Amplifier*		756053-001	2	
			.. Circuit Card, Amplifier		756052-001	1	
		Q1-Q2	Transistor Assy, Matched Pair		756914-001	4	
		Q3	Transistor	GE, 2N2712	756115-002	4	
		Q4, Q5, Q6	Transistor	National, NS663	756514-001	12	
		Q7	Transistor	National, NS734	756515-001	4	
		R1	Resistor, Variable, 50K, 0.2W, 20%	Bourns, 3068P-1-503	754523-003	4	1
		R2, R6, R9, R10	Resistor, Film, 5110, 0.5W, 1%	IRC, Type CEC T-O	750093-075	16	
		R3, R5	Resistor, Film, 348, 0.5W, 1%	IRC, Type CEC T-O	750093-010	8	
		R4	Resistor, Variable, 100, 0.5W, 10%	Bourns, 3067P-1-101	750059-006	4	1
		R7, R11	Resistor, Film, 20K, 0.5W, 1%	IRC, Type CEC T-O	750093-050	8	
		R8	Resistor, Film, 3010, 0.5W, 1%	IRC, Type CEC T-O	750093-076	4	
		R12, R13	Resistor, Film, 15K, 0.5W, 1%	IRC, Type CEC T-O	750093-049	8	
		R14, R18	Resistor, Film, 1K, 0.5W, 1%	IRC, Type CEC T-O	750093-026	8	
		R15	Resistor, Film, 2K, 0.5W, 1%	IRC, Type CEC T-O	750093-025	4	
		R16	Resistor, Film, 8205, 0.5W, 1%	IRC, Type CEC T-O	750093-077	4	
		R17	Resistor, Film, 6190, 0.5W, 1%	IRC, Type CEC T-O	750093-073	4	
6-1		A11	. Power Supply Assy		756769-001	1	
		C3, C4	.. Capacitor, Electrolytic, 500uF, 50V	Mallory HC 5005	111480	2	1
6-1		T1	.. Transformer, Power		756803-001	1	
			* Include prefix number 1, 2, 3, or 4 to schematic reference designations for the four associated amplifiers of Amplifier Circuit Card Assemblies A9 and A10.				

References			Description	Manufacturer and Part Number	Honeywell Part No.	Qty/ Unit	Spares
Fig.	Index	Schem.					
6-1			.. Circuit Card Assy.		756366-001	1	
			... Circuit Card, Power Supply		756365-001	1	
		C1, C2	Capacitor, Fixed, .01uF, 100V	Good All, X663F-103-9-1-W -2	750014-001	2	
		CR1, CR2, CR3, CR4	Rectifier, Silicon	Motorola, 1N4002	756961-002	4	
		Q1, Q4	Transistor	Motorola, 2N456A	750517-046	2	
		Q2, Q3 Q5, Q6	Transistor	TI, 2N1370	750517-071	4	1
		R1, R8	Resistor, Carbon, 2.2K, 0.5W, 5%	Ohmite, LIDFA-2.2K-5	750076-558	2	
		R2, R9	Resistor, Variable, 1K, 10%	Bourns, 3067P-1-501	750059-004	2	1
		R3, R10	Resistor, Carbon, 1K, 0.5W, 5%	Ohmite, LIDFA-1K-5	750076-549	2	
		R4, R11	Resistor, Carbon, 2.4K, 0.5W, 5%	A-B, EB-2425	107714	2	
		R5, R12	Resistor, Carbon, 30K, 0.5W, 5%	Ohmite, LIDFA-30K-5	750076-585	2	
		R6, R13	Resistor, Carbon, 3K, 0.5W, 5%	Ohmite, LIDFA-3K-5	750076-561	2	
		R7, R14	Resistor, Carbon, 2K, 0.5W, 5%	A-B, EB-2025	107724	2	
		VR1, VR3	Diode, Zener	Motorola, 1N753	756688-008	2	
		VR2, VR4	Diode, Zener	Motorola, 1N970B	750576-558	2	
6-1		DS7	. Lamp, Neon	Dial Light, NE-2D	750211-009	1	1
6-1		J1 thru J8	. Receptacle, 3 Pin	Cannon, XLB-3-32	200414	8	
6-1		J9	. Connector, 17 Pin	AMP, 3102A-20-295	100301	1	
6-1		P1	. Line Cord and Plug		100705	1	
6-1		S9	. Switch, Toggle, SPST	Ark-Les, 7007B3	756962-001	1	1
			. Connector, Input, 3 Pin	Cannon, XLR-3-11C	200413	8	

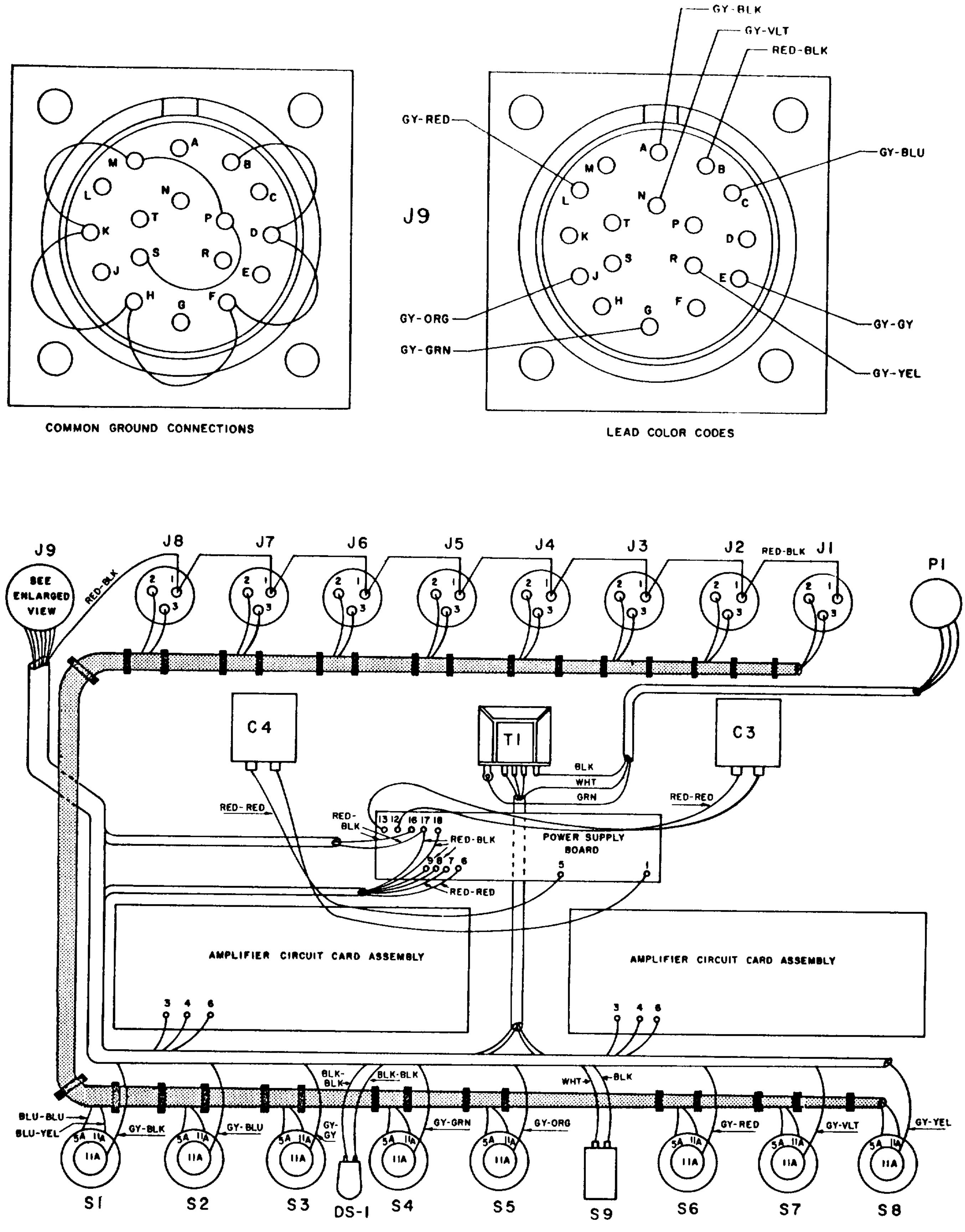


Figure 6-1. Preamplifier Wiring Diagram

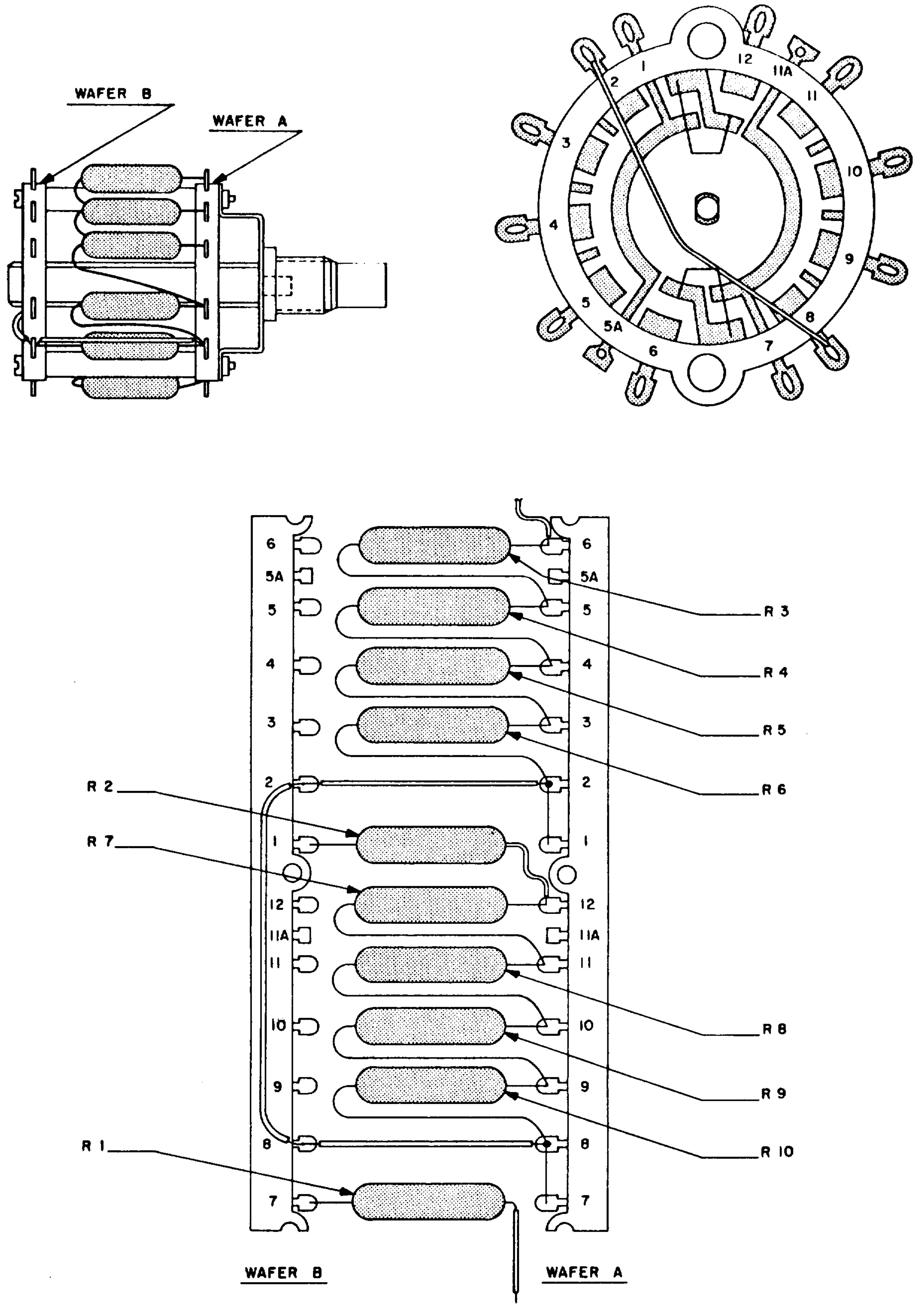
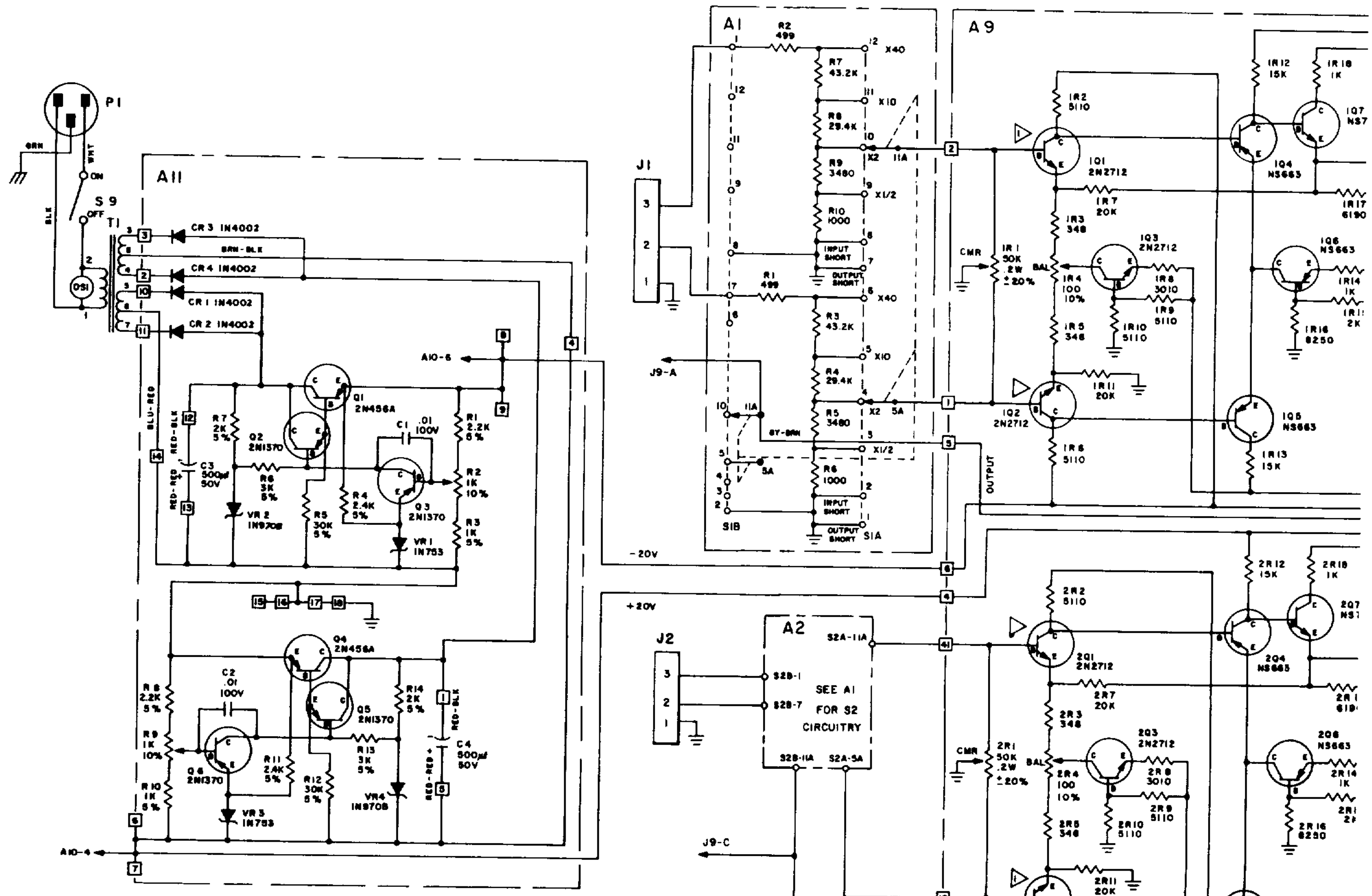


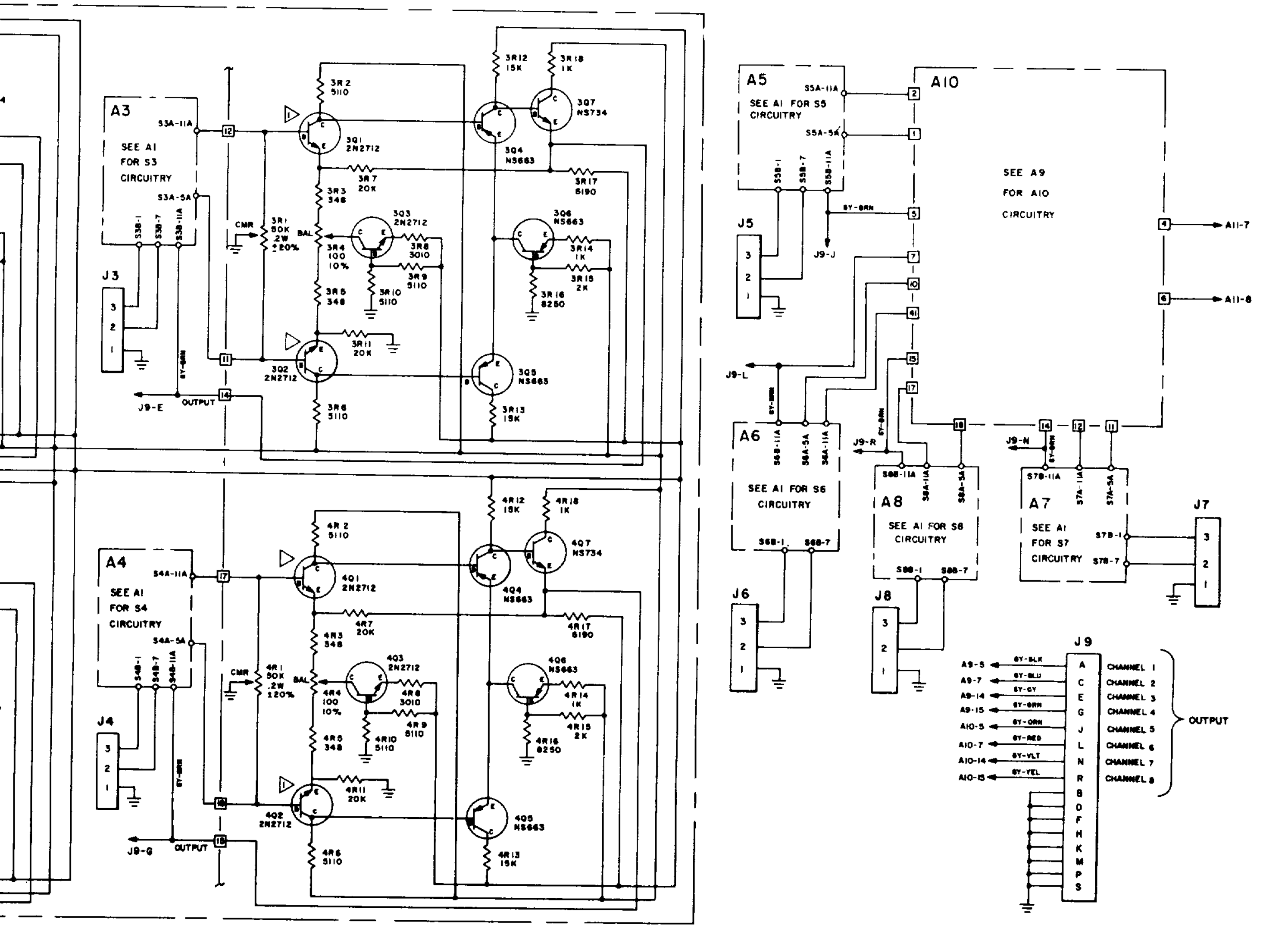
Figure 6-2. Switch Assembly Parts Location Diagram



NOTE:

ALL RESISTOR VALUES ARE IN OHMS AND ARE 1/2W 1% UNLESS OTHERWISE SPECIFIED.
ALL CAPACITOR VALUES ARE IN MICRO-FARADS UNLESS OTHERWISE SPECIFIED.
1 Q1 AND Q2 ARE MATCHED PAIR REPLACE AS ONE ASSEMBLY.
□ DENOTES CIRCUIT CARD EYELET.

1



Differential Preamplifier
Schematic Diagram
Doc. No. 75722586

2

PRELIMINARY

INSTRUCTION MANUAL

FOR

REGULATED POWER SUPPLIES

MODELS LH 124, LH 124FM, LH 124S

BEARING SERIAL NO.

PREFIX A

 All information contained herein applies to metered, non-metered, and chassis-mounting models unless otherwise specified.

LAMBDA ELECTRONICS CORP. MELVILLE, L. I., N. Y.
MAIN PLANT TELEPHONE: 516 MYrtle 4-4200

TABLE OF CONTENTS

ADDENDA

MODEL LH-124FM-0332

The paragraphs of this instruction manual apply in general to the above model.

This modified unit differs from a standard unit in that a special paint finish has been applied to the front panel.

LAMBDA ELECTRONICS CORP. MELVILLE, L. I., N. Y.

SPECIFICATIONS AND FEATURES

Specifications apply for the non-metered LH 124, metered LH 124FM and chassis-mounting LH 124S models.

DC OUTPUT--Voltage regulated for line and load

Voltage Range..................0-40 volts DC

Multi-Current Ranges...........Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range

Ambient Temperature..........	30°C	50°C	60°C	71°C
Current Range................	0-1.3A	0-1.1A	0-0.9A	0-0.7A

REGULATED VOLTAGE OUTPUT

Regulation (line)..............Less than 0.015 percent or 1.0 millivolt, whichever is greater for input variations from 105-135 or 135-105 volts AC

Regulation (load)..............Less than 0.015 percent or 1.0 millivolt, whichever is greater for load variations from 0 to full load or full load to 0

Transient Response (line).............Output voltage is constant within regulation specifications for any 15-volt line voltage change within 105-135 volts AC

Transient Response (load).............Output voltage is constant within 50 millivolts for load changes full load to 0, within 50 microseconds after application; and is constant within 10 millivolts for load changes from 0 to full load or full load to 10% of load, within 50 microseconds after application

Remote Programming Constant.....200 ohms/volt output

Internal Impedance.............Less than 4.6 milliohms DC to 1 kilocycle

Ripple and Noise..............Less than 250 microvolts rms; 1 millivolt peak to peak with either positive or negative terminal grounded

Temperature Coefficient........Output change in voltage less than 0.015%/°C

DC OUTPUT--Current regulated for line and load; Automatic Crossover with voltage limit

Multi-Current Ranges...........Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range

Ambient Temperature..	30°C	50°C	60°C	71°C
Current Range....	0.26-1.3A	0.26-1.1A	0.26-0.9A	0.26-0.7A

Voltage Range..................0-40 volts DC, for entire current range

REGULATED CURRENT OUTPUT; AUTOMATIC CROSSOVER

Regulation (line)..............Less than 15 milliamperes for input variations from 105-135 or 135-105 volts AC

Regulation (load)..............Less than 15 milliamperes for load voltage changes from 0 to 40 or 40 to 0 volts DC

Ripple and Noise...............Less than 1 ma at 55-480 cps; Less than 3 ma at 45-55 cps; both with either neg. or pos. terminal grounded

DC OUTPUT--Current regulated for line and load; Barrier strip reconnection for Precision Current Regulated Output with no voltage limiting

Multi-Current Ranges...........Current range must be chosen to suit the appropriate maximum ambient temperature. Current ratings apply for entire voltage range

Ambient Temperature..	30°C	50°C	60°C	71°C
Current Range....	0.065-1.3A	0.055-1.1A	0.045-0.9A	0.035-0.7A

Voltage Range..................0-40 volts DC, for entire voltage range

REGULATED CURRENT OUTPUT; PRECISION CURRENT REGULATED

Regulation (line)...............	Less than 0.05% or 0.5 milliampere, whichever is greater, for input variation of 105-135 or 135-105 volts AC
Regulation (load)...............	Less than 0.05% or 0.5 milliampere, whichever is greater, for load changes from 0-40 or 40-0 volts DC
Ripple and Noise................	Less than 0.5 ma at 55-480 cps; Less than 1.0 ma at 45-55 cps; both with either neg. or pos. terminal grounded
Remote Programming..............	100 ohms, 2-watt resistance for maximum rated current; adjustable over range by decreasing resistance

AC INPUT--105-135 volts AC at 45-480 CPS; 120 watts*

*With output loaded to full 30°C rating and input voltage 135 volts AC

OVERLOAD PROTECTION

Thermal.........................	Thermostat, resets automatically when over-temperature condition is eliminated
Electrical	
External..................	Adjustable, automatic, electronic current-limiting circuit, settable to 105 percent of rated current; limits output current to preset limit for protection of load and power supply when external overloads and direct shorts occur
Internal..................	Fuse provides protection against internal circuit failure

INPUT AND OUTPUT CONNECTIONS--Heavy duty terminal block on rear of chassis with 5-foot, 3-wire detachable line cord for all models; five-way binding posts provide for additional positive (+), ground, and negative (-) DC output connections on front panel of FM models

OPERATING AMBIENT TEMPERATURE RANGE AND DUTY CYCLE--Continuous duty from 0°C to 71°C ambient with corresponding load current ratings for all modes of operation

STORAGE TEMPERATURE- (non-operating) -55°C to +85°C

METERS-Voltmeter and ammeter on metered (FM) models

CONTROLS

DC output controls..............Coarse and fine voltage controls and current control permit adjustment of DC output; located on front panel of all models

Test Jacks (+) (-).....Test jacks for non-metered model permit checking DC output with external meters

Remote Sensing.........Provision is made for remote sensing to eliminate effect of power output lead resistance on DC regulation

Power..................Panel mounted switch and indicator light for all units except models with suffix (S)

PHYSICAL DATA

Size...................5-3/16"H x 4-3/16"W x 15-1/2"D (LH 124, LH 124FM)

4-5/16"H x 3-13/16"W x 15-1/2"D (LH 124S)

Weight.................14 lbs. net; 18 lbs. shipping wt.

Panel Finish...........Brushed aluminum clear anodized panels with grey inlay (standard); special finishes available to customer's specifications at moderate surcharge

MOUNTING:

Laboratory bench, table top.....LH 124, LH 124FM

Chassis Mounted.................LH 124S

NOTE: Bumpers secured to the base of LH 124S units permit circulation of air through the unit. Do not remove bumpers unless the chassis-mounting is provided with a cutout to permit free-flow of air through the unit.

Standard 19" rack.....LH 124, LH 124FM; used with rack adapters:
LRA-1 (slide accomodation provided)
LRA-2 (conventional mount) See figure 18.

THEORY OF OPERATION

GENERAL

The Lambda power supply circuitry consists of an AC input circuit and transformer; a reference supply circuit consisting of an auxiliary rectifier and filter, zener diode pre-regulator, reference element and series regulator; a main regulator circuit consisting of the main rectifier and filter, a series regulator, two emitter follower drivers, a current sensing amplifier, a voltage amplifier, the complementary differential amplifier circuit, and an output sensing circuit.

The circuit arrangement is shown in block diagram form in figure 14. The circuitry is discussed with reference to the block diagram and the schematic diagram.

FUNCTIONAL DESCRIPTION

Single phase input power is applied to transformer T1 through the input circuit containing thermostat S2 and fuse F1, which protect the supply against overheating and internal faults.

The main rectifier, a full-wave rectifier, comprised of diodes, CR12, CR13, provides the power which is filtered by capacitor C12 and then regulated via a series regulator and delivered to the output. The full-wave auxiliary rectifier CR10 and CR11, provides voltage filtered by capacitor C8 for reference series regulator Q6 and reference element Q5 of the reference supply as well as for pre-regulator CR8 and CR9. The reference supply output provides a regulated, temperature compensated reference voltage which is used to determine the output voltage of the unit. Cascade connected pre-regulator CR8, CR9, R24 and R23, provides stabilized bias voltage for current limit amplifier Q4, voltage amplifier Q3, "OR" gate CR4 and CR3, and for complementary differential amplifier Q1 and Q2.

Reference element Q5 contains a zener diode and transistor in one unit which act to reduce the effect of temperature changes and to provide a stable reference voltage for series regulator Q6.

Constant voltage or constant current crossover circuit operation is determined by changes in the load. A change in the load is sensed by sensing divider R5, R4, CR2 and R1A, B, which has a fixed current flowing in the divider elements as determined by the setting of calibration control R5. This variation causes a change to Q1 input of the complementary differential amplifier, which compares it with the reference voltage through the sensing divider, causing an error signal at the output of Q2. Simultaneously, current limit amplifier Q4 samples the load current through current sensing resistor R43. When the current reaches a preset limit, Q4 will generate an error signal.

The error outputs from Q2 and Q4 are fed through "OR" gate CR3, CR4 to voltage amplifier Q3, and one signal is amplified by Q3 and emitter follower Q9. The amplified signal from the emitter follower determines the impedance value of series regulator Q10, which acts as a varying impedance in series with the output. This power transistor functions as the active regulating element.

Auxiliary series regulator Q11 shares power with series regulator Q10 when maximum power is dissipated in the regulator. The base bias of emitter follower Q7, supplied through R25, results in a fixed base bias for regulator Q11; changes in operation for Q11 occur when the emitter bias of Q11 changes. Output voltage adjustments to less than 40 volts and crossover to constant current operation will change emitter bias of Q11 through the regulating action of Q10, thereby biasing Q11 for operation toward cut-off and accordingly, for sharing power dissipation with series regulator Q10.

Under constant voltage operation Q4 is in saturation, CR3 conducts and CR4 in the "OR" gate is turned off, and all of the current in R9 flows through Q4. When load current increases, the voltage drop across current sensing resistor R43 increases, biasing Q4 toward cut-off. When Q4 cuts off, CR4 is forward biased and conducts while CR3 ceases to conduct. The signal is amplified via voltage amplifier Q3 and emitter follower Q9, increasing the impedance of series regulator Q10, which biases auxiliary regulator Q11 so that it dissipates power with Q10 causing the output voltage to decrease toward zero and the unit to function at the fixed current limit.

Voltage amplifier Q3 operates at all times from the output of "OR" gate CR3, CR4, its action depending upon which signal the "OR" gate conducts. When Q4 is turned off due to an excessive load, Q3 will saturate, causing main series regulator Q10, and auxiliary series regulator Q11 to turn off. When load current limit is not reached or exceeded, Q4 is in saturation and Q3 will operate with the error signal derived from Q2 of the complementary differential amplifier, causing the series regulator Q10 and auxiliary series regulator Q11 to change the output voltage for the preset voltage limit.

When connected for precision current operation, the complementary differential amplifier is referenced to the current sensing resistor, with a fixed current flowing from the sensing divider through potentiometer R1A, B. Any change in load will cause an error signal in the complementary differential amplifier and the circuit functions as explained previously.

OPERATING INSTRUCTIONS

CONTROLS, INSTRUMENTS AND FUSES

POWER ON Switch. The POWER ON switch, located on the front panel, controls application of input power to the supply. When the switch is in the ON position, the red POWER ON indicator glows.

OUTPUT VOLTAGE Control. The OUTPUT VOLTAGE control is a dual control consisting of a coarse adjustment potentiometer, which varies the DC voltage over a range of 0-39 volts and a fine adjustment potentiometer, which varies the DC voltage over a one-volt range. Clockwise rotation results in increasing voltage. The total DC voltage output for voltage regulated operation, is equal to the sum of each shaft setting; for current regulated operation the maximum voltage limit is equal to the sum of each shaft setting. The control is located on the front panel of all units.

CURRENT LIMITER Control. This potentiometer varies the maximum DC current over the rated *current range and, for current or voltage regulated operation, limits the DC current output to the setting on the control. Clockwise rotation results in increasing current. This control is located on the front panel.

*Operation for output current below rated limits can result in no output or no regulation.

Output Voltage Meter. A 0-40 volt DC voltmeter monitors the voltage at the output terminals of metered (FM) units.

Output Current Meter. A 0-1.5 ampere DC ammeter monitors the load output current of metered (FM) units.

Fuse. Fuse F1, internally located, is a 3 ampere, 3AG "SLO-BLO" fuse which functions in the AC input circuit.

Connection Terminals. Make all connections to the supply at the terminal block on the rear of the supply. On FM suffixed models, DC output connections can also be made at the five-way binding posts located on the front panel. Apply input power through the line cord or directly to terminals 1 and 2 if the line cord is removed. Always connect the ungrounded (hot) power lead to terminal 1.

The supply positive terminal is brought out to terminal 6. The supply negative terminal is brought out to terminal 4. Recommended wiring of the power supply to the load and selection of wiring is shown in figures 1 through 13. Selection of proper wiring is made on the basis of load requirements. Make all performance checks and measurements of current or voltage at the rear output terminals. Connect measuring devices directly to terminals or use the shortest leads possible.

GROUND CONNECTIONS

The Lambda power supply can be operated either with negative or positive output terminal grounded or with no terminal grounded. Both positive and negative ground connections are shown in the diagrams for all suggested output connections illustrated in this manual.

> NOTE: When operating the supply with neither terminal grounded, high impedance leakage resistance and capacitance paths can exist between the power supply circuitry and chassis ground.

BASIC MODES OF OPERATION

This power supply is designed to operate as a constant voltage source or as a constant current source. Except when used for a precision constant current source, automatic crossover to either mode of operation occurs when load conditions change as follows:

Constant Voltage. The power supply will function as a constant voltage source while the load current does not equal the current value, I_{LIM}, set by the CURRENT LIMITER control. When load current $I_L = \frac{V}{R_L} = I_{LIM}$, the supply will cross over automatically and will operate as a constant current source. Further decrease in value of load resistance R_L results in decrease of voltage across the load while current remains regulated to I_{LIM}.

Constant Current (Automatic Crossover). The power supply will function as a constant current source while the load voltage V_L does not equal the voltage value set by the OUTPUT VOLTAGE control. When load voltage V_L equals the value set by the OUTPUT VOLTAGE control, the supply will automatically cross over and operate as a constant voltage source.

Constant Current (Precision). The power supply will function within rated specifications as a conventional constant current source without automatic crossover. When load voltage demand exceeds the rated voltage of the power supply, the unit output current regulation will not be within specification.

SUPPLY-LOAD CONNECTIONS

> NOTE: Refer to DETAILED OPERATING PROCEDURES for step-by-step instructions for operation of power supply.

CONNECTIONS FOR OPERATION AS A CONSTANT VOLTAGE SOURCE

The output impedance, regulation, and transient response of the power supply at the load may change when using the supply as a constant voltage source and connecting leads of practical length are used. To minimize the effect of the output leads on these characteristics, remote sensing is used. Recommended types of supply-load connections with local or remote sensing are described in the following paragraphs.

Refer to figures 1 and 2 to determine voltage drop for particular cable length, wire size and current conditions. Lead lengths must be measured from supply terminals to load terminals as shown in figure 3.

Two-Wire Connection, Figure 4. The two-wire connection, with local sensing, is the connection suitable for application with relatively constant load where extremely close load regulation and fast transient response over full-rated current excursion are not required at the load.

Improved Two-Wire Connection, Figure 5. The improved two-wire connection, with local sensing, is suitable for applications where excessively long connecting leads are not used. Using multiple paralleled leads in this type of connection reduces the supply-load lead voltage drop and permits improved regulation and transient response.

Four-Wire Connection, Figure 6. The four-wire connection with remote sensing, provides complete compensation for the DC voltage drops in the connecting cables. Compensation for lead drop is also valid for gradual changes of load current.

Programmed Voltage Connections, Using External Resistor, Figure 7. Discrete voltage steps can be programmed with a resistance voltage divider valued at 200 ohms/volt output and a shorting-type switch as shown in figure 7. When continuous voltage variations are required, use variable resistor with the same 200 ohms/volt ratio in place of the resistive voltage divider and shorting-type switch. Use a low temperature coefficient resistor to assure most stable operation.

As shown in figure 7, voltages can be programmed utilizing either local or remote sensing connections, as desired.

Programmed Voltage Connections Using Programming Voltage, Figure 8. The power supply voltage output can be programmed with an externally connected programming power supply.

The output voltage of the programmed supply will maintain a one-to-one ratio with the voltage of the programming supply.

CONNECTIONS FOR OPERATION AS A CONSTANT CURRENT SOURCE

Automatic Crossover Constant Current Connections, Figure 4. Figure 4 shows the connections which are used when operating the power supply as a constant current source with automatic crossover, using local setting of current control.*

*Setting control for output currents below rated limits can result in no output or no regulation.

In this mode of operation, when the load voltage increases, due to changing load resistance, to the limit of the OUTPUT VOLTAGE control setting, the power supply crossover circuit will cause the unit to operate as a constant voltage supply.

Precision Regulated Constant Current Connections, Figure 9. Figure 9 shows the connections which are used when operating the power supply as a precision constant current source, using local setting of current control.

In this mode of operation, the power supply functions as a conventional constant current supply with crossover circuit inoperative. The load voltage limit is fixed to the maximum voltage rating of the power supply.

Programmed Precision Regulated Current Connections, Figure 10. To provide discrete current steps from 5% to 100% of rated current, use any combination of separate 2-watt resistors totalling 100 ohms together with a shorting-type switch connected as shown in figure 10. Use resistors with low temperature coefficients to assure most stable operation.

When continuous current variations are required, use a 100 ohm, 2-watt variable resistor in place of the separate resistors and shorting-type switch.

CONNECTIONS FOR SERIES OPERATION

The voltage capability of LH power supplies can be extended by series operation of two LH power supplies of equal* voltage ratings. A maximum of 200 volts can be connected between either the +DC or -DC terminal and chassis ground.

*For applications using supplies of unequal ratings, consult factory for details of operation.

The two units are shown connected for series operation in figures 11 and 12. Figure 11 shows the series connection diagram which would be suitable for use in all applications where exact one-to-one voltage tracking of the "master" (M) unit by the "slave" (S) unit is not required. The slight offset in tracking is easily compensated for by adjusting the OUTPUT VOLTAGE controls on the (S) unit.

Figure 12 shows the series connection diagram suitable, for applications where exact one-to-one voltage tracking is required. In this series configuration resistor R_{BAL} permits the (S) unit to track the (M) unit on an exact one-to-one basis, thereby eliminating the possibility of an offset voltage existing between the two units.

Resistor R_{BAL} should be a one-watt, 10-20 kilohm resistor. This value would permit wide-range compensation for manufacturing differences inherent in the components used in each unit. Resistors R_S and R_M function in the voltage sensing circuits of both units, enabling the (S) unit to reference its output voltage to that of the (M) unit. In figure 11, R_S performs a similar function. Capacitor C_S, used to eliminate stray AC pickup, is rated at 2.5 mfd, 100 V.

For either series mode of operation, select R_S and R_M on the basis of 200 ohms per volt of (M) unit output voltage. R_S must equal R_M.

Diodes CR_M and CR_S, which protect the units against reverse voltage, must be capable of withstanding the maximum rated current of the (M) unit.

Both methods permit operation for either constant voltage or constant current with automatic crossover to either mode of operation whenever the respective limiting operating current or voltage is reached. As shown in figures 11 and 12, each method permits connection for either local or remote sensing.

CONNECTIONS FOR PARALLEL OPERATION

The current capability of LH power supplies can be extended by parallel operation of two LH power supplies of equal* voltage capacities. The two units are shown connected for parallel operation in figure 13. One power supply designated the "master" or (M) unit controls its own output as well as the output of the second power supply, designated the "slave" or (S) unit.

*For applications using supplies of unequal voltage ratings, consult factory for details of operation.

Unit (S) operates to regulate its current in a ratio to that of the (M) unit by comparing the current in its internal sampling resistor with that current sampled by the master internal sampling resistor. When power supplies of unequal current capacities are parallel connected the division of current supplied will be approximately equal to the ratio of the current ratings of the supplies.

Parallel connected units can be operated for constant voltage with local sensing as well as for constant current with automatic crossover. When operating for constant voltage, the (M) unit can automatically cross over into constant current operation.

DETAILED OPERATING PROCEDURES

SAFETY NOTICE

DANGEROUS VOLTAGES EXIST IN THIS EQUIPMENT. OBSERVE THE USUAL SAFETY PRECAUTIONS WHEN OPERATING OR SERVICING THE EQUIPMENT TO AVOID SHOCK OR INJURY.

CONSTANT VOLTAGE OPERATION, ADJUSTABLE CURRENT LIMIT

1. Remove AC power input to the supply and place POWER ON switch in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size from figures 1-3 and choose desired type of supply-load connection from figures 4-6.

3. Connect supply to load as shown on the selected connection diagram.

> NOTE: When shipped from the factory, the supply is ready for use as a constant current source with automatic crossover or as a local-sensing constant voltage source. Jumpers are connected at the factory as shown in figure 4. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the appropriate connection diagram.

4. Turn OUTPUT VOLTAGE control knobs to the desired voltage setting.

5. When current to the load must be limited to an intermediate value within the current rating of the supply, turn the CURRENT LIMITER control to the desired current limit setting. If no intermediate current limit is required, turn the control CW to the position for full current rating for the maximum ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to the supply.

7. Place POWER ON switch in ON position and check that red POWER ON indicator is lit.

8. Check that output current and output voltage meters indicate desired values; as required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 6 and 4, or at front panel test jacks (+) and (-); for remote sensing connections, check at the load terminations of sensing leads on terminals 3 and 7.

9. Power supply is now in proper operation.

PROGRAMMED CONSTANT VOLTAGE OPERATION, ADJUSTABLE CURRENT LIMIT

1. Remove AC power input to the supply and place POWER ON switch in OFF position before connecting load to the supply.

2. Determine load requirements, select wire size and length from figures 1, 2 and 3 and choose desired type of supply-load connection from figures 7 or 8. Refer to paragraph on Programmed Voltage Connections.

3. Connect supply to load as shown on the selected connection diagram. As shown in figure 7, take care to use a shorting-type switch for the external programming control when several voltages are desired and the programming voltage method is not used.

4. Turn OUTPUT VOLTAGE control knobs to the extreme CCW position. Adjust external programming voltage control to desired voltage setting.

5. When current to the load must be limited to an intermediate value within the current rating of the supply, turn the CURRENT LIMITER knob to the desired current limit setting. If no intermediate current limit is desired, turn the control CW to the position for full rated current for the ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to the supply.

7. Place POWER ON switch in ON position and check that red POWER ON indicator is lit.

8. Check that output current and output voltage meters indicate desired values; as required, adjust CURRENT LIMITER knob and external programming voltage control to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6, or at front panel test jacks (+) and (-); for remote sensing connections check at the load terminations of sensing leads on terminals 3 and 7.

9. Power supply is now operating properly.

CONSTANT CURRENT OPERATION WITH CROSSOVER, ADJUSTABLE VOLTAGE LIMIT

1. Remove AC power input to the supply and place POWER ON switch in OFF position before connecting load to the supply.

2. Determine load requirements and connect load to the supply as shown in figure 4.

3. Turn the CURRENT LIMITER knob to the desired current setting.

4. When load voltage must be limited to an intermediate value within the voltage rating of the supply, turn OUTPUT VOLTAGE control knobs to the desired voltage limit setting. If no intermediate voltage limit, within rating of supply is desired, turn controls to the full CW position to obtain voltage limit at maximum voltage rating of the supply.

5. Apply AC power to the supply.

6. Place POWER ON switch in ON position and check that red POWER ON indicator is lit.

7. Check that output current and output voltage meters indicate desired values; adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control as required to obtain correct indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6, or at front panel test jacks (+) and (-).

8. Power supply is now in proper operation.

PRECISION REGULATED CONSTANT CURRENT OPERATION

1. Remove AC power input to the supply and place POWER ON switch in OFF position before connecting load to the supply.

2. Determine load requirements and connect load to the supply as shown in figure 9.

3. Turn the CURRENT LIMITER knob to the maximum desired current setting.

4. Turn both OUTPUT VOLTAGE control knobs to extreme CCW position.

5. Apply AC power to the supply. Place POWER ON switch in ON position and check that red POWER ON indicator is lit.

6. Turn fine OUTPUT VOLTAGE control knob CW until the desired current setting as indicated by output current meter is reached.

7. Check that output current meter indicates desired value and that output voltage meter does not indicate OFF scale. Adjust fine OUTPUT VOLTAGE control knob as required, to obtain correct indication. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 9.

8. Power supply is now in proper operation.

PROGRAMMED PRECISION REGULATED CONSTANT CURRENT OPERATION

1. Remove AC power input to the supply and place the POWER ON switch in OFF position before connecting load to the supply.

2. Determine load requirements. Connect load to the supply as shown in figure 10. Refer to paragraph on Programmed Current Connections.

3. Turn the CURRENT LIMITER knob to the maximum desired setting.

4. Turn OUTPUT VOLTAGE control knobs to extreme CCW position.

5. Apply AC power to the supply. Place POWER ON switch in ON position and check that red POWER ON indicator is lit.

6. Turn fine OUTPUT VOLTAGE control knob CW until the desired current setting is reached, as indicated by output current meter.

7. Check that output current meter indicates desired value and that output voltage meter does not indicate OFF scale. As required, adjust external current programming control to obtain correct indication. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 9.

8. Power supply is now in proper operation.

SERIES CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to the "slave" (S) and "master" (M) units and place POWER ON switches in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1-3 and choose correct type of series supply-load connections from figures 11 and 12. Refer to paragraph on Connections for Series Operation.

3. Connect supply to load as shown on the selected connection diagram. As required, select resistor R_{BAL}, R_S and R_M, and diodes CR_S and CR_M in accordance with instructions contained in Connections for Series Operation.

4. Turn (M) unit OUTPUT VOLTAGE control knobs to the desired voltage setting. This setting will be approximately one-half of the combined (M) and (S) unit output voltage.

5. Turn (S) unit OUTPUT VOLTAGE control knobs and CURRENT LIMITER control to extreme CW position.

6. When current to the load must be limited to an intermediate value within current rating of the unit with lower current capacity (M unit) turn the (M) unit CURRENT LIMITER control to the desired setting. If no intermediate current limit is required, turn the control CW to the position for full current rating for the maximum ambient temperature of operation. Refer to section on specifications.

> NOTE: When units of equal current rating are series connected, the (M) unit CURRENT LIMITER control must be set at a position slightly less than that of the (S) unit.

7. Apply AC power to the supplies.

8. Place POWER ON switches of both units in ON position and check that red POWER ON indicators are lit.

9. Check that output current and output voltage meters indicate desired values; total voltage is equal to sum of (S) and (M) units.

As required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control of (M) unit to obtain correct indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals of the (S) and (M) units; positive (+) terminal of (M) unit and minus (-) terminal of the (S) unit are the output terminals of the series combination.

Use front panel jacks (+) of (M) unit and (-) of (S) unit to make current and voltage checks for the appropriate units. For remote sensing connection, make checks at the load terminations of sensing leads from terminals 7 of (M) unit and from R_S connection of (S) unit.

10. Power supplies are now in proper operation.

SERIES CONNECTION CONSTANT CURRENT OPERATION, WITH VOLTAGE LIMIT

1. Remove AC power input to the (S) and (M) units and place POWER ON swithes in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1-3 and choose correct type of series supply-load connections from figures 11 and 12. Refer to paragraph on Connections for Series Operation.

3. Connect supply to load as shown on the selected connection diagram. As required, select resistors R_{BAL}, R_S and R_M and diodes CR_S and CR_M as instructed in Connections for Series Operation paragraph.

4. Turn (M) unit CURRENT LIMITER control to the desired setting.

> <u>NOTE:</u> When units of equal current rating are series connected, the (M) unit CURRENT LIMITER control must be set at a position slightly less than that of the (S) unit.

5. Turn (S) unit OUTPUT VOLTAGE control knobs and CURRENT LIMITER control to extreme CW position.

6. When load voltage must be limited to an intermediate value within the voltage rating of the series combination, turn the (M) unit OUTPUT VOLTAGE control knobs to a position approximately one-half the total voltage rating for the combination.

If no intermediate voltage limit is required, turn the control to the full CW position to obtain voltage limit at the maximum combined ratings of the supplies.

7. Apply AC power to the supplies.

8. Place POWER ON switches of both units to ON position and check that red POWER ON indicators are lit.

9. Check that output current and output voltage meters indicate desired values; total voltage is the sum of (S) and (M) unit voltages. As required, adjust OUTPUT VOLTAGE control knobs and CURRENT LIMITER control of (M) unit to obtain correct indications. For non-metered models, use externally connected meters and check that correct meter indications exist at output terminals of the (S) and (M) units; positive (+) terminal of (M) unit and minus (-) terminal of the (S) unit are the output terminals of the series combination.

Use front panel jacks (+) of (M) unit and (-) of (S) unit to make current and voltage checks for the appropriate units. For remote sensing connections make checks at the load terminations of sensing leads from terminal 7 of (M) unit and from R_S connection of (S) unit.

10. Power supplies are now in proper operation.

PARALLEL CONNECTION CONSTANT VOLTAGE OPERATION, WITH CURRENT LIMIT

1. Remove AC power input to each supply and place POWER ON switch on both (M) and (S) units in OFF position before connecting load to the supplies.

2. Determine load requirements, select wire size from figures 1-3 in the manual. Refer to paragraph on Connections for Parallel Operation.

3. Connect supplies to load as shown in connection diagram, figure 13.

> NOTE: When shipped from the factory, each supply is ready for use as a constant current source or as a local-sensing constant voltage source. Jumpers are connected at the factory. Take care to remove the appropriate jumpers for load requirements that need different supply-load connections. Refer to the appropriate connection diagram.

4. Turn OUTPUT VOLTAGE control knobs on the (M) unit to the desired voltage setting, and turn the controls on the (S) unit to fully CCW position.

5. When current to the load must be limited to an intermediate point, turn the CURRENT LIMITER control on both the (M) and (S) units to the desired current limit setting. Set current limit control on the (M) and (S) units to the position indicating the current value to be delivered by the respective unit. If no intermediate current limit is desired, turn the control CW on both (M) and (S) units to the position for full rated current for the maximum ambient temperature of operation. Refer to section on specifications.

6. Apply AC power to each supply.

7. Place POWER ON switches on (M) and (S) units in ON position and check that red POWER ON indicators are lit.

8. Check that output current and output voltage meters on both (M) and (S) units indicate desired values; as required, adjust OUTPUT VOLTAGE control and CURRENT LIMITER control on (M) unit to obtain correct meter indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6 of the (M) unit, or at front panel jacks (+) and (-) of the (M) unit; for remote sensing connection, check at the load termination of sensing leads on terminals 3 and 7 of the (M) unit.

9. Power supplies are now in proper operation.

PARALLEL CONNECTION CONSTANT CURRENT OPERATION, WITH VOLTAGE LIMIT

1. Remove AC power input to each supply and place POWER ON switch on both (M) and (S) units in OFF position before connecting load to the supplies.

2. Determine load requirements and connect load to the supplies as shown in figure 13. Refer to paragraph on Connections for Parallel Operation.

3. Turn the CURRENT LIMITER knob on (M) unit to the desired current setting. Turn OUTPUT VOLTAGE control knobs on the (S) unit to full CCW position.

NOTE: When setting the CURRENT LIMITER knob on the (M) and (S) units take care to set the control so that each unit indicates the proportion of total current that the unit must supply.

4. When load voltage must be limited, turn OUTPUT VOLTAGE control knobs on the (M) unit to the desired voltage limit setting. If no voltage limit, within rating of the supply is desired, turn controls on the (M) unit to the full CW position.

5. Apply AC power to each supply.

6. Check POWER ON switches on (M) and (S) units in ON position and check that red POWER ON indicators are lit.

7. Check that output current and output voltage meters on both units indicate desired values; adjust OUTPUT VOLTAGE control and CURRENT LIMITER control, as required, to obtain correct indications. For non-metered models use externally connected meters and check that correct meter indications exist at output terminals 4 and 6 of the (M) unit, or at front panel jacks (+) and (-) of the (M) unit.

8. Power supply is now in proper operation.

OPERATION AFTER PROTECTIVE DEVICE SHUTDOWN

Thermostat Shutdown

The thermostat opens the input circuit only when the temperature of the transistor heat radiator exceeds a maximum safe value. The thermostat will automatically reset when the temperature of the radiator decreases to safe operating value. After eliminating the cause(s) for overheating and allowing time for the power supply to cool to a proper temperature, resume operation of the supply. Refer to appropriate operation paragraph in DETAILED OPERATING PROCEDURES.

Fuse Shutdown

Internal component failure is prevented by fuses which protect the components from damage caused by excessive currents. Fuses will blow when the maximum rated current value for the fuse is exceeded. Fatigue failure of fuses can occur when mechanical vibrations from the installation combine with thermally induced stresses to weaken the fuse metal. Many fuse failures are caused by a temporary condition and replacing the blown fuse will make the fuse protected circuit operative.

MAINTENANCE

GENERAL

This section describes trouble analysis routine, replacement procedures, calibration and test procedures that are useful for servicing the Lambda power supply. A trouble chart is provided as an aid for the troubleshooter. Refer to the section on specifications and features for the minimum performance standards.

TROUBLE ANALYSIS

Whenever trouble occurs, systematically check all fuses, primary power lines, external circuit elements, and external wiring for malfunction before trouble shooting the equipment. Failures and malfunctions often can be traced to simple causes such as improper jumper and supply-load connections or fuse failure due to metal fatigue.

Use the electrical schematic diagram and block diagram, figure 14, as an aid to locating trouble causes. The schematic diagram contains various circuit voltages that are averages for normal operation. Measure these voltages using the conditions for measurement specified on the schematic diagram. Use measuring probes carefully to avoid causing short circuits and damaging circuit components.

CHECKING TRANSISTORS AND CAPACITORS

Check transistors with an instrument that has a highly limited current capability. Observe proper polarity for PNP or NPN to avoid error in measurement. The forward transistor resistance is low but never zero; backward resistance is always higher than the forward resistance. Resistance between transistor collector and emitter, in either direction, varies with temperature; variation is greater for the forward direction resistance.

For good transistors, the forward resistance for any junction is always greater than zero.

Do not assume trouble is eliminated when only one part is replaced. This is especially true when one transistor fails, causing other transistors to fail. Replacing only one transistor and turning power on, before checking for additional defective components could damage the replaced component.

When soldering semi-conductor devices, hold the lead being soldered with a pair of pliers placed between the component and the solder joint to provide an effective heat sink.

NOTE: The leakage resistance obtained from a simple resistance check of a capacitor is not always an indication of a faulty capacitor. In all cases the capacitors are shunted with resistances, some of which have low values. Only a dead short is a true indication of a shorted capacitor.

PRINTED CIRCUIT BOARD MAINTENANCE TECHNIQUES

1. If foil is intact but not covered with solder it is a good contact. Do not attempt to cover with solder.

2. Voltage measurements can be made from either side of the board. Use a needle-point probe to penetrate to the wiring whenever a protective coating is used on the wiring. A brass probe can be soldered to an alligator clip adapted to the measuring instrument.

3. Always use a heat sink when soldering transistors.

4. Broken or damaged printed wiring is usually the result of an imperfection, strain or careless soldering. To repair small breaks, tin a short piece of hook-up wire to bridge the break, and holding the wire in place, flow solder along the length of wire so that it becomes part of the circuitry.

5. When unsoldering components from the board, flow the solder onto the soldering iron tip; never pry or force loose a part to be removed.

TROUBLE CHART

The trouble chart is intended as a guide for locating trouble causes, and is used along with the schematic diagram.

The operating conditions assumed for the trouble chart are as follows:

(a) AC power of proper voltage and frequency is present at input terminals.

(b) Either positive or negative terminal is connected to chassis ground.

(c) The power supply is connected for constant voltage with local sensing. See schematic; dotted lines indicate jumpers connected for local sensing operation.

TROUBLE CHART

Symptom	Probable Cause	Remedy
1. POWER ON lamp DS1 does not light with POWER ON switch in ON position; no output voltage	No power input; POWER ON switch S1 defective; defective fuse F1; thermostat S2 open, fuse F1 blown	Check power source, line cord and line cord plug; replace S1; replace F1; shut off unit, allow to cool and check ambient temperature
		Replace F1; if it blows immediately, check diodes CR12, CR13 and capacitor C12, replace as necessary
2. Unable to adjust output voltage	Damaged OUTPUT VOLTAGE controls	Check R1A and R1B for shorts and/or open, replace as necessary
	Supply operating as constant current source with crossover at CURRENT LIMITER setting	Remove load and check for shorts and/or improper supply-load connections; refer to appropriate diagram for correct connections
3. Zero volts DC output, with POWER ON indicator lit	OUTPUT VOLTAGE controls turned fully CCW	Check OUTPUT VOLTAGE controls for proper setting and correct as necessary
	Short circuit across output of supply	Check load and load connections, correct as necessary
	Series regulator section open	Check Q10 and Q11 for open, replace as necessary
	Open Q4, CR14, CR15, CR20	Q4, CR14, CR15, CR20 for open, replace as necessary
	Emitter followers are open	Check Q7 and Q9 for open, replace as necessary
	Current sensing resistor open	Check R43 for open, replace as necessary
	Improper reference supply operation as indicated by voltage between output terminal 7 and T.P. on	The reference voltage between terminal 7 and T.P. should be 7.5 to 8.5 volts, if this voltage does not exist, then check Q6 for

TROUBLE CHART (cont'd)

Symptom	Probable Cause	Remedy
(step 3 cont'd)	fine regulator board	open, Q5 for short, CR8 and CR9 for short or CR10 and CR11 for open; replace as necessary
4. High ripple at line frequency or twice line frequency and unregulated DC output	Series regulator transistors shorted; emitter followers shorted; voltage amplifier open	Check and replace as necessary: Q10, Q11; Q7, Q9; and Q3
	Defective main rectifier causes ripple at twice line frequency	CR12, CR13 in addition to Q7, Q9, Q10, Q11 and Q3
	Line voltage too low	Check and correct AC input voltage at supply terminals
5. Same as 4, except intermittent	Foreign matter fallen into unit	Check for loose bench hardware and wire clippings that may have fallen through cover
	Emitter followers Ico resistors open or changed value causing thermal run-a-way	Check R26, R28, R34 and R36 values and replace as necessary
6. High ripple at frequency other than line or twice line frequency	Oscillation due to defective component in filter network	Check for open C1, C2 and check for open and/or short in R13, C6 and C5, R11 network and replace defective component
7. Large spikes at output	Capacitor C10, C11 open	Replace C10, C11 as necessary

ADJUSTMENT OF CALIBRATION CONTROLS

Whenever parts are replaced, adjust calibration controls only when voltage and current indications are improper and do not reflect maximum ratings.

Adjust Calibration Control R5 as Follows:

1. Remove AC power input to the supply and place POWER ON switch in OFF position.

2. Unsolder wiper of R14 from resistor housing.

3. Operate the power supply for constant voltage with local-sensing jumpers connected as shown in figure 4, and no external load.

4. Turn OUTPUT VOLTAGE control knobs fully clockwise and, using a DC voltmeter of one percent accuracy or better, adjust R5 to provide output voltage E_O MAX + 0.25 volts at 25°C ambient; where E_O MAX is the rated output voltage of the supply.

5. After adjustment is completed, remove AC power input to the supply and solder wiper of R5 to potentiometer housing.

Adjust Calibration Control R14 as Follows:

1. Remove AC power input to the supply and place POWER ON switch in OFF position.

2. Unsolder wiper of R14 from resistor housing.

3. Turn OUTPUT VOLTAGE control knobs and CURRENT LIMITER control fully CW.

4. Operate the power supply for constant current crossover, connected as shown in figure 4, with a short circuit across the output terminals.

5. Adjust R14 for 1.37-ampere output, using any DC ammeter of one percent accuracy or better.

6. After adjustment is completed, remove the power input to the supply and solder wiper of R14 to potentiometer housing.

PERFORMANCE CHECKS

Checks With Constant Voltage Operation

Check the ripple and regulation of the power supply using the test connection diagram shown in figure 15. Use suggested test equipment or equivalent to obtain accurate results. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Set the differential meter, DC VTVM (John Fluke Model 801H or equivalent) to the selected power supply operating voltage. Check the power supply load regulation accuracy while switching from the load to no-load condition. Long load leads should be a twisted pair to minimize AC pick-up.

Use a Variac to vary the line voltage from 105-135 or 135-105 volts AC and check the power supply line regulation accuracy on the VTVM differential meter.

Use a VTVM, Ballantine 320 or equivalent, to measure rms ripple voltage of the power supply DC output. Use oscilloscope to measure peak to peak ripple voltage of the power supply DC output.

Checks With Constant Current Operation

Check the ripple or regulation of the power supply using the test connection diagram shown in figures 16 or 17. Refer to SPECIFICATIONS AND FEATURES for minimum performance standards.

Check the power supply load regulation accuracy while switching from the short circuit to load condition. Measure the voltage across sensing resistor Rs. Use John Fluke Model 801H or equivalent for the VTVM connected across Rs. For Rs, use a resistor having the same value as resistor R43 in the unit being tested. To obtain regulation figure, substitute values obtained into regulation formula:

$$\frac{\Delta E}{Rs} = \text{Regulation in milliamperes,}$$

where ΔE is the voltage change in millivolts and Rs is the resistance of the sensing resistor.

Use a Variac to vary the line voltage from 105-135 or 135-105 volts AC and check the power supply line regulation accuracy using VTVM and the regulation formula:

$$\frac{\Delta E}{Rs}$$

To measure rms ripple current of the power supply DC output, use a Ballantine Model 320 or equivalent meter and obtain ripple current Ir by substituting measured values into formula:

$$\frac{\text{V.A.C. rms}}{Rs} = Ir$$

SERVICE

When additional instructions are required or repair service is desired, contact the nearest office of the Lambda Electronics Corp. where trained personnel and complete facilities are ready to assist you.

Please include the power supply model and serial number together with complete details of the problem. On receipt of this information, Lambda will supply service data or advise shipping for factory repair service.

All repairs not covered by the warranty will be billed at cost and an estimate forwarded for approval before work is started.

PARTS ORDERING

Standard components and special components used in Lambda power supply can be obtained from the factory. In case of emergency, critical spare parts are available through any Lambda office.

The following information must be included when ordering parts:

1. Model number and serial number of power supply and purchase date.
2. Lambda part number.
3. Description of part together with circuit designation.
4. If part is not an electronic part, or is not listed, provide a description, function, and location of the part.

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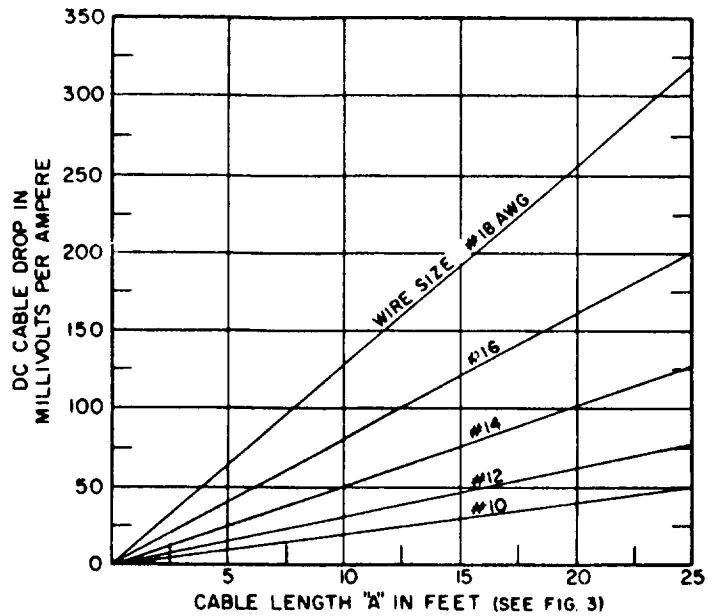


FIG. 1. 2-WIRE CONNECTION (SEE FIG. 4)

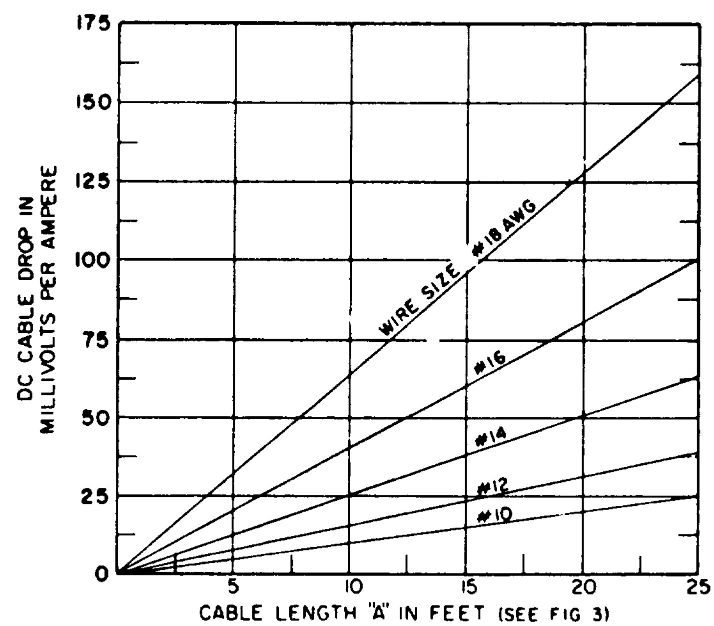


FIG. 2. IMPROVED 2-WIRE CONNECTION (SEE FIG. 5)

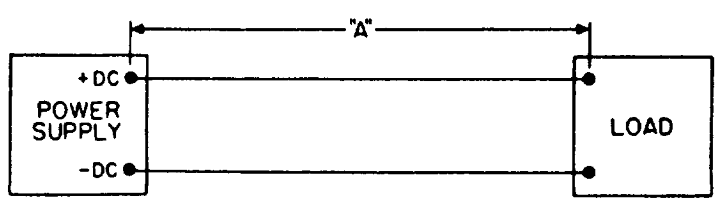
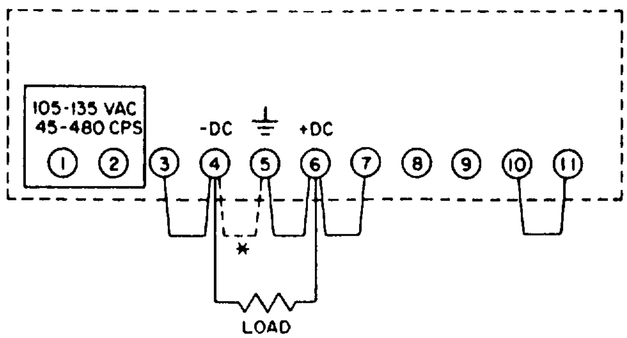
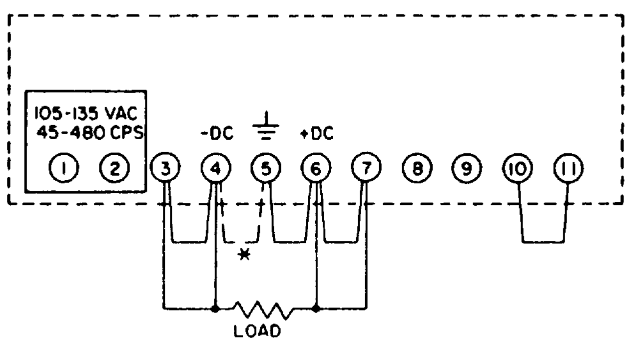


FIG. 3. CABLE LENGTH "A" IN FEET



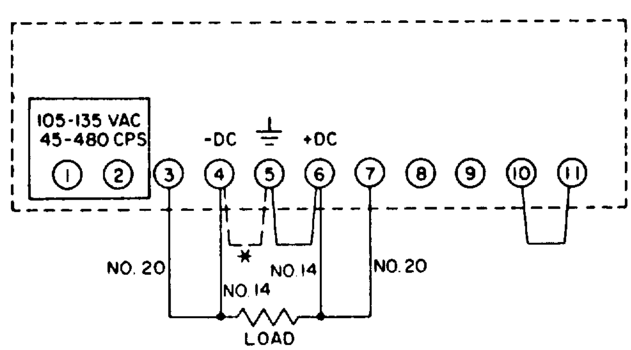
NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 4. TWO-WIRE CONNECTION



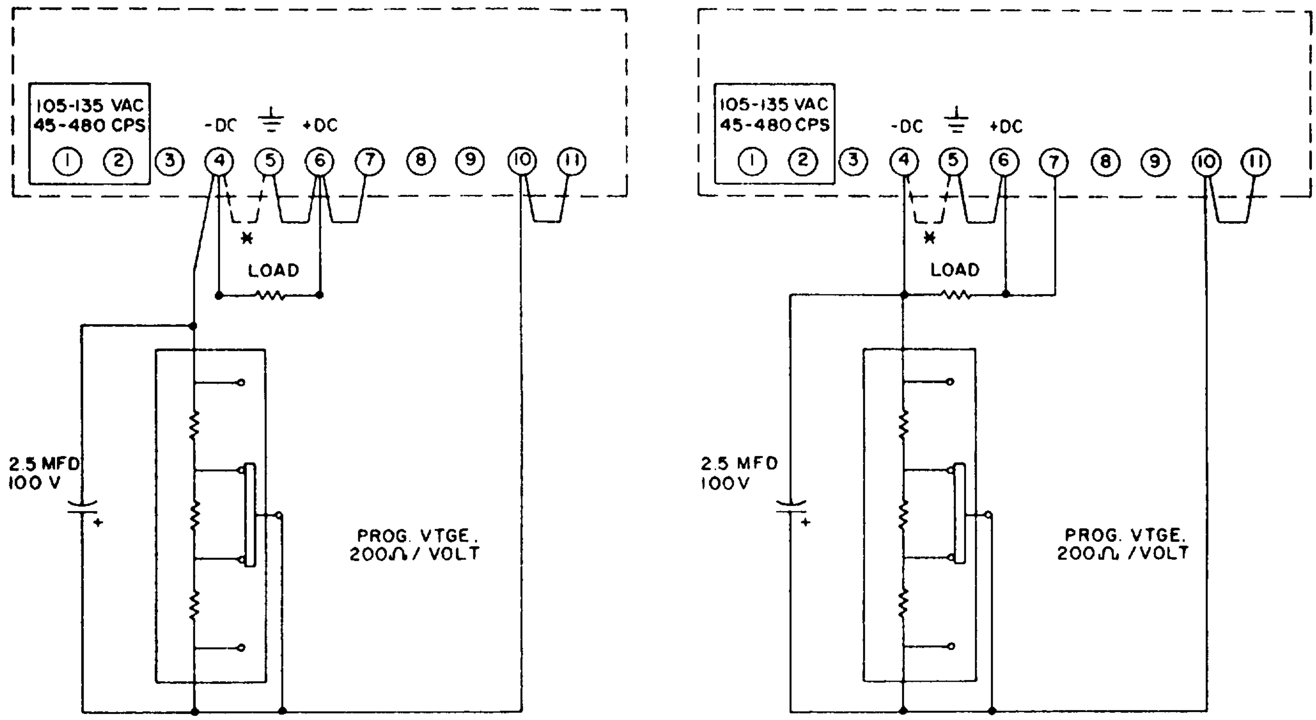
NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 5. IMPROVED TWO-WIRE CONNECTION



NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 6. FOUR-WIRE CONNECTION

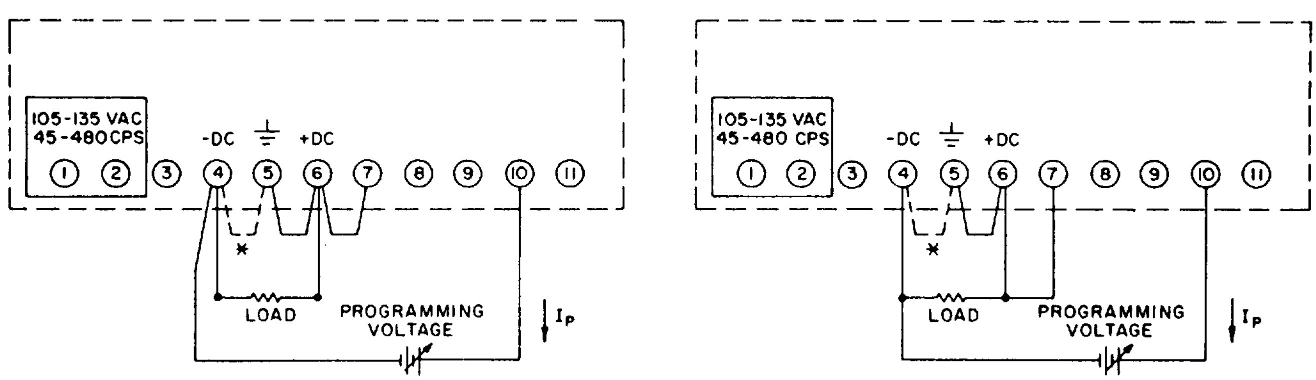


(A) LOCAL SENSING

(B) REMOTE SENSING

NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 7. PROGRAMMED VOLTAGE, WITH EXTERNAL RESISTOR

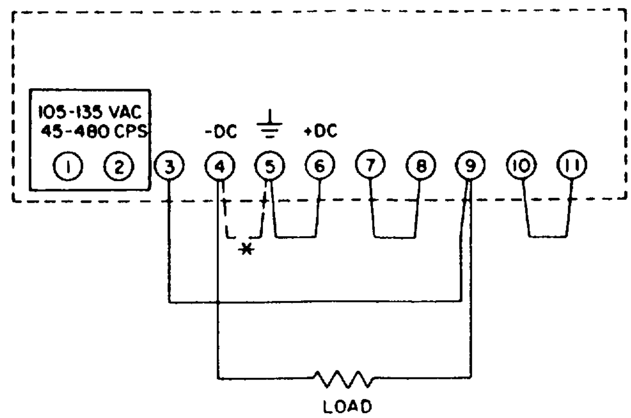


(A) LOCAL SENSING

(B) REMOTE SENSING

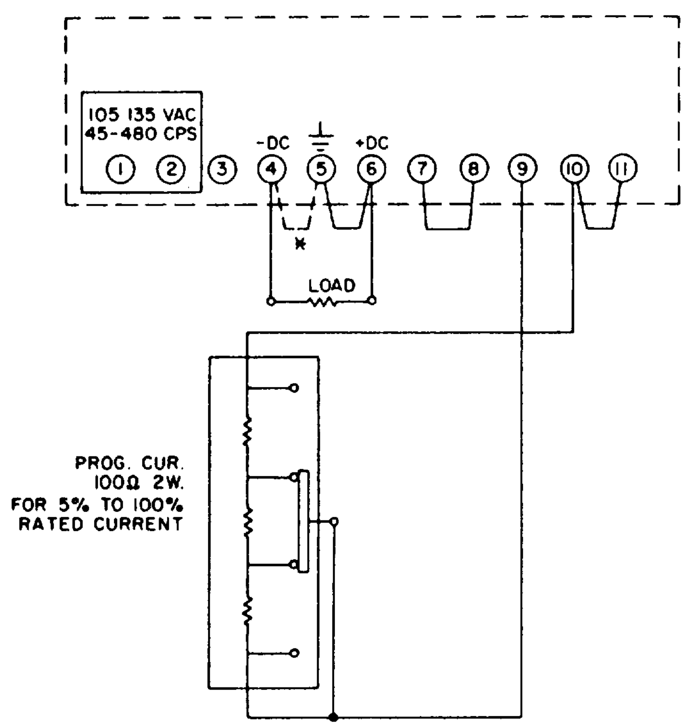
NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 8. PROGRAMMED VOLTAGE, WITH EXTERNAL PROGRAMMING VOLTAGE SOURCE



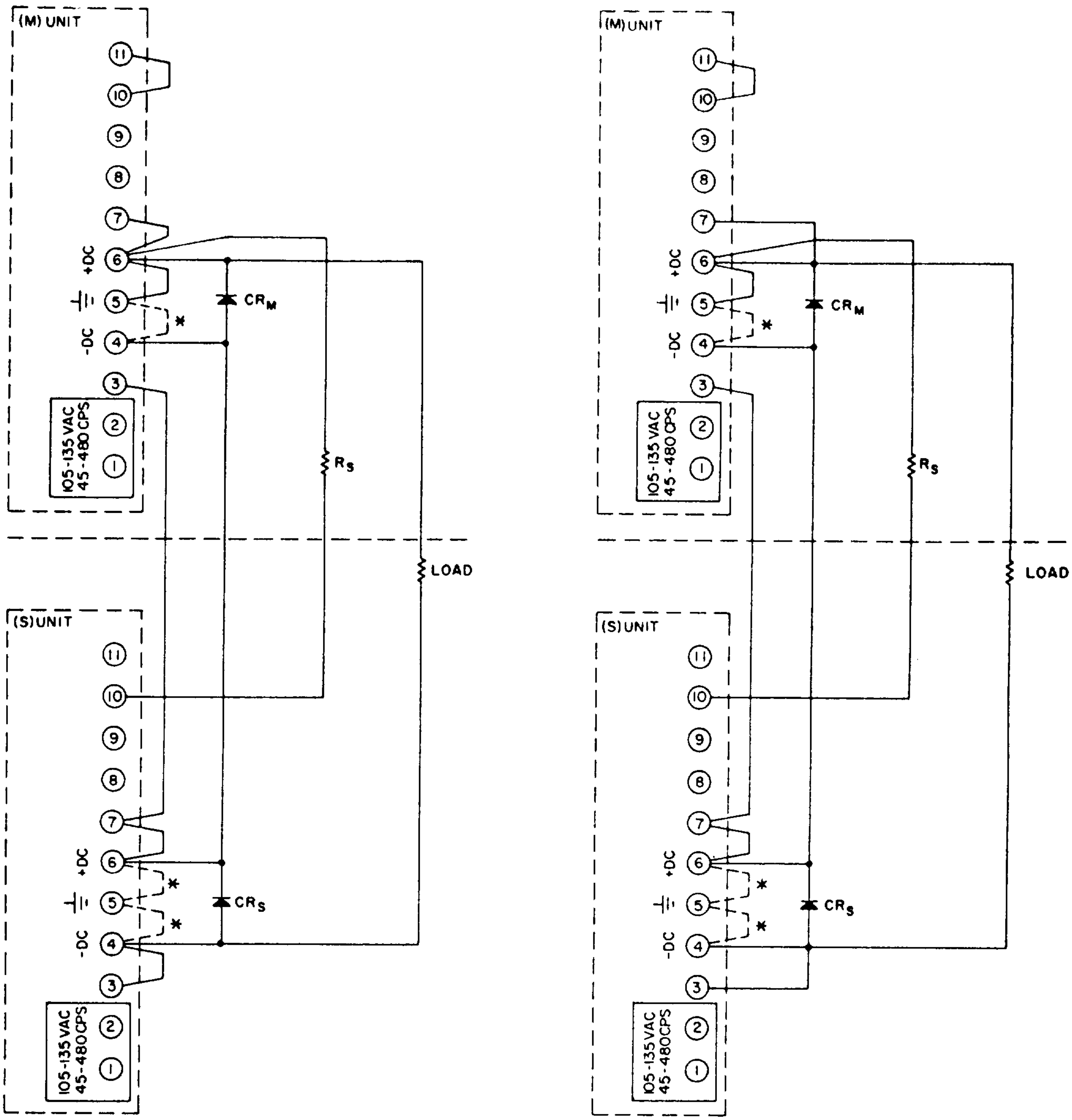
NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPERS FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 9. PRECISION CONSTANT CURRENT



NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 10. PROGRAMMED PRECISION CONSTANT CURRENT

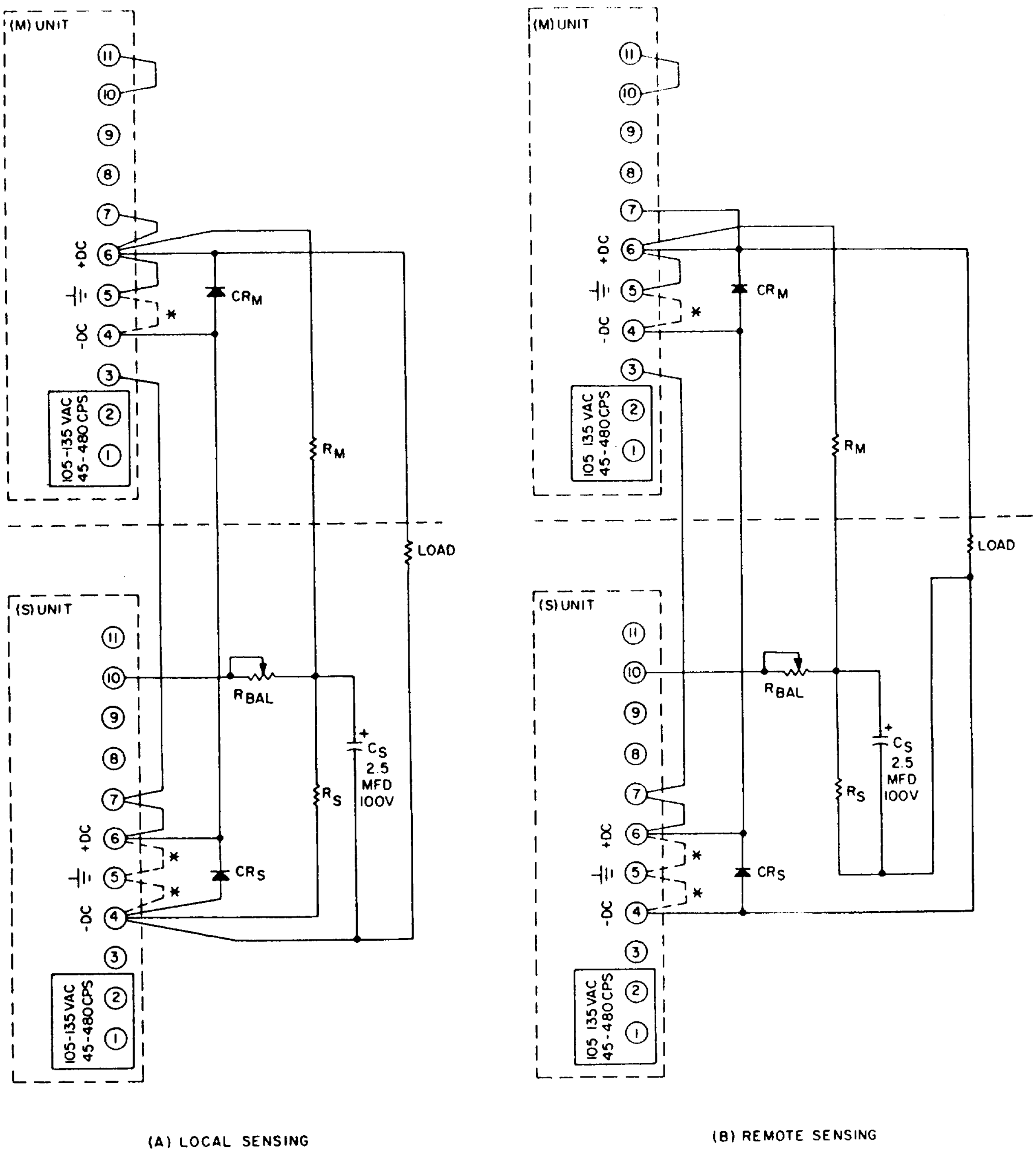


(A) LOCAL SENSING

(B) REMOTE SENSING

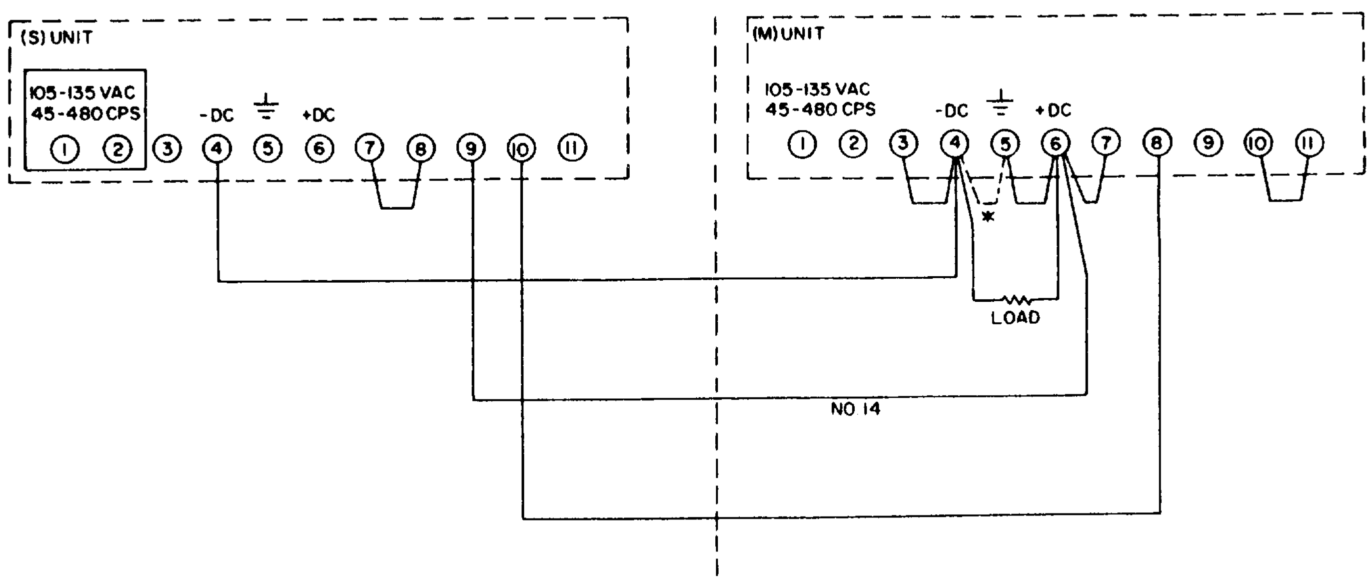
NOTE:
MAKE ONLY ONE GROUND CONNECTION FOR THE SERIES COMBINATION, TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FORM TERMINALS 5 AND 6 ON (M) UNIT AND CONNECT ANY <u>ONE</u> OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.

FIGURE 11. SERIES CONNECTION



NOTE:
* MAKE ONLY ONE GROUND CONNECTION FOR THE SERIES COMBINATION; TO CHANGE GROUND AS SHOWN, REMOVE JUMPER FROM TERMINALS 5 AND 6 ON (M) UNIT AND CONNECT ANY ONE OF THE OTHER JUMPERS AS SHOWN IN DOTTED LINE.

FIGURE 12. ALTERNATE SERIES CONNECTION



NOTE:
* FOR NEGATIVE GROUND, DISCONNECT JUMPER FROM TERMINALS 5 AND 6 AND RECONNECT TO TERMINALS 4 AND 5.

FIGURE 13. PARALLEL CONNECTION, LOCAL SENSING

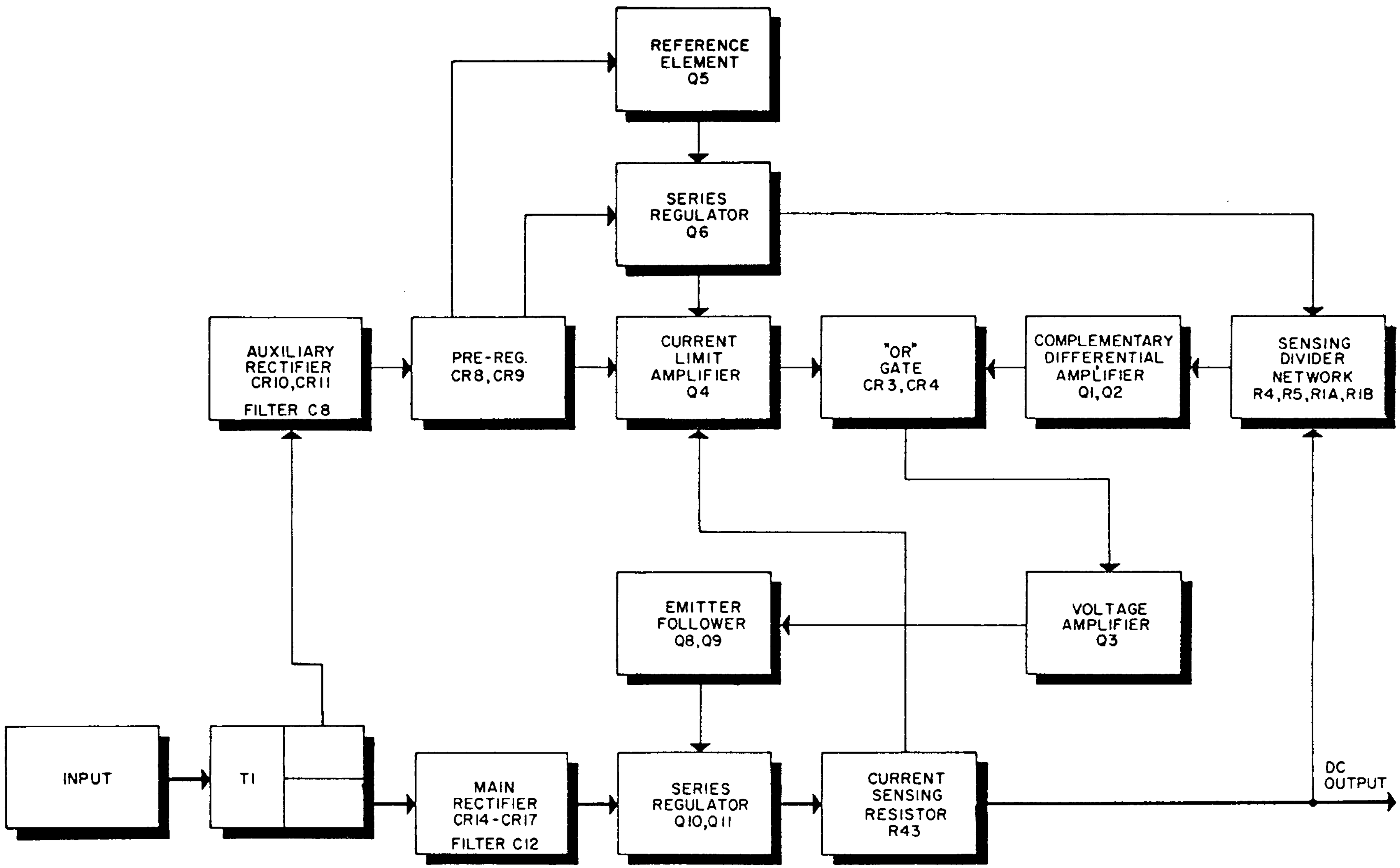
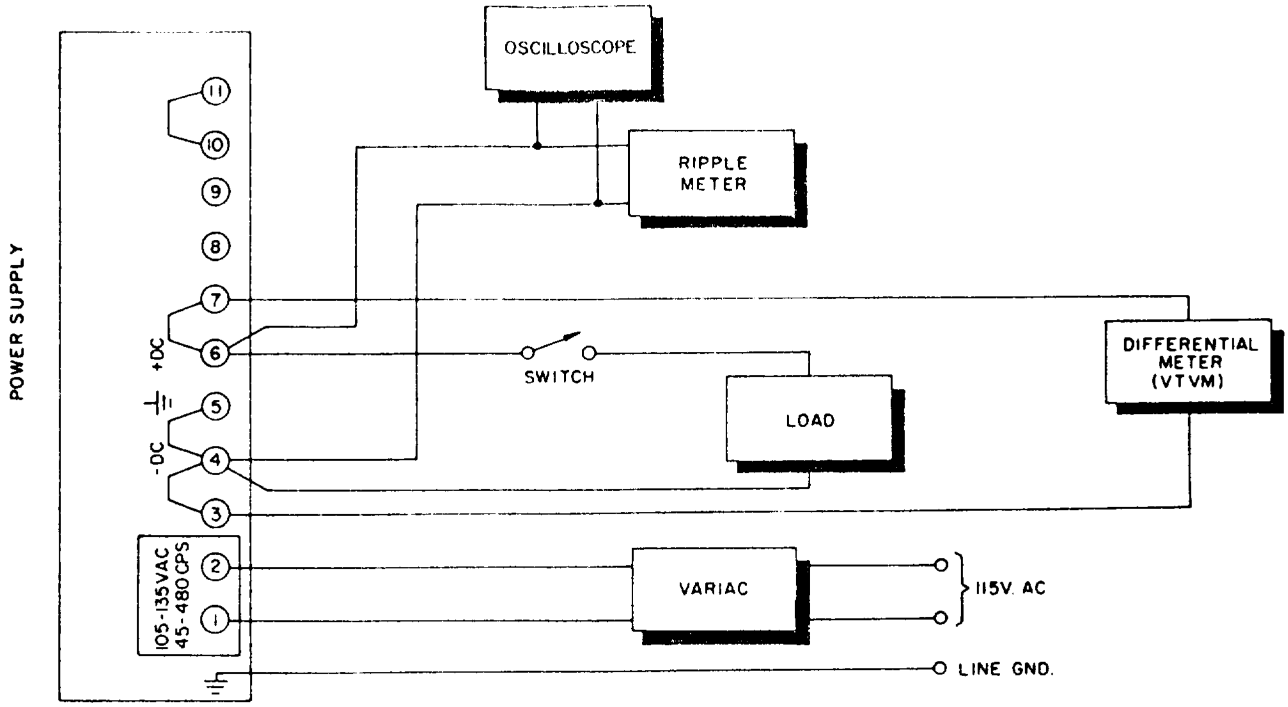
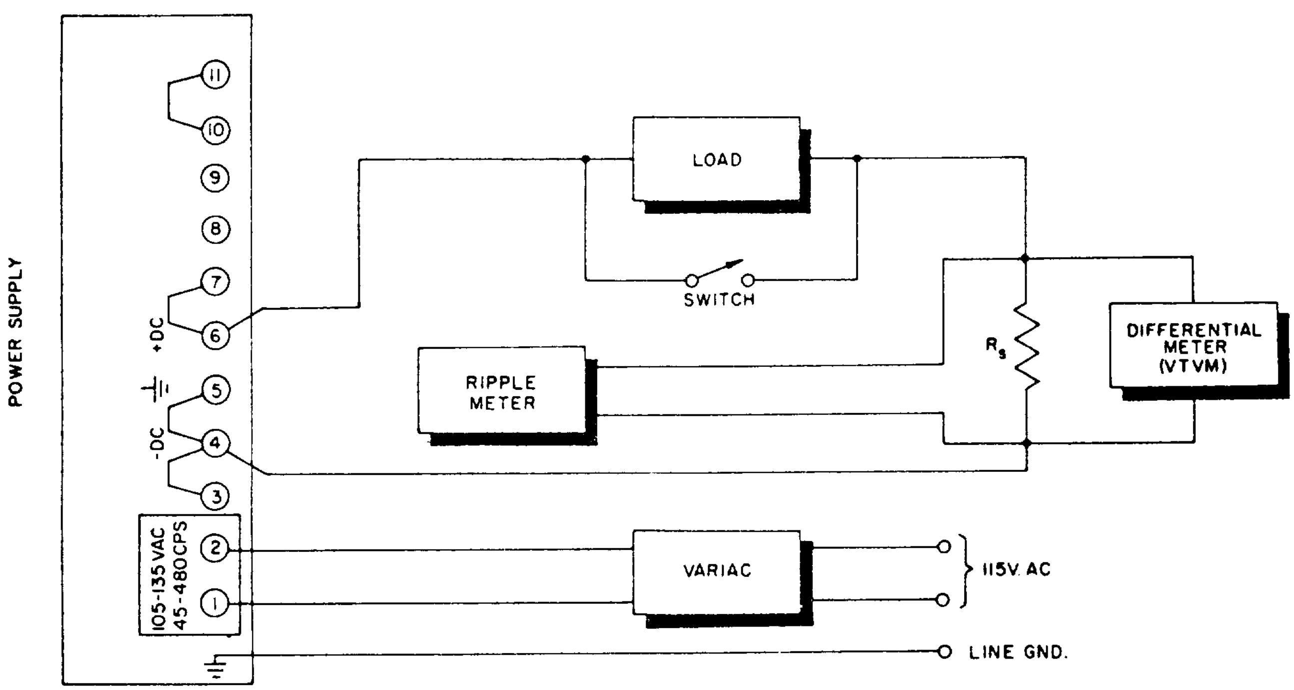


FIGURE 14. BLOCK DIAGRAM, CONSTANT VOLTAGE AND CONSTANT CURRENT CROSSOVER



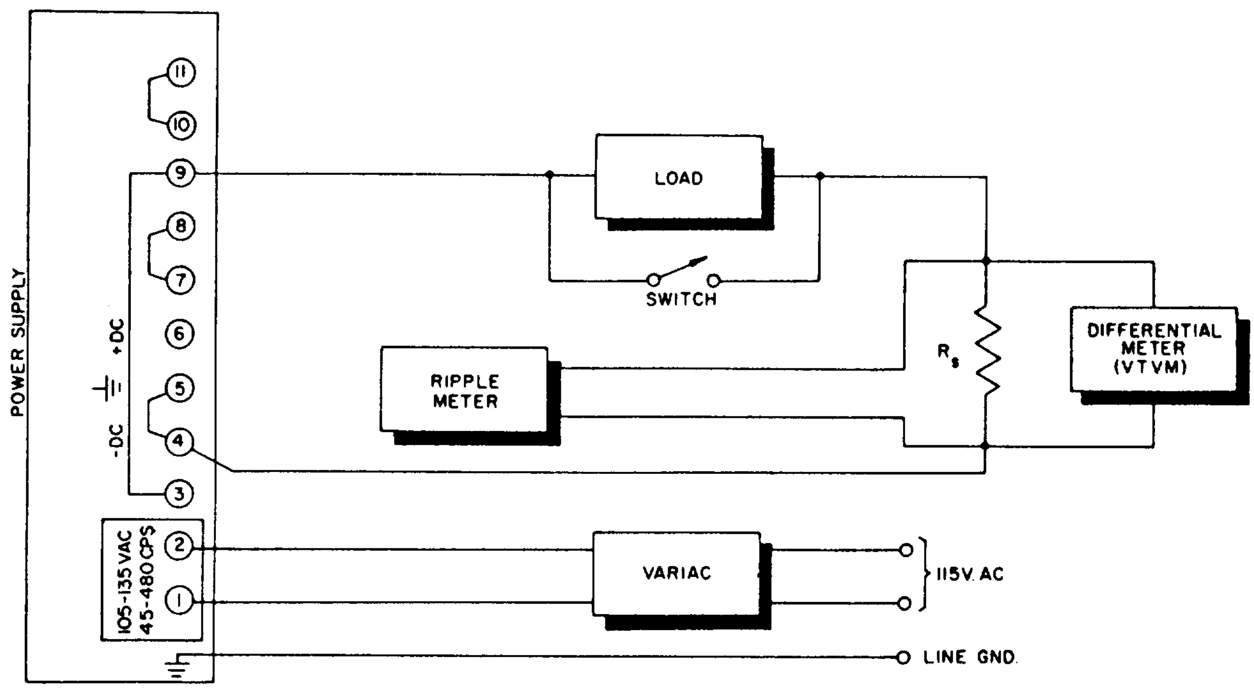
NOTES:
1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

FIGURE 15. TEST CONNECTIONS FOR CONSTANT VOLTAGE PERFORMANCE CHECKS



NOTES:
1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

FIGURE 16. TEST CONNECTIONS FOR CONSTANT CURRENT PERFORMANCE CHECKS



NOTES:

1. REGULATION AND RIPPLE CHECK METERS MUST NOT BE GROUNDED THROUGH THREE-WIRE LINE CORD TO GROUND.
2. PERFORM CHECKS WITH LOCAL SENSING CONNECTIONS ONLY.

FIGURE 17. TEST CONNECTIONS FOR PRECISION CONSTANT CURRENT PERFORMANCE CHECKS

GENERAL DESCRIPTION

Rack adapter LRA-1 is designed for use in equipment racks where ruggedized mounting of units is required. The adapter can be used with or without chassis slides.

Rack adapter LRA-2 is designed for simple applications of rack installation where chassis slides and ruggedized mounting of equipment are not required.

Both rack adapter LRA-1 and LRA-2 can be used to install 1/4-rack or 1/2-rack power supply units into equipment racks. Each adapter can accept various combinations of 1/4 and 1/2-rack units up to four 1/4-rack units or two 1/2-rack units.

INSTALLATION OF 1/2 RACK UNITS INTO LRA-1

To install 1/2-rack power supply units, remove slide numbers 2 and 3 and/or 6 and 7, together with securing hardware and associated slide bar nut.

Using slide screws and slide bar nuts that were removed, store removed slides on the frame at the rear of the adapter where screw clearance holes are provided for securing each slide to the adapter.

SHIPMENT OF UNITS MOUNTED IN LRA-1

To protect the unit against damage from shock and vibrations when transporting adapter with installed units, eight universal tie-down mounting holes, located in the adapter base, at the rear of the rack adapter, are used to secure 1/4-rack and/or 1/2-rack units into the rack adapter. Secure each unit using two 6-32 x 5/8 screws, two lockwashers and two spacers installed from the bottom side of the rack adapter. See detail A for typical securing hardware. Eight spacers are supplied with rack adapter LRA-1.

RUGGEDIZED MOUNTING

When ruggedized mounting of units is required, follow the procedure described for SHIPMENT OF UNITS MOUNTED IN LRA-1. See detail A for typical securing hardware.

MOUNTING CHASSIS SLIDES

Mount chassis slides using the following hardware. To assure unrestricted mounting of units into the adapter designated screw lengths must not be exceeded. Insert screws into designated holes and secure slide in position using long bar nut supplied with rack adapter LRA-1.

CHASSIS TRAK NO. CTS.-116:
10-32 x 7/16 fl-hd;
use A holes.

JONATHAN NO. 130 QD:
6-32 x 5/16 pan hd;
use B and C holes.

GRANT PULLEY NO. 4435:
6-32 x 5/16 fl-hd;
use B and D holes.

USING BLANK PANELS AND BLANK CHASSIS

Blank front panels Model LBP-10 and LBP-20 are available for covering any 1/4-rack or 1/2-rack opening respectively. The blank panels can be used with rack adapter LRA-1 and LRA-2 whenever a 1/4-rack or 1/2-rack space in the adapter is not occupied by a unit. Secure each panel in position using four 6-32 x 3/8 pan-head screws supplied with the rack adapter.

Paneled blank chassis Models LBC-10 (1/4-rack size) and LBC-20 (1/2-rack size) are available for any 1/4-rack or 1/2-rack equipment design package. These blank chassis enable the user of rack adapters LRA-1 and LRA-2 to design system equipment that can be packaged on ready-made chassis that are compatible with existing system components. Both blank chassis can be used with rack adapters LRA-1 and LRA-2.

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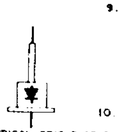
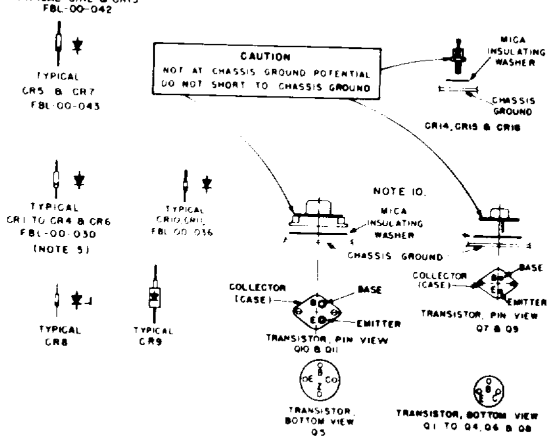
NOTES

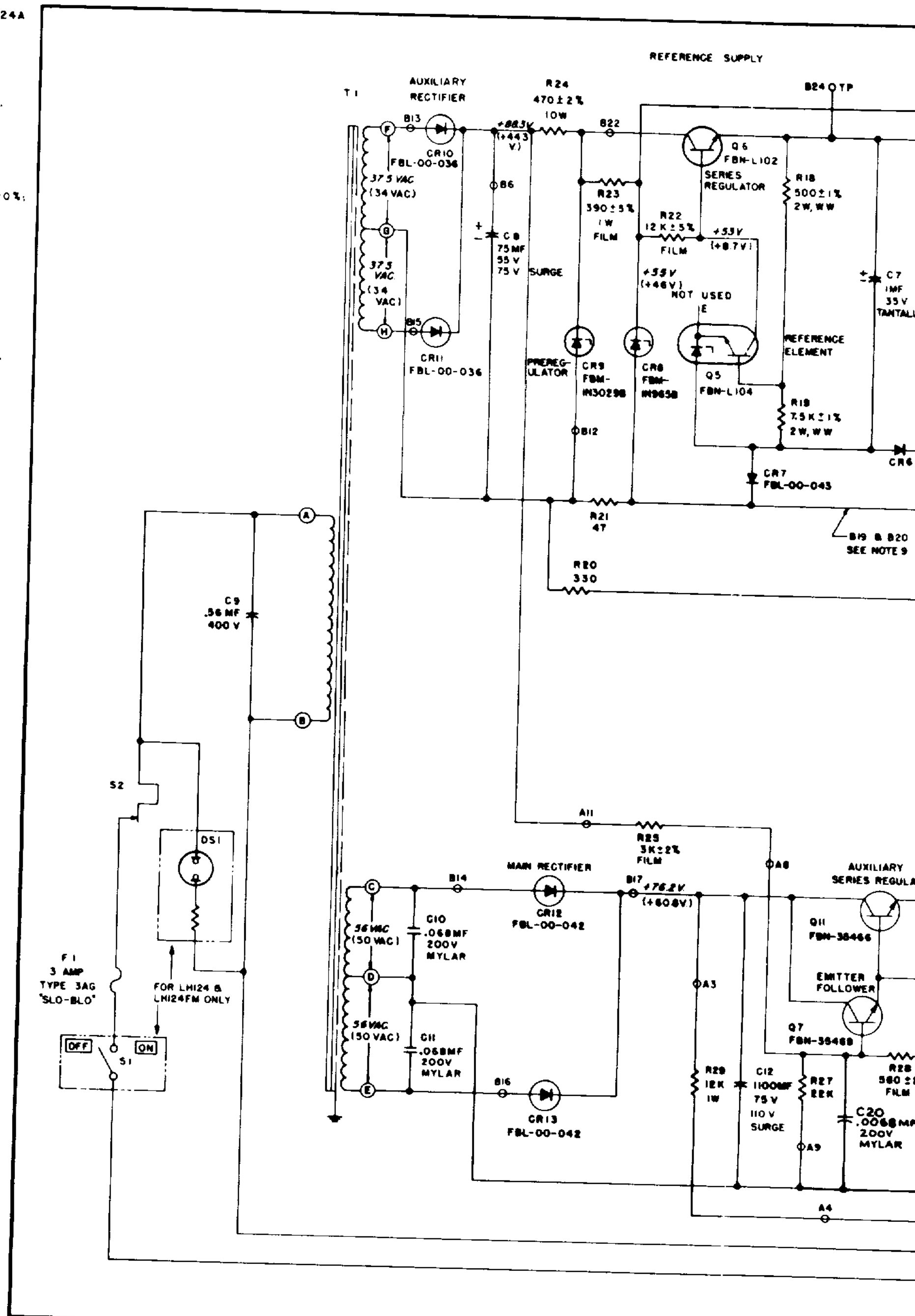
1. RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE NOTED.
2. RESISTOR WATTAGE 1/2 WATT; RESISTORS ABOVE 2 WATTS ARE WIREWOUND UNLESS OTHERWISE NOTED.
3. RESISTOR TOLERANCES: COMPOSITION ±10%: WIREWOUND ±5% UNLESS OTHERWISE NOTED.
4. CAPACITOR TOLERANCES: ELECTROLYTIC, -10% + 100%; TANTALUM, -15% +75%; PAPER, ±10%; CERAMIC, ±20%; MICA, ±20%; MYLAR, ±10%, UNLESS OTHERWISE NOTED
5. SYMBOLS:
   - INDICATES CLOCKWISE ROTATION OF SHAFT.
   - INDICATES CONNECTION TO CHASSIS.
   - INDICATES ADJUSTMENT OR CALIBRATION CONTROL.
   - INDICATES ACTUAL UNIT MARKING.
   - INDICATES FRONT-PANEL MOUNTED COMPONENT.
   - INDICATES FACTORY ADJUSTMENT; SEE INSTRUCTION MANUAL.
   - INDICATES TRANSFORMER LUG TERMINAL.
   - THIS DIODE IS LAMBDA PART NO. FBL-00-030; CAN BE REPLACED WITH STANDARD TYPE 1N645 DIODE UNLESS OTHERWISE NOTED.
6. CONDITIONS FOR CIRCUIT POINT VOLTAGE MEASUREMENTS.
   A. CONSTANT VOLTAGE
      READ ITALICIZED NUMBERS FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT VOLTAGE OPERATION.
      INPUT: 120 VAC, 60 CPS.
      OUTPUT: 40 VOLTS, OUTPUT CURRENT ZERO.
   B. CONSTANT CURRENT
      READ NUMBERS IN PARENTHESES FOR CIRCUIT POINT VOLTAGES WHILE IN CONSTANT CURRENT OPERATION.
      INPUT: 120 VAC, 60 CPS, 30°C AMBIENT.
      OUTPUT: 0 VOLTS, OUTPUT CURRENT 1.3 AMPS (SHORT CIRCUIT).

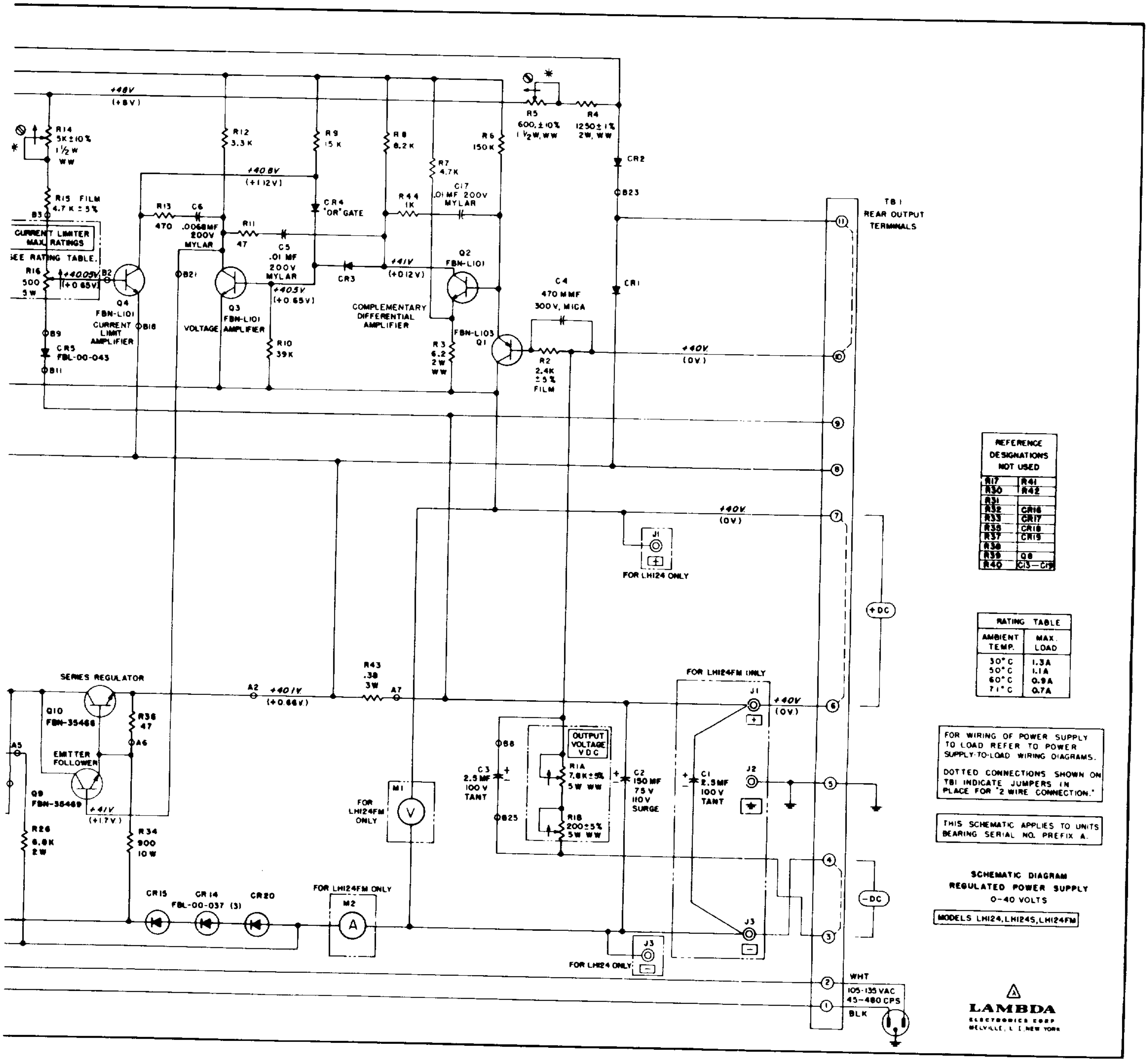
   INDICATED VOLTAGES ARE TYPICAL VALUES AND ARE DC UNLESS OTHERWISE NOTED.

   DC MEASUREMENTS TAKEN WITH 20,000 OHMS / VOLT VOLTMETER BETWEEN - DC (TERM. 4) AND INDICATED POINTS UNLESS OTHERWISE NOTED.
7. DESIGNATIONS ARE LAMBDA PART NUMBERS.
8. INDICATES TERMINAL LOCATED ON PRINTED WIRING BOARD "A" (SMALL BOARD) OR "B" (LARGE BOARD).
9. TERMINAL NO. 19 ON PRINTED WIRING BOARD "B" IS COMMON CONNECTION POINT FOR CR8, R21 AND EMITTER OF Q3; TERMINAL NO. 20 ON BOARD "B" IS COMMON CONNECTION POINT FOR CR7, R10, R3 AND COLLECTOR OF Q1; TERMINAL NOS. 19 AND 20 OF BOARD "B" ARE INTERNALLY CONNECTED TO TERMINAL NO 25 OF REAR OUTPUT TERMINAL BOARD.
10. COAT BOTH SIDES OF MICA WASHER WITH DOW CORNING NO. 340 SILICONE GREASE.









REFERENCE DESIGNATIONS NOT USED

R17	R41
R30	R42
R31	
R32	CR16
R33	CR17
R35	CR18
R37	CR19
R38	
R39	Q8
R40	C13—C19

RATING TABLE

AMBIENT TEMP.	MAX. LOAD
30°C	1.3A
50°C	1.1A
60°C	0.9A
71°C	0.7A

2

FRAME-
REAR

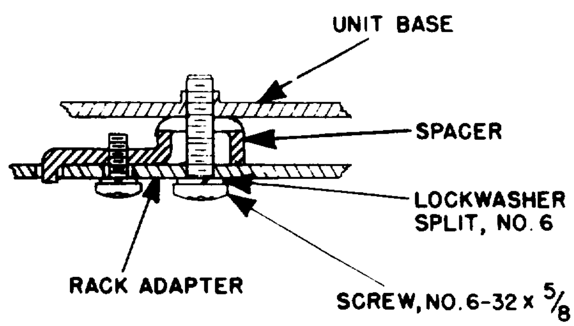
REAR TIE-DOWN MOUNTING HOLES
(FOR RUGGEDIZED MOUNTING
SEE DETAIL "A")

SLIDE BAR NUT

SLIDE
NOS. 2 & 3

LRA-1

$1\frac{11}{16}$



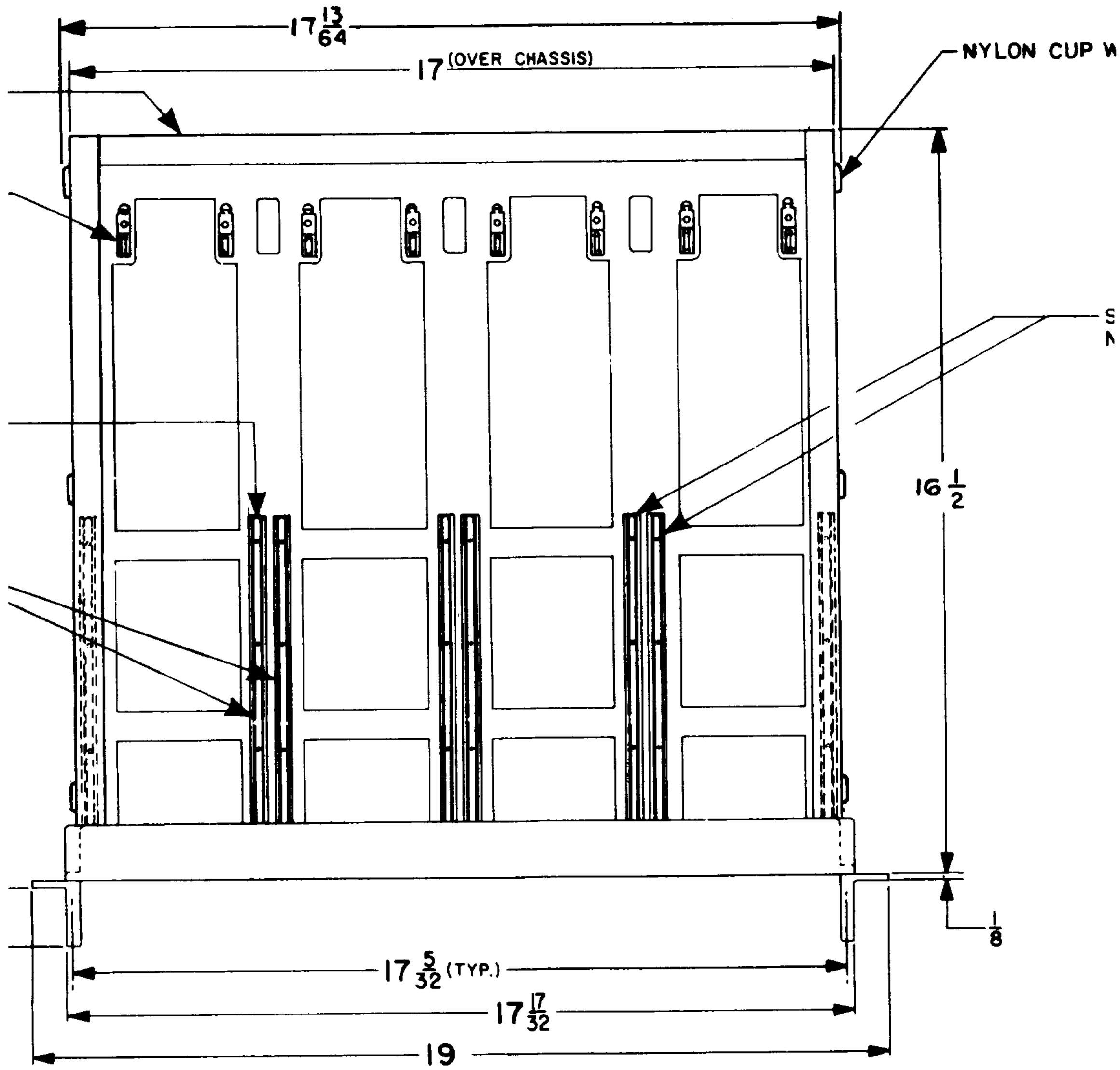
DETAIL A

$5\frac{7}{32}$

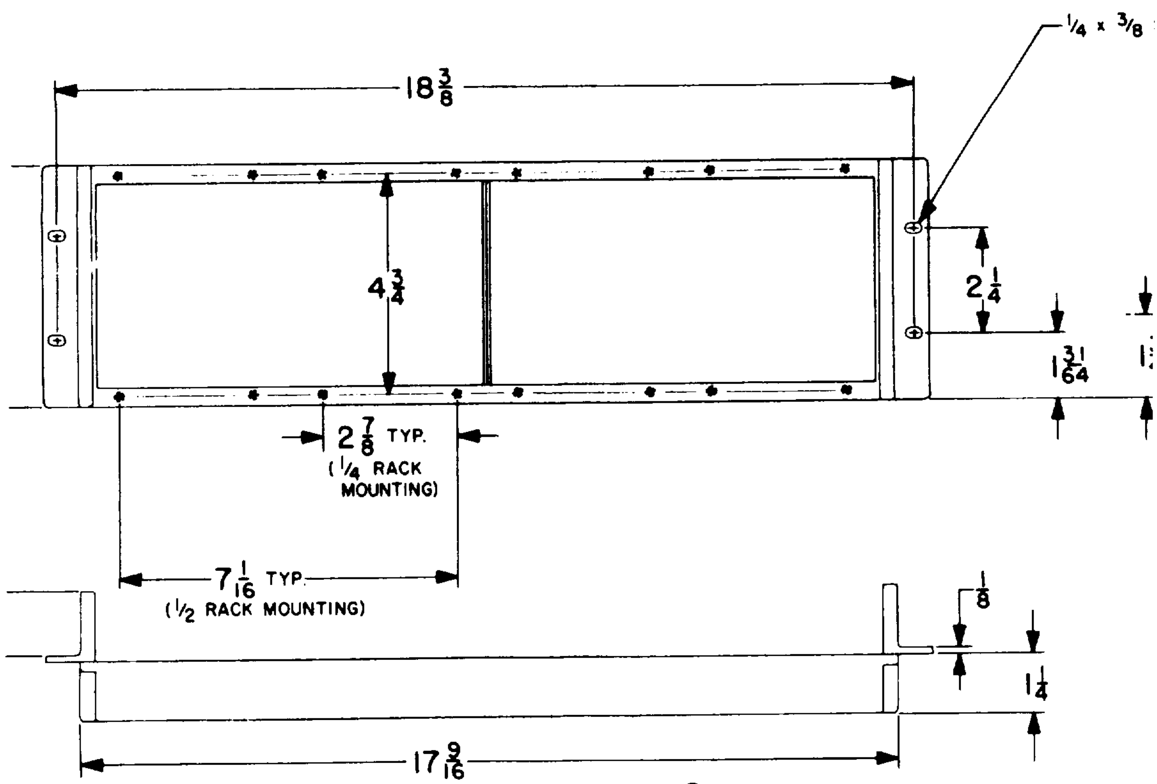
$1\frac{11}{16}$

LRA-2

18-1



$17\frac{13}{64}$
17 (OVER CHASSIS)
NYLON CUP W
$16\frac{1}{2}$
$\frac{1}{8}$
$17\frac{5}{32}$ (TYP.)
$17\frac{17}{32}$
19



$18\frac{3}{8}$
$\frac{1}{4} \times \frac{3}{8}$
$4\frac{3}{4}$
$2\frac{1}{4}$
$1\frac{31}{64}$
$2\frac{7}{8}$ TYP.
($\frac{1}{4}$ RACK MOUNTING)
$7\frac{1}{16}$ TYP.
($\frac{1}{2}$ RACK MOUNTING)
$\frac{1}{8}$
$1\frac{1}{4}$
$17\frac{9}{16}$

18-2

/ASHER

;LIDE
IOS. 6 & 7

TABLE OF WEIGHTS

MODEL	NET (LBS)	SHIPPING (LBS)
LRA-1	12	16
LRA-2	3	4

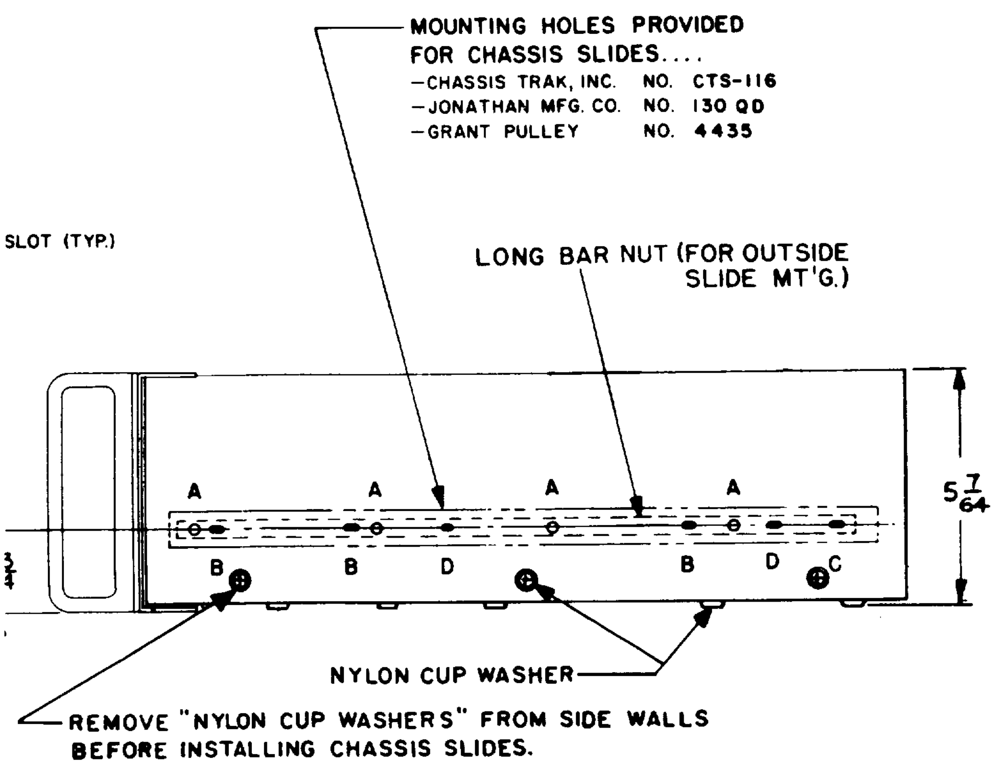


FIGURE 18. RACK ADAPTERS LRA 1, AND LRA 2

SECTION II

OPERATIONS

2.0 GENERAL.

2.1 This section contains step-by-step procedures to be followed in shipment, handling, installation, interfacing with MSC subsystems, calibration, system startup, normal operation, emergency operation and system shutdown. The operation portion of the section is divided into parts A and B. Part A covers normal operating procedures and part B contains emergency operating procedures.

2.2 SHIPMENT.

2.2.1 All components of the ADTD are prepared for shipment in accordance with good commercial practice. All major components are skid mounted and enclosed by suitable crating and environmental barriers.

2.2.2 The ADTD components are packaged separately as follows:

Component	Type of Container
General Assembly (ADTD and seismic mass) - (359-60004)	Polyethylene bag
Hydraulic Power Pack with hoses to connect to General Assy - (359-11401)	Wooden skid
Vacuum System with hoses - (359-11010 and -11011)	Enclosed wooden crate
Accumulator Racks - (359-61009)	Open wooden crate
Control Console (seven cabinets) - (359-62002)	Enclosed wooden crate
Transmission Line Cabinet (for computer room) - (359-62520)	Enclosed wooden crate
Transmission Cables (long and short) - (359-11012)	Wrapped spools
Shock Mounts (4 units) - (359-30101)	Enclosed crates
Installation Hardware - (Mechanical)	Enclosed crates
Installation Hardware - (Hydraulic)	Enclosed crates

Component	Type of Container
Installation Hardware - (Electrical)	Enclosed crates
Installation Hardware - (Vacuum System)	Enclosed crates
Special Tools - (Maintenance and Overhaul)	Enclosed crates
Spare Parts - (Maintenance and Overhaul)	Enclosed crates
Control Console Recorders and Oscilloscope	Enclosed crates

2.2.3 Dismantling Sequence for Shipment of ADTD to MSC.

2.2.3.1 Hydraulic Hose Supports.

2.2.3.1.1 Remove screws and nuts securing hose clamps to tension springs supporting hydraulic lines. Release spring eye end from clamp and resecure clamps to hydraulic lines.

2.2.3.1.2 Disassemble hose support structure from ADTD main support structure by removing u-bolts and nuts. Do not disassemble tension springs from main lateral member. Dismantle structure to basic elements and crate for shipment as in 2.2.2.

2.2.3.2 Hydraulic Lines.

2.2.3.2.1 Decouple pressure and return lines at penetration assemblies.

2.2.3.2.2 Install seal caps on quick-disconnect coupling halves on exterior flexible hoses.

2.2.3.2.3 Stow pressure and return lines on the ADTD by recoiling from pressure and return manifolds over ADTD support structure. Secure penetration assemblies by lockwiring through bolt holes to the support structure at any convenient location.

2.2.3.2.4 Do not disassemble or uncouple any other fluid lines.

2.2.3.3 Vacuum System.

2.2.3.3.1 Decouple vacuum system lines at penetration plate.

2.2.3.3.2 Install plugs in flexible hoses attached to penetration assembly.

2.2.3.3.3 Stow vacuum lines similar to hydraulic lines.

2.2.3.4 Electrical System.

2.2.3.4.1 Disconnect all hermetic connectors on both sides of electrical penetration plate. Cap all plugs and receptacles.

2.2.3.4.2 Recoil and stow all cables on ADTD by taping to the cable tray at convenient locations.

2.2.3.4.3 Recoil and stow exterior cables at point of origin.

2.2.4 Dismantling Sequence for Shipment of ADTD within MSC.

2.2.4.1 For transporting the ADTD from Buildings 13 to 32, or visa versa, the procedure outlined in 2.2.3 should be followed with the exception that the hydraulic hose support (see 2.2.3.1) need not be disassembled. Care should be exercised, however, in the rigging of the lifting slings for the ADTD assembly to avoid sling interference with the hydraulic lines. The spreader bar of the lifting sling 359-01003, must be installed beneath the longitudinal members of the hose support assembly to ensure correct lifting configuration.

2.3 METHODS OF PRESERVATION AND PACKING.

2.3.1 The ADTD assembly is cleaned in accordance with paragraph 3.2. Polyethylene material is placed around the unit, with the lifting lugs exposed for handling purposes.

2.3.2 The Hydraulic Power Pack is mounted on a skid with wheels blocked and axles guyed to the skid.

2.3.3 The vacuum system dolly is enclosed in a crate. All exposed ports, valves, fittings and lines are suitably capped or plugged with plastic closures.

2.3.4 Accumulator assemblies are skid mounted and enclosed by an open type crate to provide necessary support to the structure. All exposed connections are suitably capped with rigid plates to prevent damage to sealing joint surfaces, and wrapped to prevent entry of foreign matter. (Note: All but 1-2 gals of hydraulic fluid is drained from the accumulators, the shut off valves closed and the gas precharge reduced to 125 psi guage.)

2.3.5 Control console is mounted on a skid, with dolly wheels blocks, and an enclosing crate secured to the skid. All console openings will be sealed and taped for protection against elements.

2.3.6 Transmission Line Cabinet is packaged the same as 2.3.5 above.

2.3.7 Transmission cables are rolled upon spools, wrapped in cardboard and banded.

2.3.8 Shock mounts are individually wrapped and packed in an enclosed crate. Assemblies are cleaned in accordance with paragraph 3.2 chamber usage.

2.3.9 Mechanical installation hardware is bulk packaged after cleaning, in tagged bags marked with part number or description, quantity, and next assembly. Bags are sealed plastic material. Brackets, hangers, and similar items are individually tagged with part number and next assembly. O-ring seals, gaskets and similar soft-ware is repacked in original containers except a label or tag is affixed indicating next assembly and quantity. All items as cleaned in accordance with paragraph 3.2, and securely packed in a crate. A packing list by item and quantity is secured to the crate in a weatherproof envelope. Refer to AMF QATP-21-16-E022 for detailed inspection and test procedures for installation of ADTD in Buildings 13 and 22.

2.3.10 Hydraulic installation hardware is packaged in the same as above, except unusual lengths of pipe, tubing, or hose is regrouped and crated separately and marked to indicate contents and next assembly.

2.3.11 Electrical installation hardware is packaged the same as 2.3.9 above.

2.3.12 Vacuum system installation hardware is packaged the same as 2.3.10 above.

2.3.13 Special tools are bagged and/or tagged with nomenclature and tool number (tool number keyed to assembly usage). The crate is clearly marked and contains a packing list of items included.

2.3.14 Spare parts are cleaned in accordance with AMF cleanliness specifications and are wrapped in sealed moisture vapor barrier material. Packaged same as 2.3.9 above.

2.3.5 Chart recorders and oscilloscope are dismounted from their panel locations, wrapped in moisture barrier material, and packed in suitable shock absorbant material in paperboard cartons. Cartons are labelled with part number description and next assembly of contents. Any loose mounting hardware, connectors, gaskets or loose cables are securely wrapped or bagged and attached to the component in a prominent location. Crate is clearly marked with contents. Crate is clearly marked with suitable labels indicating fragile nature of contents.

2.4 SHIPPING.

2.4.1 All equipment is shipped to the following address:

W. L. Green
NASA Manned Spacecraft Center
2101 Webster-Seabrook Road
Bldg. 13
Houston, Texas

2.4.2 The ADTD Assembly (Ref. AMF DWG NO. 359-60004) is shipped by tractor-low boy trailer equipped with "Air-Ride". A paper case liner will be placed on the trailer floor and secured to the underside and edges of the seismic mass. A nylon tarpaulin will be placed over the entire unit and secured to trailer. The unit is suitably blocked, braced and tied down with chain binders affixed to the lifting lugs on the seismic mass.

2.4.3 All other components and equipment are shipped by tractor enclosed van flat bed trailer. Crates are arranged for transmission line cabinet and transmission cables to be unloaded first for direct movement to computer room, building 13, MSC. The balance of the items can be unloaded and installed in accordance with paragraph 2.6 of this section. Handling equipment required for installation is specified in paragraph 2.5.

2.5 HANDLING. The installation of the ADTD equipment is initially accomplished by AMF.

2.5.1 The following tools and equipment will be required to be furnished by NASA at both buildings 13 and 32.

2.5.1.1 Fork lift truck with adjustable tynes and tow bar, 2 ton capacity.

2.5.1.1.1 The fork lift truck will be used to transport ADTD components which are skid mounted. These include the Hydraulic Power Pack, Vacuum System, Accumulator Racks, Control Console, Transmission System, and various crated sub-assemblies and components such as installation hardware, spare parts and special tools. All skids are designed for broadside fork lifting to facilitate handling. Care must be exercised in correctly adjusting lifting tines to avoid damage to equipment. Avoid heavy bumbing of crated items containing instrumentation. (Look for Fragile and Handle with Care labels on containers and handle accordingly.)

2.5.1.1.2 The fork lift truck will also be used for towing the Hydraulic Power Pack. A steering draw bar is provided with a lunette suitable for this purpose on the power pack. Towing speeds must not exceed 20 MPH on level areas, and 5 MPH on grades. Avoid transverse grades in excess of 5%. Manual parking brakes on rear wheels must be fully released prior to towing and reset after positioning. Only qualified truck operators should be used in handling ADTD equipment.

2.5.1.2 Overhead bridge crane, 30 ton capacity.

2.5.1.2.1 The overhead bridge crane will be required for transport and positioning of the ADTD general assembly. It may also be used for transport of skid mounted components where fork lift or towing is not feasible due to obstructions. The ADTD lifting sling should be arranged as shown in sling usage illustration in Data Section IB. Proper rigging procedures must be followed in the assembly of all sling configuration with appropriate precautions taken to avoid kinks and sharp bends in wire ropes, loose shackle pins, and similar hazards. Where adjustable leg portions of the lifting sling are used, set lengths of legs to center eye approximately over the center of gravity (CG) of the item to be lifted. Take up slack in slings and observe for any tendency of item to rotate about the lifting point. If necessary, lower item and re-adjust leg lengths to compensate for CG location.

2.5.1.2.2 For safe handling of the ADTD assembly when transporting by crane, the lifting slings should be supplemented by guy ropes. A minimum of three half-inch manila lines or equivalent should be affixed to the lifting legs on the seismic mass to prevent rotation and assure lateral control. Guys should be attended at all times that ADTD is suspended by the lifting slings. During installation and removal of ADTD from Chamber B_1 extreme care must be exercised to avoid contact between ADTD and chamber structure and panels due to minimal clearance (approximately 2 foot radial) available between seismic mass envelope and LIN panels in chamber. Only qualified riggers and crane personnel should be used in handling the ADTD assembly.

2.5.2 The following is a list of common tools and equipment which should be supplied by the personnel assigned to perform the mechanical, electrical and hydraulic installations. Their use and applications are basic to the skills involved.

2.5.2.1 Socket Wrench Set.

2.5.2.2 Hex Socket Allen Key Set.

2.5.2.3 Torque Wrench with up to 500 ft./pound Capacity.

2.5.2.4 Plumbing tools such as tube bending and flaring equipment, pipe threaders, equipment, basin wrenches, etc.

2.5.2.5 Standard Mechanical Hand Tools.

2.5.2.6 Standard Electrical Hand Tools.

2.5.3 The ADTD components are handled in the following manner.

2.5.3.1 Lifting sling 359-01003 is secured to the ADTD assembly at shipment and is used for lifting the unit off the truck. (See illustration in Data Section IB for lifting seismic mass.)

2.5.3.2 The Hydraulic Power Pack skid is designed to facilitate slinging. The skid is suitable for fork lift broadside handling. (See illustration in Data Section IB for lifting hydraulic power pack.)

2.5.3.3 The Vacuum System crate is suitable for broadside fork lift. Suitable bracking is included to prevent straining of dolly mounted components. (See illustration in Data Section IB for lifting vacuum system.)

2.5.3.4 Lifting lugs on the Accumulator assemblies are exposed for ease of handling. The skid is suitable for broadside fork lift handling. (See illustration in Data Section IB for lifting accumulator racks.)

2.5.3.5 The control console skid is suitable for broadside fork lift handling. The skid is designed to facilitate slinging. (See illustration in Data Section IB for lifting control console.)

2.5.3.6 The shock mount crates are suitable for fork lift handling. Included are two 5/8-inch bolt size eyebolts with nuts for slinging assembly after uncrating.

2.5.3.7 Mechanical,hydraulic, electrical and vacuum system installation hardware are packed in a crate suitable for fork lifting.

2.5.3.8 The transmission line cabinet skid is suitable for broadside fork lift handling. The skid is designed to facilitate slinging.

2.5.3.9 Special tools are in an enclosed crate suitable for fork lifting.

2.5.3.10 Chart recorders and oscilloscope are packed in an enclosed crate suitable for fork lifting.

2.6 INSTALLATION.

2.6.1 Installation procedures for the ADTD are divided into two phases, they are: (1) installation in building 13, and (2) installation in building 32. Each installation is separated into three parts: (1) mechanical installation covering the actual set-up of all components, (2) electrical installation covering wiring and cabling of AMF equipment and interface areas, (3) hydraulic installation covering installation of piping, tubing, hoses and fittings.

2.6.2 Special Tools.

2.6.2.1 The only special handling tool required is the ADTD handling sling, AMF No. 359-01003.

2.6.3 Building 13.

2.6.3.1 Mechanical Installation (Building 13).

2.6.3.1.1 Mount shock absorbers (359-30101) on top of the MSC furnished beams as follows: (See AMF DWG. NO. 359-09007 for mounting details.)

2.6.3.1.1.1 The shock absorbers are numbered to correspond to the numbers stamped on the edge of the seismic mass at the mounting locations of each shock absorber. Orientation of the seismic mass is shown in AMF DWG 359-61016.

2.6.3.1.1.2 Place each shock absorber on top of the MSC furnished beams. Line up mounting holes with a drift pin and secure the shock absorbers with 5/8-11 UMC-3 by 2-3/4 lg screws, 50FA1011 nuts and 5/8-inch flat washers, as shown on AMF DWG. 359-60004. This task will require a rigger and the overhead bridge crane with the necessary operating personnel to lift and emplace the shock mounts and two millwrights to bolt them in place. The estimated time is two hours for all four shock mounts.

2.6.3.1.1.3 Set the shock absorber leveling screws at their mid-point. Leave the jam nuts loose to permit later adjustment of the shock mount. Measure the free height of the lower half of the shock mount for later reference.

2.6.3.1.2 Install the general assembly (359-60004) on top of the shock absorbers as follows:

2.6.3.1.2.1 Using the 30 ton bridge crane and handling sling (see data section IB for illustration of sling use) place the ADTD over the shock absorbers. The crane should lower the ADTD to a position approximately 3/4-inch from the top of the shock mounts (See paragraph 3.5.1.2 for crane handling procedures.)

2.6.3.1.2.2 Attach shock mounts to ADTD seismic mass with 5/8-18UNF-3 bolts and 5/8-inch washers (see AMF DWG. 359-60004). The bolts should be inserted and secured by at least three full threads as the ADTD seismic mass is aligned by tag lines and crane motion. The ADTD can be slowly lowered until all the bolts are started and then fully lowered on the shock absorbers. The bolts can then be tightened and torqued. Use a 5/8 inch socket wrench and torque to 1300 inch/pounds.

2.6.3.1.2.3 While the ADTD is still rigged for lifting check for level by using either the probe actuator guide rail for an X-axis reference and a straight-edge across the two probe guide rails for a Y-axis reference. Lift the ADTD until the shock mount springs are at rest position as previously measured in paragraph 2.6.3.1.1.3 and adjust leveling nuts. Lower ADTD and check and readjust shock absorber leveling screw and nuts until assembly is level within 1-degree.

2.6.3.1.3 Install accumulator racks (359-61009) in the location shown in AMF DWG. 359-61016.

2.6.3.1.3.1 The accumulator racks are shipped as two sub-assemblies and must be positioned and then joined by assembling and torquing the "graylock" flanges. Use a 3/4-inch socket wrench and torque to 2400 inch/pounds.

2.6.3.1.3.2 Racks can be lifted by the overhead crane (see illustration in data section IB) or forklift truck and spotted as shown on AMF DWG. 359-61016. The estimated time for this work is two hours and will require operating personnel, one rigger and one pipefitter.

2.6.3.1.4 Place the hydraulic power pack (359-11401) in the location shown on AMF DWG. 359-61016.

2.6.3.1.4.1 The hydraulic power pack is mounted on a steerable wheeled chassis and can be manually moved into position and brakes set. The estimated time is 1/2 hour for two riggers.

2.6.3.1.5 Place the vacuum system (359-11010 and -11011) in the location shown on AMF DWG. 359-61016.

2.6.3.1.5.1 The vacuum system is on wheels, two of which are castered and can be manually moved to position. Estimated time is 1/2 hour for two riggers.

2.6.3.1.6 Place control console (359-62002) in the location shown on AMF DWG. 359-62001, sheet 3. Also install recorders and oscilloscope into the control console. (See AMF DWG. 359-62002)

2.6.3.1.6.1 The control console is mounted on casters and can be manually positioned. Estimated time is 1/2 hour for two riggers.

2.6.3.1.6.2 The recorders and oscilloscope are plug-in units and need only be bolted into place. Estimated time is 1/2 hour for one electrician.

2.6.3.1.7 Place the transmission line cabinet (359-62530) in the location shown on AMF DWG 359-62001, sheet 2.

2.6.3.1.7.1 The transmission line cabinet is mounted on casters and can be manually positioned. Estimated time is 1/2 hour for one rigger.

2.6.3.1.8 Install hydraulic penetration plates (VS101, VS102 and D101 as shown on AMF DWG. 359-61016.

2.6.3.2 Electrical Installation (Building 13). All installation wiring should be accomplished in accordance with AMF DWG 359-62001. Also refer to Electrical interface drawing 359-62020.

2.6.3.2.1 Install penetration plates (VS103 and VS104) in the location shown on AMF DWG 359-62001, sheet 3.

2.6.3.2.1.1 The penetration plates are bolted to mounting supports supplied by NASA/MSC and should not be removed from their protective plywood sandwiches.

2.6.3.2.2 Connect cables W40 through W52 from the control console to the general assembly through the penetration plates.

2.6.3.2.3 Coil and store cables W1 through W11 and W30 and W31, as required.

2.6.3.2.4 Connect control cables between control console and: (1) hydraulic power pack, (2) vacuum system and (3) the short transmission line cabinet in computer room 147.

2.6.3.2.5 Connect power cable between power source and: (1) vacuum system, (2) hydraulic power pack and (3) control console.

2.6.3.2.5.1 Cable and termination hardware at vacuum system, hydraulic power pack, and control console provided by AMF. The connectors at the power source to be provided by NASA.

2.6.3.2.5.2 Estimated time is 16 hours for four electricians for wiring and two hours for one millwright to mount the penetration plates.

2.6.3.3 <u>Hydraulic Installation</u> (Building 13). Install hydraulic piping, tubing, hoses, penetration plates and associated fittings in accordance with AMF DWG. 359-61016.

2.6.3.3.1 Connect cooling water lines to the hydraulic power pack and cooling water and air lines to the vacuum pumps. Water, air, and fittings are supplied by NASA and connected by AMF. Estimated time is 8 hours for two pipefitters.

2.6.3.3.2 Connect flexible hose assemblies between the hydraulic power supply and the accumulator rack.

2.6.3.3.3 Uncoil pressure and return hose and penetration plate assemblies from the shipping and storage position on the ADTD and route hoses as shown on 359-61016.

2.6.3.3.4 Assemble the flexible hoses from the hydraulic power pack to the return penetration plate and from the accumulator rack to the pressure penetration plate. Estimated time for steps 2.6.3.3.2, 2.6.3.3.3 and 2.6.3.3.4 in 8 hours for 2 pipefitters and 2 laborers or helpers.

2.6.3.3.5 Adjust hose routings and secure penetration plates and hoses to stanchions (to be supplied by NASA). Estimated time is 2 hours for two millwrights.

2.6.3.3.6 Assemble vacuum system hard tubing to vacuum penetration plate assembly. Dead-end at the penetration plate. Estimated time is 2 hours for one pipefitter.

2.6.4 Vacuum Penetration Installation.

2.6.4.1 Prior to ADTD installation in Chamber B perform following:

2.6.4.1.1 Remove protective packaging material from penetration assembly DWG 359-61012.

2.6.4.1.2 Remove four screws securing retainer to adapter section and reserve with seal washers and interface O-seals.

2.6.4.1.3 Carefully wipe clean and dry the exposed face of adapter and plug three ports with clean plastic closures. Tape in place.

2.6.4.2 After ADTD installation in Chamber B, release vacuum lines from secured position on support structure.

2.6.4.3 Extend vacuum line through clearance hole in seismic mass, route through annular clearance in lunar plane between electrical data connector plate and plenum. Pass line through 20-inch clearance hole in conical shroud and insert adapter into D101.

2.6.4.4 Install Parker O-seals Nos. 2-154 and 2-115, in face of retainer plate and orient 12 Torr and .01 Torr exterior hoses with unplugged ports in adapter. Secure with four screws and seal washers. Secure Retainer plate to penetration flange with four bolts and nuts provided.

2.6.4.5 Complete vacuum system connection in accordance with DWG 359-61006.

2.6.4.6 Refer to section 3.8.4 for vacuum penetration removal procedure.

2.6.5 Building 32.

2.6.5.1 Mechanical Installation (Building 32).

2.6.5.1.1 Install the general assembly (359-60004) with shock absorbers (359-30101) attached (see paragraph 2.6.3.1.2) on top of the MSC furnished beam supports attached to the Chamber B lunar plane.

2.6.5.1.1.1 Remove Chamber B lid. This task will require 200 manhours (22 men/shift, 3 shift/day, 3 days).

2.6.5.1.1.2 Lay staging boards from outside of Chamber B to Lunar Plane (Note: Load on dollies to carry support beam is 1000 lbs. This test will require one hour for 2 riggers.

2.6.5.1.1.3 Pick up 14 foot beam (one end at a time). Place on dollies, roll in Chamber B, place on standoffs farthest into Chamber (opposite manlock) place bolts loose (4 bolts at each end of beam). This task will require one hour for 4 riggers (to carry) 2 machinists (to place bolts).

2.6.5.1.1.4 Same as 2.6.5.1.1.3 above with 8-1/2 foot beam (800 lbs.). This task will require one hour for 4 riggers (to carry) 2 machinists (to place bolts).

2.6.5.1.1.5 Alignment of standoffs and beams (with a measuring tape) to receive ADTD isolation mounts (enlarge holes in standoff if necessary, by taking standoff outside Chamber B). Align adapter beam centerlines (previously layed out by machinists after beams were painted) to dimensions shown on SE-103201, Rev. D.

2.6.5.1.1.6 Use O.H. crane to lift four (4) standoffs (150 lbs. each) and two (2) adaptor beams (1000 lbs. each) from truck at Building 32 big door to zero foot level near manlock of Chamber B. This task will require 60 minutes for 2 riggers, 1 crane operator, and 1 supervisor.

2.6.5.1.1.7 Remove existing 12 inch by 12 inch by 1/4 inch aluminum lunar plane cover plates. 5 minutes for 2 machinists. Time to clean off beams is 30 minutes for 2 machinists.

2.6.5.1.1.8 Carry in standoffs, set in place according to DWG SE-103201. This task will require 60 minutes for 2 riggers.

2.6.5.1.1.9 Using DWG SE-103201, check hole matchup, insert 8 bolts per standoff (loose). This task will require 60 minutes for 2 machinists.

2.6.5.1.1.10 Rig sling (AMF furnished) on seismic mass. This task will require 1 hour and 4 riggers, 1 crane operator and 1 supervisor. (See illustration in Data Section IB.)

2.6.5.1.1.11 Position ADTD above open Chamber B. This task will require 1/2 hour and 4 riggers, 1 crane operator and 1 supervisor.

2.6.5.1.1.12 Lower ADTD until shock isolation units just clear their respective mounting beams. This task will require 15 minutes and 4 riggers. Positioned around top of Chamber B with centering ropes with the supervisor (in the Manlock position and 1 crane operator.

2.6.5.1.1.13 Align shock isolation units with support beam pads using drift pins or spud wrench (3/4" diameter hole). (Note: Spud wrench must be less than 12" long. Note: Each of the four (4) riggers should be equipped with a spud wrench, a drift pin, two bolts and a hammer. This task will require 15 minutes and 4 riggers, 1 supervisor, 1 crane operator.

2.6.5.1.1.14 Remove personnel from Chamber B, supervisor signals crane operator to lower ADTD until sling goes slack, then riggers re-enter Chamber B with 24 bolts, lock washers (?), and 32 nuts, eight 15/16" wrenches and two 15 ton hyd. jacks. The collapsed height of jack must be less than 10 inches. The sling should not be removed until all bolts are set.

2.6.5.1.1.15 Riggers position themselves at each adapter beam mounting pad. Machinist carries one precision level and one span rod 48" long into Chamber B. Machinist places span rod across the probe guide rails and places level on span bar. Machinist stands on seismic mass (near vertical centerline through hole in seismic mass for lunar plane access) and observes level when placed on (a) span bar, and (b) 90° away on guide rails, leveling proceeds, per 2.6.3.1.2.3. This task will require 2 hours and 4 riggers, 2 machinists, 1 supervisor, and 1 crane operator.

2.6.5.1.1.16 Riggers remove ADTD lifting sling hooks from seismic mass lifting eyes, and crane removes sling from Chamber B. Riggers remove all tools mentioned in (d) from Chamber B. This task will require 1/2 hours and 4 riggers, 1 crane operator and 1 supervisor.

2.6.5.1.1.17 Store all slings and tools. This task will require 1/2 hour and 2 riggers and 1 supervisor.

2.6.5.1.2 Install accumulator racks (359-61009) in the location shown on AMF DWG 359-61016 and as follows:

2.6.5.1.2.1 The accumulator racks are shipped as two subassemblies and must be positioned and then joined by assemblind and torquing the "graylock" flanges.

2.6.5.1.2.2 Racks can be lifted by the overhead crane or forklift truck and spotted as shwon on AMF DWG 359-61016. The estimated time for this work is two hours and will require operating personnel, one rigger and one pipefitter.

2.6.5.1.3 Place the hydraulic power pack (359-11401) in the location shown on AMF DWG 359-61016.

2.6.5.1.3.1 The hydraulic power pack is mounted on a steerable wheeled chassis and can be manually moved into position and brakes set. The estimated time is 1/2 hour for two riggers. Can be lifted by the overhead crane or forklift truck and spotted as shown on AMF DWG 359-61016.

2.6.5.1.4 Place the vacuum system (359-11010 and -11011) in the location shown on AMF DWG 359-61016. See procedures for installing Teflon tubing in paragraph 2.6.6 and vacuum penetration installation in paragraph 2.6.4.

2.6.5.1.4.1 The vacuum system is on wheels, two of which are castered and can be manually moved to position. Estimated time is 1/2 hour for two riggers.

2.6.5.1.5 Place control console (359-62002) in the location shown on AMF DWG 359-62001, sheets 1 and 2. Can be lifted by the overhead crane or forklift truck and spotted as shown on AMF DWG 359-61016.

2.6.5.1.5.1 The control console is mounted on casters and can be manually positioned. Estimated time is 1/2 hour for two riggers.

2.6.5.2 Electrical Installation (Building 32). All installation wiring should be accomplished in accordance with AMF DWG 359-62001.

2.6.5.2.1 Connect calbes 359-62515, 359-62516, 359-62517, and 359-62518 between the control console and the transmission line cabinet as shown on drawing 359-62001, sheet 1. Use interconnection diagram 359-72031, sheet 1, to connect cable ends at control console and amplifier-terminal cabinet.

2.6.5.2.2 Connect wiring from control console to the electronic feed-thru penetration plate VS-104 in accordance with drawing 359-62001 and interconnection diagram 359-72030, sheet 1. Use the appropriate zipper tubing and connectors specified in drawing 359-62001.

2.6.5.2.3 Connect cables W40 through W52 from the test device to the electronic feedthru penetration plates VS-103 and VS-104, as shown on drawing 359-62001.

2.6.5.3 Hydraulic Installation (Building 32). Install hydraulic piping, tubing, hoses and associated fittings in accordance with AMF DWG. 359-61006. Note requirements for air and cooling water supplied by NASA.

2.6.5.3.1 Connect cooling water lines to the hydraulic power pack and cooling water and air lines to the vacuum pumps. Water, air, and fittings are supplied by NASA and connected by AMF. Estimated time is 8 hours for two pipefitters.

2.6.5.3.2 Connect flexible hose assemblies between the hydraulic power supply and the accumulator rack.

2.6.5.3.3 Uncoil pressure and return hose and penetration plate assemblies from the shipping or storage position on the ADTD and route hoses as shown on 359-61006. See procedure for coupling ADTD fluid lines in Chamber 3 in paragraph 2.6.6.1.

2.6.5.3.4 Assemble the flexible hoses from the hydraulic power pack to the return penetration plate and from the accumulator rack to the pressure penetration plate. Estimated time for steps 2.6.5.3.2, 2.6.5.3.3 and 2.6.5.3.4 is 8 hours for 2 pipefitters and 2 laborers or helpers.

2.6.6 Procedure for Installing Vacuum System Teflon Tubing.

2.6.6.1 Types of Tubing Runs.

2.6.6.1.1 Teflon - Single Line.

2.6.6.1.2 Teflon - Coaxial (Small Teflon Tubing within larger Teflon Tubing).

2.6.6.1.3 Teflon over flexible hose or hard steel hydraulic tubing.

2.6.6.2 Installation Procedure.

2.6.6.2.1 Teflon - Single Line.

2.6.6.2.1.1 Determine path of run and overall length.

2.6.6.2.1.1.1 How many bends required.

2.6.6.2.1.1.2 Location of bends.

2.6.6.2.1.2 Check Teflon tubing fit on spud diameter or fitting diameter, to determine if expansion of tubing ends will be required.

2.6.6.2.1.3 Bend Teflon tubing. (See list of Special Tools in Section III for procedure.) Convoluted tubing is inserted at each bend. Cut Teflon tubing to required length. Heat if necessary to remove convolutions so as to fit tubing over sleeve.

2.6.6.2.1.4 Expand Teflon tubing ends (if necessary). See list of Special Tools in Section III for procedure.

2.6.6.2.1.4.1 If the length of run is greater than any single length of tubing as purchased, then two lengths will have to be coupled together by means of a metallic sleeve, which may make expansion of the ends a necessity.

2.6.6.2.1.5 Clean inside and outside of tubing with a cleaning solvent. (Trichloroethylene or equal.)

2.6.6.2.1.6 Dry with dry nitrogen.

2.6.6.2.1.7 Lay tubing in the desired position with the ends over the fittings.

2.6.6.2.1.8 For Teflon tubing of 1 inch or less, twist lockwire around the Teflon tubing, drawing the tubing into the grooves on the fittings or sleeve.

NOTE

The double row of lockwire at each fitting end should be installed so that the twisted ends are not in line. (Should be 90° to 180° apart.)

2.6.6.2.1.9 Bend twisted lockwire ends against tubing to prevent damage to adjacent lines.

2.6.6.2.1.10 For Teflon tubing larger than 1 inch place an appropriate O-ring in the (first) end groove of fitting. Place Teflon tubing over O-ring and fitting. Be sure that Teflon tubing also covers the second groove. Wind spring wire over the Teflon tubing directly over the second (inner) groove. Place a hose clamp over the wire and Teflon tubing and tighten.

2.6.6.2.2 Teflon - Coaxial. (Tubing over flexible hose or hard steel hydraulic tubing.

NOTE

> To allow for lockwiring or applying a hose clamp to the inner tube on a coaxial Teflon run, and for torquing the inner fittings on the flexible hose or steel tubing run, the outer Teflon tube will have to be slid back over the ends at each fitting prior to the final lock wiring or clamping of the outer ends. To accomplish this, the end fittings must have a sufficiently long neck so as to be able to slide the Teflon tubing back. If a coupling sleeve is used, enough travel length must be introduced into the outer Teflon tubing to be able to slide the tubing back. This should be carefully checked before completing the final lockwiring.

2.6.6.2.2.1 Perform steps outlined in paragraph 2.6.6.2.1.

2.6.7 <u>Procedure for Coupling and Decoupling ADTD Fluid Lines in Chamber B.</u>

2.6.7.1 <u>Coupling.</u>

2.6.7.1.1 After mechanical installation of ADTD in Chamber B is complete, carefully release supply and return fluid lines from their secured position on the support structure.

2.6.7.1.2 Remove penetration closures from VS101 and VS102.

2.6.7.1.3 Remove protective packaging material from penetration assemblies. All required hardware and seals are prepacked with penetration assemblies.

2.6.7.1.4 Remove four screws and washers securing retainer plates to each penetration adapter. Reserve for later use.

2.6.7.1.5 Insure adapter "O" seal (Parker 2-271) is properly seated and lubricated with DC33 vacuum grease. Install retainer plates on VS101 and VS102 with bolts and O-seals reserved from closure assembly. Relubricate o-seal if necessary.

2.6.7.1.6 Carefully extend return line with penetration assembly attached through the Manlock B-2 opening in the LIN panels and route between LIN panels and outer chamber wall to penetration VS101. Insert penetration assembly through the penetration flange until the adapter is seated on the retainer plate. Use care to insure proper installation of adapter seal; and avoid damaging quick disconnect coupling halves, exterior hose jackets, or vacuum shroud tubing.

NOTE

> Quick disconnect coupling has a spring loaded check valve which retains fluid in hydraulic lines. However, sealed shipping cap should be retained on couplings until penetration installation is complete to avoid inadvertent release of fluid in chamber.

2.6.7.1.7 Orient bolt holes in adapter with clearance holes in retainer plate and secure with four screws.

2.6.7.1.8 Remove sealed shipping caps from coupling halves and make up with coupling halves assembled on flexible hose lines installed in return system to power pack (refer to AMF DWG. 359-61006 - Hydraulic installation, outer Chamber "B").

CAUTION

> Prior to assembly of quick disconnect coupling halves, inspect upper and coupling sleeve seals for damage or deterioration. Replace if required. See parts list for seal data in Data Section IB. Seals may be removed without release of fluid in lines if check valve is not depressed.

2.6.7.1.9 The Supply line installation is similar to that of Return line with the following exceptions:

2.6.7.1.9.1 Route line from Pressure Manifold on ADTD through Manlock B1 opening in LIN panel and between LIN panels and ante chamber wall. passing behind Manlock B2 to penetration VS102. Note that coupling is screw type, Use care to avoid damage to coupling threads. Before engaging coupling halves check gage in power pack to verify that hydraulic fluid pressure is absent to minimize engaging forces. Insert nipple half directly into sleeve without rotation, and hold nipple securely in place while tightening sleeve nut. Prevent relative rotation of nipple and sleeve to avoid damaging coupling seal.

2.6.7.2 Decoupling.

2.6.7.2.1 Hydraulic quick disconnects may be decoupled with fluid pressure present in lines. Check valves will prevent gross fluid leakage; however, some fluid remaining in the coupling between check valves will escape at decoupling.

2.6.7.2.2 Decoupling should always be accomplished prior to removal of penetration assemblies from the chamber. All exposed portions of the couplings should be wiped clean and dry of spillage before starting removal procedure, and sealing caps installed on coupling halves. (Refer to 3.8.4 for Removal procedures.)

2.7 CONTROL AND INDICATORS.

2.7.1 The functions and reference designations of various AMF control console panel controls and indicators required to operate the ADTD are shown in tables in Data Section IB. The functions of the various standard commercial components which are a part of the control console are also included in the commercial data provided with section IB.

2.8 OPERATION - PART A

For operating procedures see End Item Test and Inspection Procedure (Buildings 13 and 32), AMF Document No. QATP-21-16-E022.

2.9 OPERATION - PART B

For operating procedures see End Item Test and Inspection Procedures (Buildings 12 and 32), AMF Document No. QATP 21-16-E022.

SECTION III

MAINTENANCE

3.0 GENERAL.

3.1 This section covers the repair and maintenance of the ADTD. Instructions are provided for cleaning, inspection, lubrication, removal, disassembly, reassembly, and reinstallation of components. Special tools required to perform these tasks are included in the text and in a separate table. Throughout this section references are made to AMF drawings which are required to support the maintenance instructions, and where applicable, components are identified by commercial or military standard part numbers. Also included in this section are detailed instructions for storage of the complete ADTD.

NOTE

Refer to the applicable operating procedures in Section II when required to operate the equipment during maintenance.

3.2 CLEANING.

3.2.1 All components removed from the ADTD must be cleaned prior to reassembly and installation. The following paragraphs contain the instructions for cleaning aluminum, steel and stainless steel components. After cleaning and drying of component parts, plug or cap all openings and vent-holes with clean plastic plugs equivalent to Military Specification MIL-C-5501.

NOTE

When using commercial cleaners other than those specified, equivalent concentrations of the solutions should be used.

3.2.2 Cleaning Aluminum Components.

3.2.2.1 Component Parts (Small enough for tank-cleaning).

3.2.2.1.1 Vapor degrease parts, using inhibited trichlorethylene or equivalent.

3.2.2.1.2 Soak parts in an alkali solution, using Oakite No. 30 or equivalent, in a concentration of 4 to 6 oz/gal. of water. Keep parts immersed until a uniform gassing is observed all over the part surface.

3.2.2.1.3 Rinse parts in cold water.

3.2.2.1.4 Soak parts in an acid solution, using Oakite No. 34 solution or equivalent, in a concentration of 14 to 16 oz/gal. Keep parts immersed until black smut is completely removed.

3.2.2.1.5 Rinse parts in cold water.

3.2.2.1.6 Rinse parts in hot water.

3.2.2.1.7 Dry parts, using oil and moisture-free compressed air or a clean lint-free cloth.

3.2.2.1.8 Wrap and store parts in polyethylene bags or equivalent.

3.2.2.2 Component Parts (Too large for tank-cleaning).

3.2.2.2.1 Degrease parts by wiping surfaces with a lint-free cloth wetted with inhibited trichlorethylene or equivalent.

3.2.2.2.2 Steam-alkaline clean, using steam jenny with Oakite No. 30 or equivalent, in a concentration of 4 to 6 oz/gal. of water.

3.2.2.2.3 Rinse parts using a water spray.

3.2.2.2.4 Using rubber gloves and protective clothing, wipe all surfaces with a clean lint-free cloth saturated with a solution Oakite No. 34 or equivalent, in a concentration of 14 to 16 oz/gal, until black smut is completely removed.

3.2.2.2.5 Rinse parts clean using a water spray.

3.2.2.2.6 Dry parts as rapidly as possible. If compressed air is used, be sure that air is oil and moisture free.

3.2.2.2.7 Wrap and store in polyethylene sheeting or equivalent.

3.2.3 Cleaning Steel Components.

3.2.3.1 Component Parts (Small enough for tank-cleaning)

3.2.3.1.1 Vapor degrease parts, using inhibited trichlorethylene or equivalent.

3.2.3.1.2 If part has scaled or rusted surfaces, vapor blast to remove scale or rust completely.

3.2.3.1.3 Dry as rapidly as possible.

3.2.3.1.4 Wrap and store in VPI (vapor phase inhibitor) paper.

3.2.3.2 Component Parts (Too large for tank-cleaning)

3.2.3.2.1 Degrease parts by wiping surfaces with a clean, lint-free cloth saturated with inhibited trichlorethylene or equivalent.

3.2.3.2.2 If part has scaled or rusted surfaces, wire brush to remove scale or rust completely.

3.2.3.2.3 Wrap and store in VPI paper.

3.2.4 Cleaning Stainless Steel Components.

3.2.4.1 Component Parts (Small enough for tank-cleaning)

3.2.4.1.1 Vapor degrease parts, using inhibited trichlorethylene or equivalent.

3.2.4.1.2 Soak parts in an alkaline solution, using Oakite No. 30 or equivalent, in a concentration of 4 to 6 oz/gal. of water. Keep all parts immersed until all surface dirt has been removed.

3.2.4.1.3 Rinse parts in cold water.

3.2.4.1.4 Rinse parts in hot water.

3.2.4.1.5 Dry parts immediately.

3.2.4.1.6 Wrap and store in a polyethylene bag or equivalent.

3.2.4.2 Components Parts (Too large for tank-cleaning)

3.2.4.2.1 Degrease parts by wiping surfaces with a clean lint-free cloth saturated with inhibited trichlorethylene or equivalent.

3.2.4.2.2 Steam-alkaline clean, using a steam jenny with a solution of Oakite No. 3, in a concentration of 4 to 6 oz/gal.

3.2.4.2.3 Rinse parts clean using a water spray.

3.2.4.2.4 Dry parts. If compressed air is used, be sure that air is oil and moisture free.

3.2.4.2.5 Wrap and store in polyethylene sheeting or equivalent.

3.2.5 Seismic Mass Cleaning.

3.2.5.1 Mechanical Cleaning.

3.2.5.1.1 Intent.

3.2.5.1.1.1 To mechanically grind down high spots around the edges of the seismic mass and remove that chemically modified material which resulted from the power cutting operation used by the manufacturer.

3.2.5.1.1.2 To mechanically grind down high spots to attain a smoother surface and permit easier subsequent cleaning.

3.2.5.1.2 Technique.

3.2.5.1.2.1 Removed seismic mass from ADTD by lifting simulator and sliding seismic mass out from under. ADTD then sets a temporary base to permit continued testing concurrent with cleaning of mass.

3.2.5.1.2.2 Use hand disc grinders to grind edges and floor sanding machine to grind top and bottom.

3.2.5.1.3 Results.

3.2.5.1.3.1 Both edges and top and bottom surface should approach a generally polished appearance but need not be completely polished by the hand tools. Low spots in both edges and flat surfaces would require removing roughly an additional .100 to .200 inches from most of the mass to completely clean the mass. This would require machining all over. This is not considered feasible with hand tools.

3.2.5.2 Chemical Cleaning.

3.2.5.2.1 Intent.

3.2.5.2.1.1 To remove local ferrous inclusions which are too deep to remove mechanically.

3.2.5.2.2 Technique.

3.2.5.2.2.1 Two temporary tanks large enough to submerge the mass should be constructed with a wooden frame lined with a plastic film. The seismic mass is then slung from a portable yard crane so that it could be lowered into either tank.

3.2.5.2.2.2 The mass should now be heated with steam and lowered into a 20% solution of muriatic acid in one of the tanks. The solution should be agitated and the mass surfaces scrubbed with hair brushes continuously for an eight-hour period. The mass should then be removed from the tank and rinsed with clear water.

3.2.5.2.2.3 The procedures of paragraph 3.2.5.2.2.2 was repeated with a 20% solution of nitric acid.

NOTE

Extended period of cleaning in acids may be necessitated by cold weather and working outdoors. This is due to the danger inherent in using these acids indoors without proper protection. Rinse times could also be reduced by holding solutions and the mass at higher temperatures, preferably 140°F minimum.

3.2.5.2.2.4 After each acid bath and rinse the mass was checked to be sure it was acid free with litmus paper. If not free, the rinse was continued and the test with litmus repeated.

3.2.5.2.2.5 After an acid free condition is attained, any suspicious areas (those areas which did not appear clean) should be checked with copper sulphate to be sure that the areas in question are free of ferrous inclusions. If not free, the area in question should be scrubbed with a stainless steel power brush and the test repeated. The seismic mass should be supported out of the tanks with a portable yard crane and thoroughly cleaned with a steam sprayer using a solution of trisodium-phosphate (steam sprayer liquid cleaner). This process is used in order to neutralize the acids and to remove any impurities which neither chemical attacked. A water rinse should then be used to remove any traces of the Oakite solution.

3.2.5.2.2.6 The mass should then be swabbed with commercial trichlorethylene to remove any further foreign matter.

3.2.5.3 Protection.

3.2.5.3.1 Intent.

3.2.5.3.1.1 To prevent recontamination by any means during further testing and handling.

3.2.5.3.2 Technique.

3.2.5.3.2.1 The mass should now be completely wrapped with three alternate layers each of a plastic film and corrugated paper padding. The paper protect the plastic film from mechanical damage and the plastic film provided an oil proof barrier. Both are overlapped and held in place with conventional masking tape.

3.2.5.3.2.2 Holes should be cut in the covering to permit installation of items such as the shock mounts. The subassembly joints should be immediately rewrapped.

3.2.5.4 Reassembly.

3.2.5.4.1 The seismic mass and shock mount subassembly is now reinstalled to the ADTD by lifting the ADTD and sliding the seismic mass in place under it.

3.3 INSPECTION.

3.3.1 Periodic inspection of the ADTD is not required. However, a visual inspection of the system should be performed before and after each test to ensure that components have not been damaged. Particular attention should be paid to all hydraulic and vacuum lines, and connections to check for evidence of hydraulic leaks.

3.4 LUBRICATION.

3.4.1 Periodic lubrication of the ADTD is not required. However, lubrication should be done after a repair has been accomplished, as required in accordance with the applicable reassembly instructions described in the Removal and Installation section of this manual.

3.5 ADJUSTMENTS.

3.5.1 Where required, adjustment procedures are contained within the applicable reassembly and reinstallation instructions described in the Removal and Installation section of this manual.

3.6 SPECIAL TOOLS.

3.6.1 The special tools required for removal and installation procedures are presented in Special Tools Table 2.

3.7 REMOVAL AND INSTALLATION. (See parts list in Data Section I B when replacing components removed during disassembly procedures.)

3.7.1 Probe Transducers.

3.7.1.1 Removal (see AMF DWG NO. 359-60201).

3.7.1.1.1 Disconnect plugs at each of the six transducers (359-11008).

3.7.1.1.2 Remove the probe mechanism. Removal of the probe mechanism and, if required, the docking ring should be performed in accordance with North American Aviation Co. LEM docking instructions.

3.7.1.1.3 Secure the hook of an overhead hoist to the LEM docking. Take up any slack in the fall.

3.7.1.1.4 Remove twelve, 3/8-24UNF-2 by 1-1/4 inch LG capscrews and twelve, 3/8-24UNF-2 by 2-1/4 inch long capscrews securing the single-load cell mounts (359-40314-7) to transducer support (359-40206-7). Note the position of each load cell mount for reinstallation.

NOTE

Note number and total thickness of shims (359-40237) at each load cell mount to facilitate reinstallation.

3.7.1.1.5 Guide the probe ring support, transducers, and single-load cell mounts clear of the dowel pins. Remove shims (359-40237).

3.7.1.1.6 Back off the locknut and rotate the single-load cell mount (359-40314-7) clockwise until clear of the transducer. Remove the locknut.

3.7.1.1.7 Back off the locknut and rotate the transducer counterclockwise until clear of the double load cell mount (359-40313-7). Remove the locknut.

3.7.1.1.8 Repeat steps 3.7.1.1.6 and 3.7.1.1.7 to remove the remaining transducers.

TABLE 2
SPECIAL TOOLS

Number	Name	Application
359-60201T1 (see figure 22)	Beam, Lifting Probe Assembly	Used for assembly and disassembly of Probe Transducer Support and attached parts into Probe Roll Drum. Insert machined end of beam into Support Casting bore. Attach to a one ton hoist hook at eyebolt. Counterbalance other end and steer assembly into alignment and engage casting on rod end of Probe HF actuator. (Approximately 40 pounds required at outboard end to accomplish counterbalance.)
359-60201T2 (see figure 23)	Wrench, Probe HF Retainer Nut	A socket wrench with tubular extension. Use to secure self-locking retainer nut which holds probe transducer support on Probe HF actuator or rod. Proper use requires maintaining clearance over probe HF transducer electrical connector.
359-61202T1 (see figure 24)	Wrench, Probe HF Actuator	A tubular spanner wrench used for assembly of the 359-61202-11 gland. Note: Wrench is also used for Probe Traverse Actuator gland 359-61201-11.
359-60301T1 (see figure 25)	Wrench, Gimbal Actuator	A tubular socket wrench used on locknut securing rod end fitting inside bellows.
359-60303T1 (see figure 26)	Wrench, Drogue HF Horizontal Actuator Retainer	A tubular wrench used on retaining ring to secure drogue horizontal HF actuator to drogue gimbal assembly.
359-60303T2 (see figure 27)	Retainer, Bellows Compression, Horizontal HF Actuator	Used to compress and hold horizontal HF bellows during assembly of horizontal small motion ring on drogue pivot table. Engage split bushing in internal grooves in rod seal end of bellows. Engage threaded tie rod into collars from inside Pivot Table to lock bushing. Slip retainer bar over inner end and align on casting surface approximately square to rod. Engage nut and tighten until bellows is compressed solid (Note: 4 tools provided to compress all bellows prior to assembly of horizontal motion ring.)

TABLE 2

SPECIAL TOOLS (Continued)

Number	Name	Application
359-61008-T1 through -T13	Teflon Tubing Installation	-T1 Use to expand 7/8 inch ID tubing to 1 inch ID. -T2 Use to expand 1-1/4 inch ID tubing to 1-3/8 inch ID. -T3 Use to expand 1-1/2 inch ID tubing to 1-3/4 inch ID. -T4 Use to expand 2 inch ID tubing to fit over connectors. -T5 Use to expand 2 inch ID tubing to 2-1/4 inch ID. -T6 Use to expand 2-1/2 inch tubing to fit over connectors. -T7 Use to expand 2-1/2 inch tubing to 2-3/4 inch ID. The following tools are springs used to shape Teflon Tubing on the vacuum system: -T8 Use inside 3/8 inch tubing. -T9 Use inside 7/8 inch tubing. -T10 Use outside 7/8 inch tubing. -T11 Use inside 2 inch tubing. -T12 Use inside 2-1/2 inch and outside 2 inch tubing. -T13 Tube Heating Element (Hair Dryer) Procedure for Using Tools T1 through T13 Note All bent sections are to be replaced with convoluted tubing sections.

TABLE 2
SPECIAL TOOLS (Continued)

Number	Name	Application
		Expanding Tube Ends: a. Apply Insulating and Sealing compound, MIL-I-8660 Amend 2, to surface of Mandrel (T1 to T7). b. Hold Mandrel being worked in a vice and heat to approximately 170°F with torch. c. Slowly force tubing over the Mandrel. d. Place Mandrel and tubing end into room temperature water. e. Replace the Mandrel in the vise and remove tubing from Mandrel. Immediately place the tubing back into the water to prevent shrinking.
359-61302-T1 (see figure 28)	Jet Installation and Extraction	Anvil - This tool is used as a driver to press the jet into the orifice of the vacuum connectors on the servo actuators of the Drogue Gimbal Assembly.
359-61302-T2 (see figure 28)	Jet Installation and Extraction	Threaded Rod - used to engage the insert of the Jet to install or extract same.
359-61302-T3 (see figure 28)	Jet Installation and Extraction	Threaded Rod - used to engage the body of the set in order to extract the part from the connector.
359-60301-T2 (see figure 29)	Retainer, Bellows Gimbal Actuator	Used to hold the Bellows compressed in place to facilitate nut adjustment rod end of the Actuator. Two of these items are needed for each Bellows.
359-60301-T3 (see figure 30)	Y and Z LF Bellows Installation	Used to draw bellows over the drogue actuator gimbal rod evenly.
359-60004-T1 (see figure 31)	Load Cell Calibration Box	Consists of a group of shunt variators and a switch. This box is switched into the load cell circuit heaters between the load cell and its signal conditioning equipment load. All readings are of 0, 25%, 50%, 75% and 100% of full scale.

TABLE 2
SPECIAL TOOLS (Continued)

Number	Name	Application
359-61020-T1 (see figure 32)	Vacuum Pump (.01 Torr) Drain	Used to tighten or loosen drain fitting.
359-61020-T2 (see figure 32)	Vacuum Pump (12 Torr) Drain	Used to tighten or loosen drain fitting.

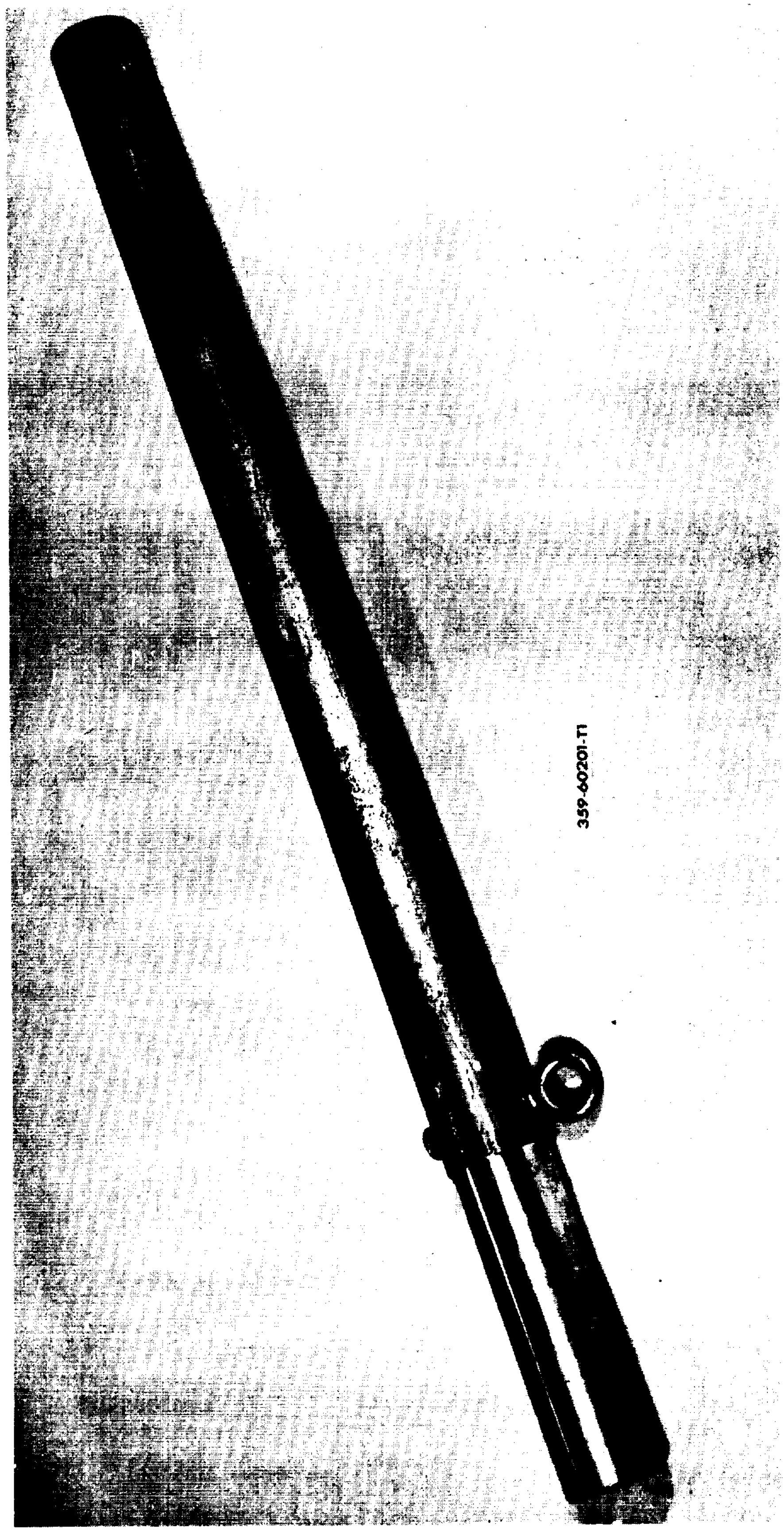


Figure [illegible]-2. Beam, Lifting Probe Assembly Tool

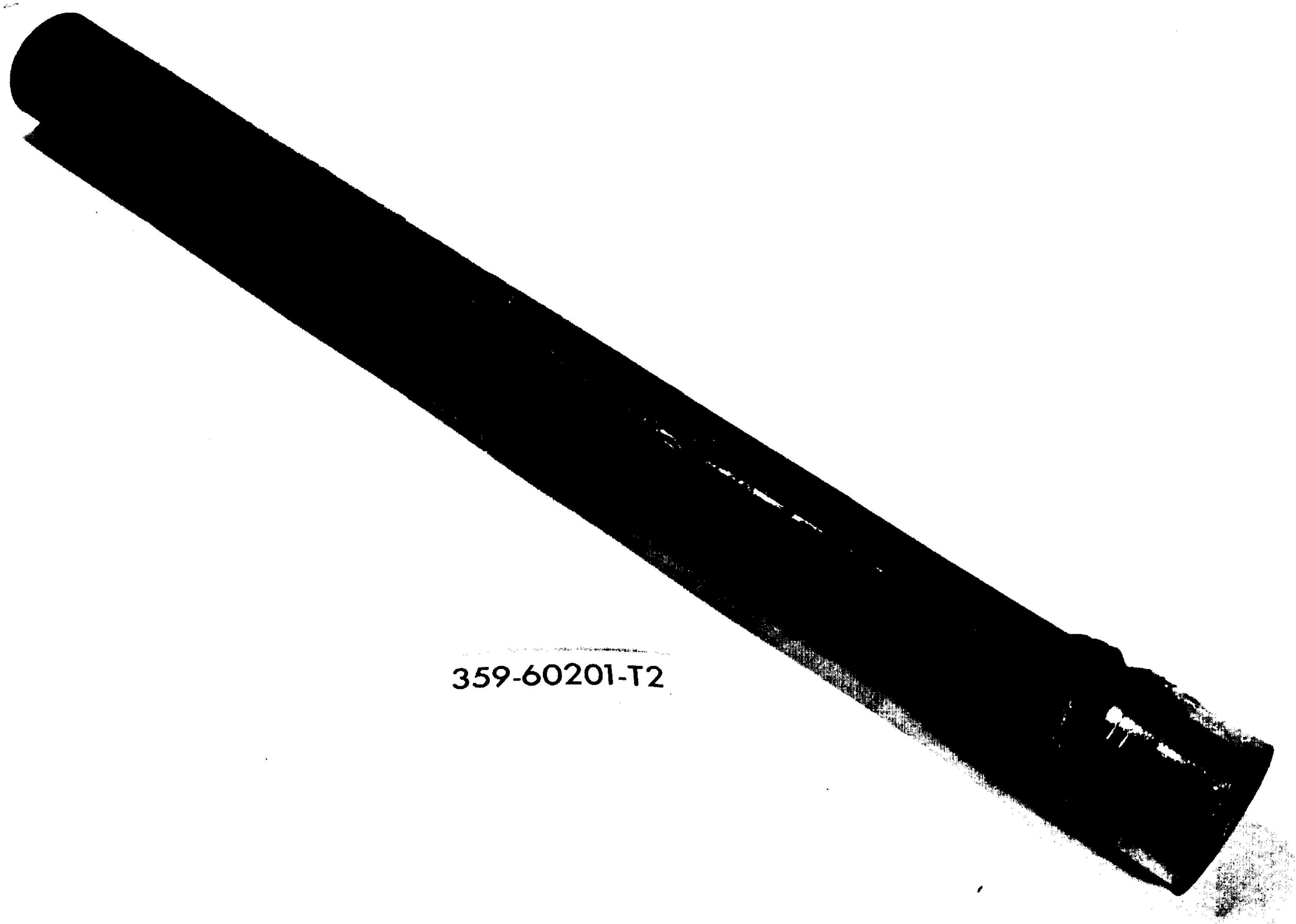


Figure 23. Wrench, Probe HF Retainer Nut Tool

Figure 24. Wrench, Probe HF Actuator Tool

Figure 25. Wrench, Gimbal Actuator Tool

Figure 26. Wrench, Drogue HF

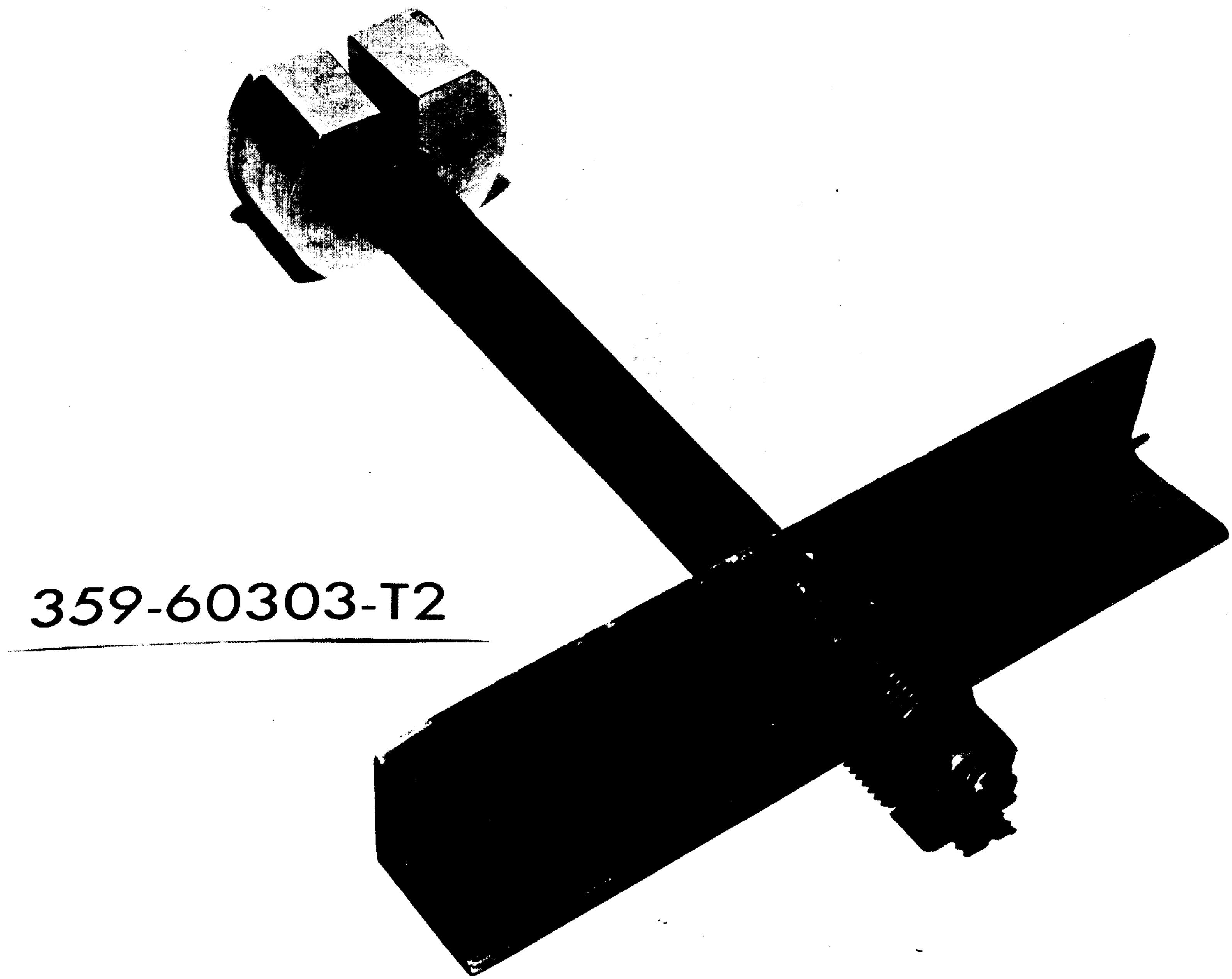


Figure 27. Retainer, Bellows Compression, Horizontal HF Actuator Tool

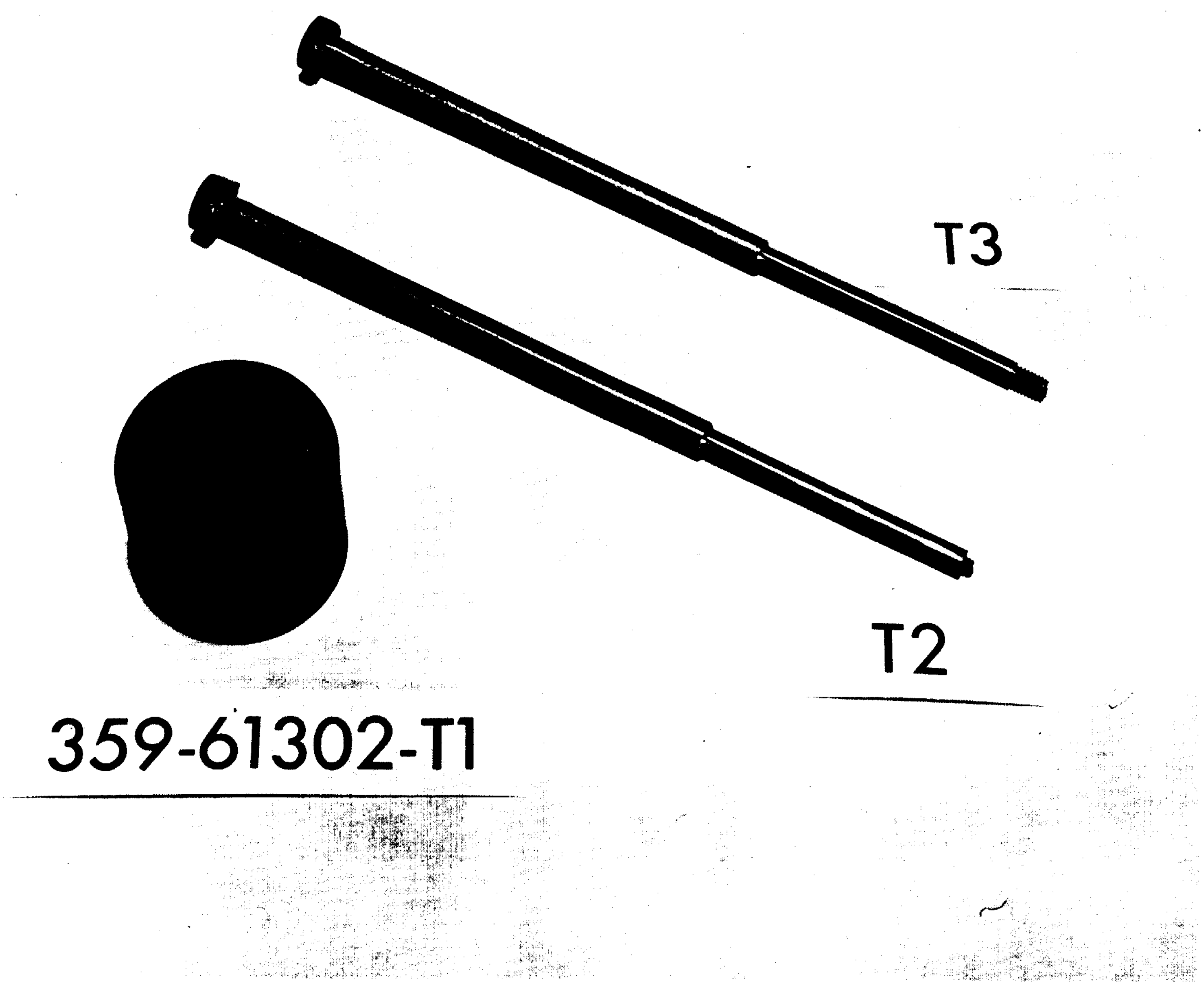


Figure 28. Jet Installation and Extraction Tool

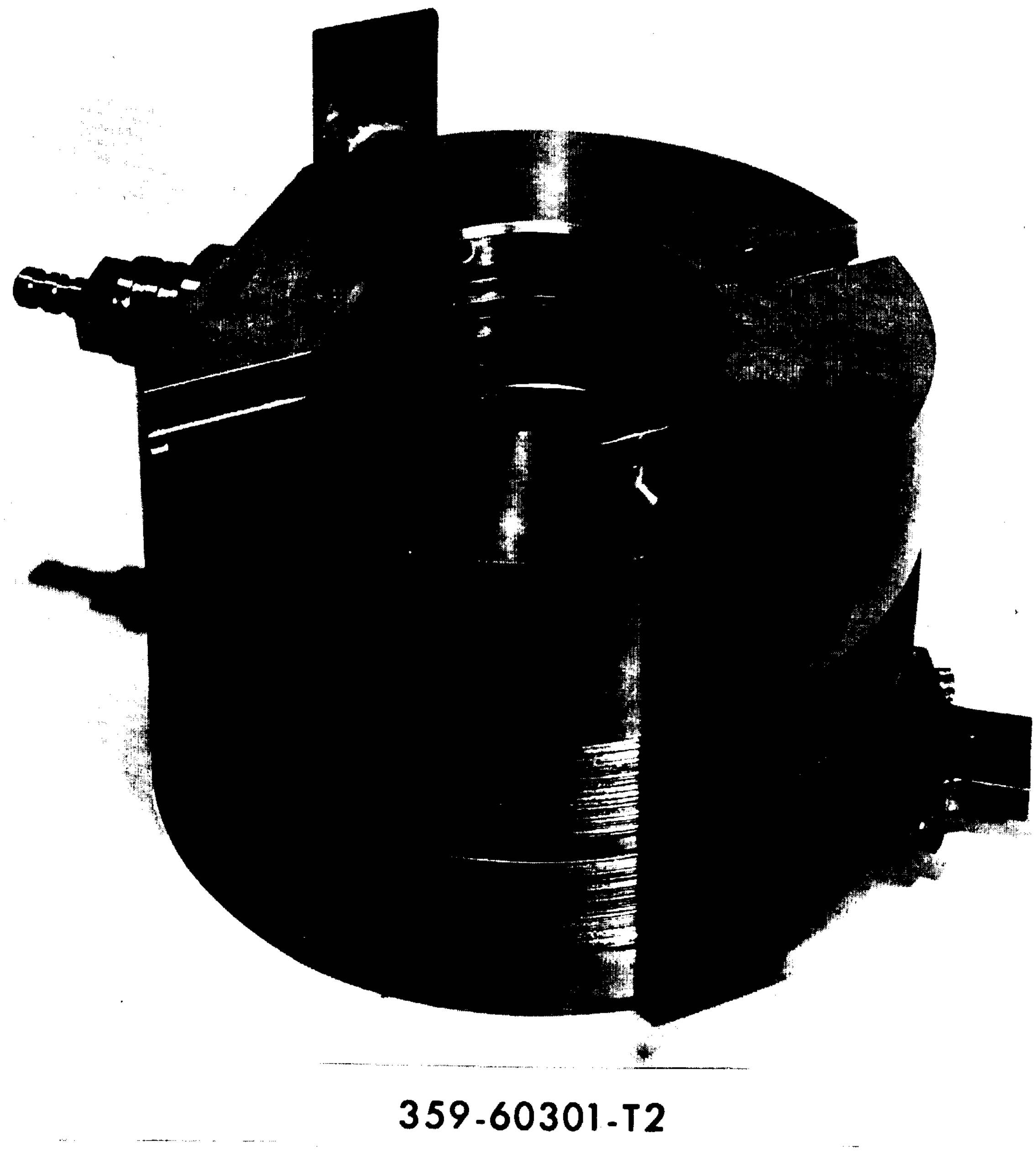


Figure 29. Retainer, Bellows Gimbal Actuator Tool

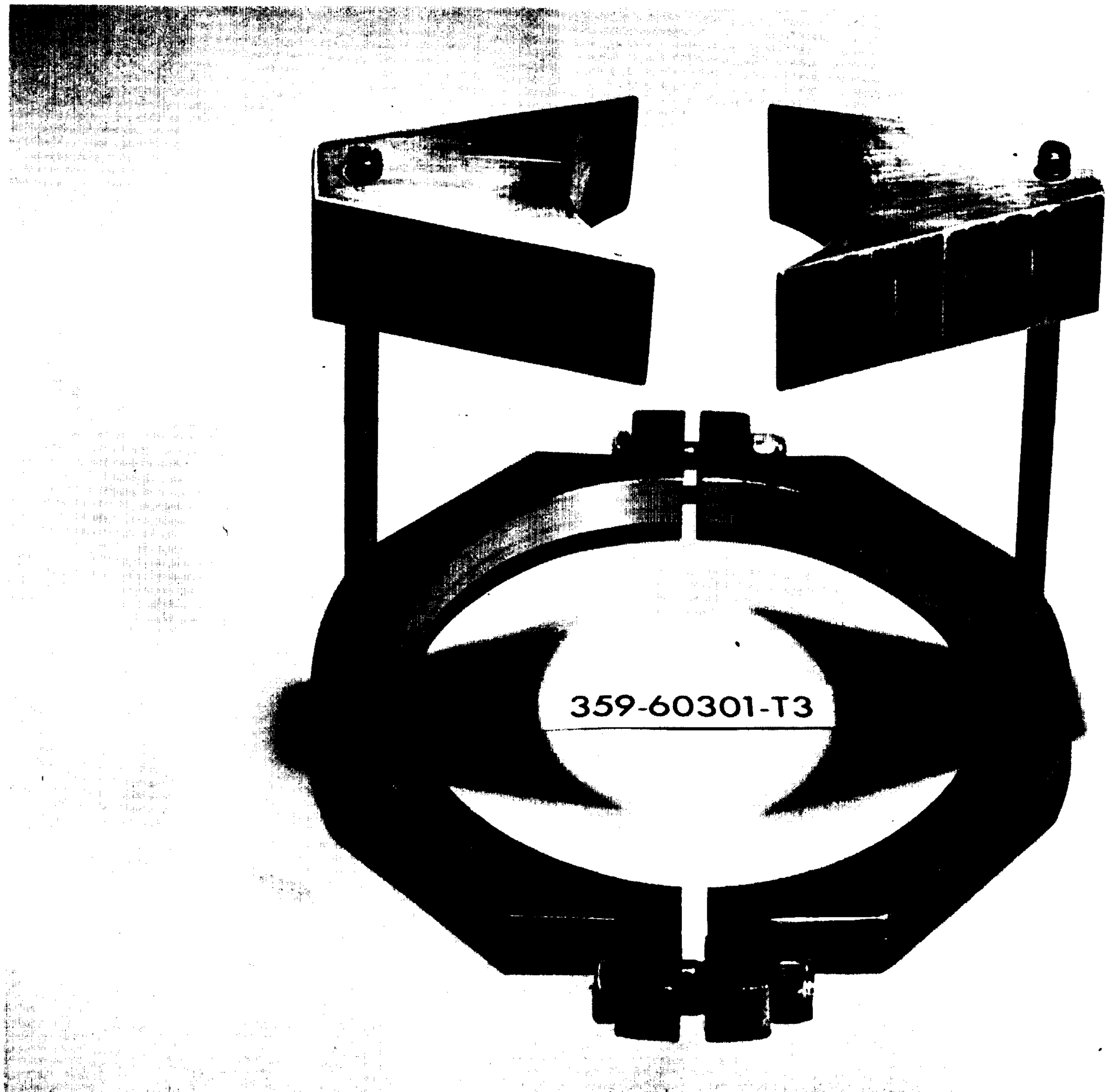


Figure 30. Y and Z LF Bellows Installation Tool

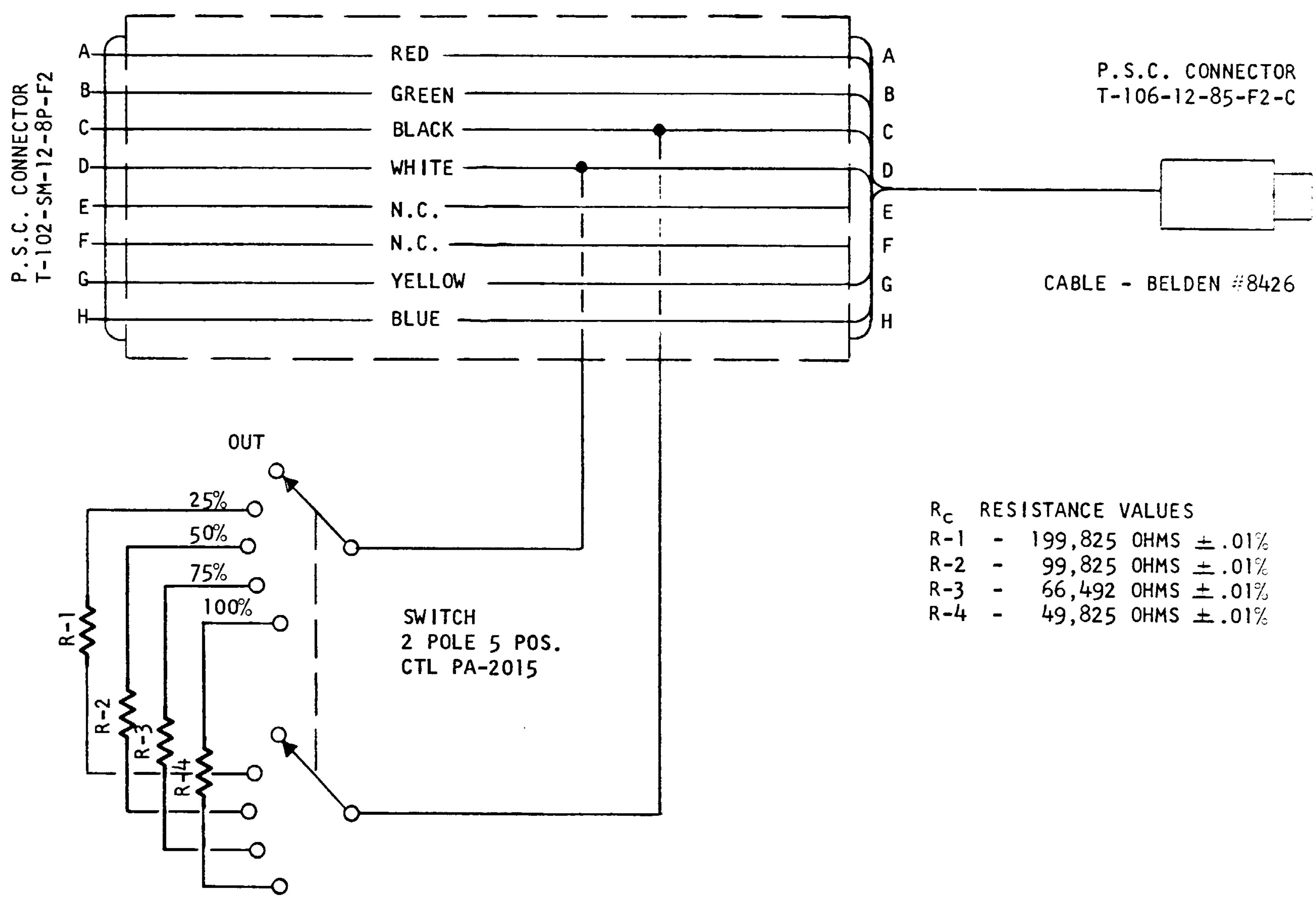


Figure 31. Load Cell Calibration Box Schematic

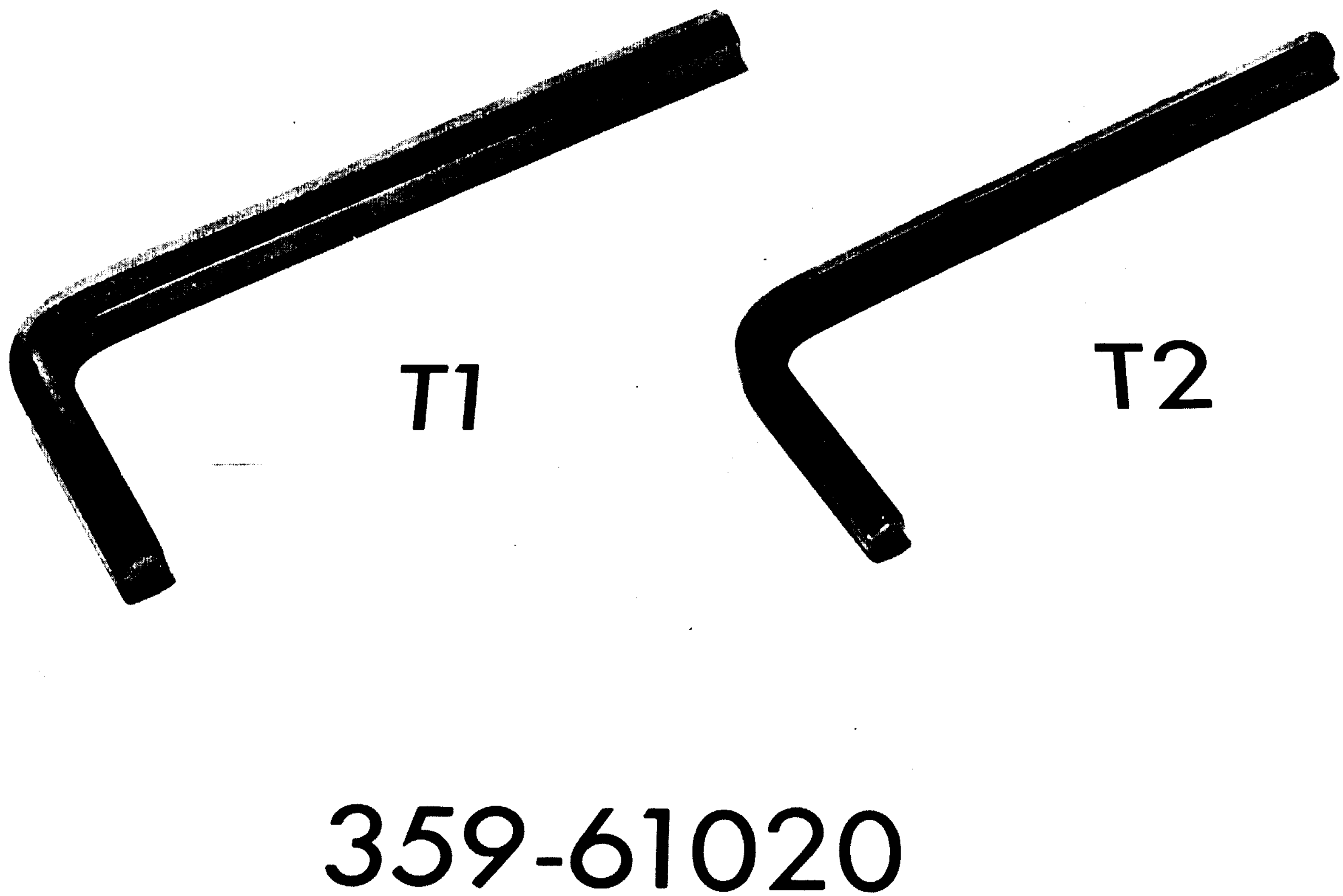


Figure 32. Vacuum Pump (.01 and 12 Torr) Drain Tool

3.7.1.2 Installation. The installation procedures for the transducers and probe ring are the reverse of the removal procedures described in paragraph 3.7.1.1 except for the following:

3.7.1.2.1 Before tightening the locknuts, adjust each transducer as required to obtain the 8.00±0.001 inch gap between the spacer ring (359-40240-7) and transducer support (359-40206-7).

3.7.2 Potentiometers. Roll and Probe High Frequency (205989-3 and -4)

3.7.2.1 Removal (see DWG NO. 359-60201).

3.7.2.1.1 Actuate probe traverse servo actuator (359-61201) to move the probe actuator assembly approximately 24 inches from its full-retracted position.

3.7.2.1.2 Remove the bolts and washers securing cylinder adapter block (359-40117) to probe guide support (359-40213).

WARNING

Be certain all power to the probe traverse servo actuator is OFF and all hydraulic pressure is dumped. Failure to do so may result in injury to personnel and damage to the equipment.

3.7.2.1.3 Actuate probe traverse servo actuator (359-61201) to retract piston rod and cylinder adapter block (359-40117) sufficiently to provide access to the blind end of the high-frequency servo actuator (359-61202-1).

3.7.2.1.4 Disconnect electrical leads at the roll potentiometer.

3.7.2.1.5 De-energize traverse servo actuator (359-61201).

3.7.2.1.6 Remove seals (2-377) located on cylinder adapter block (359-40117). Discard seals if damaged.

3.7.2.1.7 Back off the two setscrews securing the shaft of potentiometer (205989-4) to coupling (359-40239).

3.7.2.1.8 Remove capscrews and cleats securing the potentiometer to mounting plate (359-40221).

NOTE

Complete paragraphs 3.7.2.1.9 through 3.7.2.1.13 only if required to remove probe HF potentiometer (20598-3). To reinstall potentiometer (20598-4) refer to paragraph 3.7.2.3.

3.7.2.1.9 Remove the capscrews securing mounting plate (359-40221) and remove the mounting plate and spacers.

3.7.2.1.10 Back off capscrews (M60AS1032-8N) and remove adapter (359-40210).

3.7.2.1.11 Remove roll pin (79-012-062-0375) securing the adapter (359-40210) to the shaft of potentiometer (205989-3). Remove the adapter.

3.7.2.1.12 Unsolder and move the connector at the end of guide tube (359-40224-7) sufficiently to disconnect the lead wires from potentiometer, (205989-3).

3.7.2.1.13 Remove the capscrews securing potentiometer, (205989-3) to the guide tube. Remove the potentiometer.

3.7.2.2 Installation of Potentiometer (X-HF) (205989-3).

3.7.2.2.1 Slide adapter (359-40210) over the shaft of replacement potentiometer (205989-3) and transfer drill the roll-pin hole through the shaft using a 0.062/ 0.064 drill and insert roll pin (79-012-062-0375). (See AMF DWG No. 359-60201).

NOTE

Step 3.7.2.2.1 is not required if the original potentiometer is to be reinstated.

3.7.2.2.2 Insert the potentiometer wire leads and potentiometer into guide tube (359-40224-7) at the blind end of servo actuator (359-61202-1). Be certain the wire leads extend out the opposite end of the guide tube.

3.7.2.2.3 Install capscrews (M60AS932-8N) to secure the potentiometer.

3.7.2.2.4 Connect free ends of potentiometer wire leads to the connector as shown on AMF DWG NO. 359-62003, and solder connector to end of guide tube (359-40224-7).

3.7.2.2.5 Slide adapter (359-40210) over coupling (359-40239) and tighten setscrews.

3.7.2.2.6 Secure to bearing retainer (359-40211-7), using capscrews (M60AS1032-8N).

3.7.2.2.7 Reinstall coupling (359-40239) on end of adapter (359-40210), and insert roll pin (79-012-062-0375).

3.7.2.2.8 Manually extend and retract servo actuator (359-61202-1) to determine its full piston stroke. With piston fully extended, manually retract the piston to a position equal to one-half of the full stroke. Note this position to ensure that it does not change while adjusting potentiometer, (205989-3) in step 3.7.2.2.9.

3.7.2.2.9 Move the potentiometer shaft using the coupling (359-40239) and center the stroke of the potentiometer electrically. After centering, tighten setscrews (M70AS1032-5N) to secure potentiometer shaft and adapter (359-40210).

3.7.2.2.10 Refer to paragraph 3.7.2.3 to complete the installation procedures for potentiometer (205989-4).

3.7.2.3 Installation of Roll Potentiometer (X-LF) (205989-4)

3.7.2.3.1 Install mounting plate (359-40221) and spacers (359-4024) on the transducer support plate (359-40235-7) and secure loosely with capscrews (M60AS-1032-8N).

3.7.2.3.2 Position potentiometer (205989-4) on the mounting plate, inserting the potentiometer shaft into adapter, (359-40210-7). Secure potentiometer to plate with capscrews (M60AS440-4N) and cleats (L2-1).

3.7.2.3.3 With the potentiometer shaft centered in the roll mount adapter, tighten capscrews (M60AS1032-8N) to secure the plate to the support transducer ring.

NOTE

The mounting plate contains 4 oversized mounting holes to permit proper alignment of the potentiometer and roll mount adapter.

3.7.2.3.4 Tighten setscrews (M70AS1032-5N) to secure shaft to coupling (359-40239).

3.7.2.3.5 Connect the potentiometer (205989-4) to wire leads from the connector as shown on AMF DWG NO. 359-62003.

3.7.2.3.6 Rotate the roll potentiometer (205989-4) to center it electrically over rod drive angular orientation.

3.7.2.3.7 Install seals (2-377) on cylinder adapter block (359-40117). Lubricate seals with Dow Corning grease D-33, or equivalent (see AMF DWG NO. 359-60004).

3.7.2.3.8 Remove bolts receiving rod bellows to adapter block (359-40117). Slide bellows back and remove clevis bolt.

CAUTION

Do not attempt to engage the cylinder adapter block and probe guide support hydraulically. Failure to observe this caution may result in damage to the equipment.

3.7.2.3.9 Install adapter block (359-40117) into probe support (359-40213) and secure with bolts.

3.7.2.3.10 Energize probe traverse servo actuators and drive into position. Then clevis shaft can be reinstalled and rod bellows resecured.

3.7.2.3.11 Install bolts (5/16-24UNF2 by 1-1/2) and washers to secure adapter block to probe guide support. Tighten bolts to 360±25 inch-pounds torque.

3.7.3 XHF Servo Actuator (359-61202-1).

3.7.3.1 Removal (see AMF DWG NO. 359-60201).

3.7.3.1.1 Remove capscrews (M60CR1018-28E) securing flexure ring to roll drum (359-40205). Remove end cap (359-40209). Remove nut (NAS 1021-C20) allowing transducers (359-11008), single-load cell mounts (359-40314-7) and spacer ring (359-40240-7) with probe transducer support (359-40206) and flexure ring (359-40207) to be removed as a unit.

CAUTION

> Do not damage guide keys (359-40220) or the mating anti-roll keyways (359-40215) when removing the transducer support.

3.7.3.1.2 Remove potentiometers (205989-3 and -4). Refer to paragraph 3.7.2.1. Remove leads and connectors in probe support casting.

3.7.3.1.3 Remove the capscrews that lock support transducer ring (359-40235) to the probe guide support. Back off transducer ring until free of probe guide support.

3.7.3.1.4 Remove capscrews, securing bearing retainer (359-40211-7) and remove bearing retainer.

3.7.3.1.5 Remove shims (359-40236-7). Record number and total thickness of shims to facilitate reinstallation.

3.7.3.1.6 Back off setscrews (M73AS420-16N) and remove bearing retainer ring (359-40226-7).

3.7.3.1.7 Remove bolts (M60FS820-28N) and seals (NAS1598C8Y) securing dual element bellows assembly (359-31203-7) and roll drum (359-40205-7) to servo actuator flange. Discard all seals (NAS1598C8Y) if damaged.

CAUTION

> Exercise care so as not to damage the gear teeth when removing the roll drum.

3.7.3.1.8 Remove the dual element bellows assembly and roll drum (359-40205-7) clear of the probe guide support.

3.7.3.1.9 Remove dual element bellows assembly and seals as follows: two seals (2-143), located on the inside diameter of the bellows assembly; and the larger diameter seal (2-274). Discard seals if damaged.

3.7.3.1.10 Remove and discard seal (2-169) located on roll drum (359-40205-7) if damaged.

3.7.3.1.11 Remove servo actuator (359-61202) clear of probe guide support. (Tool 60201T3).

3.7.3.1.12 Remove bearing cone (99575) and cup (99100).

3.7.3.1.13 Remove rotary joint (359-61202-13), seals (S-12546-435), O-rings (MS28775-436 and 2-273-N304). Discard all seals and O-rings if damaged.

3.7.3.1.14 To complete the disassembly of high-frequency probe servo actuator (359-61202), refer to paragraph 3.7.4.1.

3.7.4 HF Probe Servo Actuator (359-61202).

3.7.4.1 Disassembly (see AMF DWG NO. 359-61202).

3.7.4.1.1 Cut lockwire and remove capscrews (AN500A08-4) at the flange end of the actuator.

3.7.4.1.2 Using wrench (359-60202T1) remove bearing (item 11) at the piston end of the servo actuator.

3.7.4.1.3 Remove seal gland (item 10) and piston rod (item 8). If necessary, the piston rod may be used to free the seal gland of the barrel (item 7).

3.7.4.1.4 Remove and discard seal (Parbak series 8-240) and packing (MS28775-240) from seal gland (item 10) if damaged.

3.7.4.1.5 Remove and discard seals (S-12546-143) and packings (MS28775-144) on the inside diameter of seal gland (item 10) if damaged.

3.7.4.1.6 Remove the seal-gland spring pin.

CAUTION

During reassembly, be certain the spring pin is centered in the pin recess of barrel (item 7). Failure to do so will result in damage to the equipment.

3.7.4.1.7 Remove seals (S-12547-240) and packings (MS28775-239) from piston rod (item 8). Discard seals if damaged.

3.7.4.1.8 Using a spanner wrench, remove bearing (item 12).

3.7.4.1.9 Remove seal gland (item 9) clear of the barrel (item 7).

3.7.4.1.10 Remove seal (Parbak series 8-233) and packing (MS28775-233) located on the outer diameter of seal gland (item 9). Discard seals if damaged.

3.7.4.1.11 Remove seals (S-12546-143) and packings (MS28775-144) located on the inside diameter of seal gland (item 9). Discard seals if damaged.

3.7.4.2 Reassembly. The reassembly procedures for the probe high-frequency servo actuator are the reverse of those described in paragraph 3.7.4.1 except for the following:

3.7.4.2.1 Lubricate all vacuum seals with Dow Corning grease D-33, or equivalent.

3.7.4.2.2 Secure all lockwire in accordance with MS33540 requirements.

3.7.4.3 Installation.

3.7.4.3.1 Install seals (S-40080-2 and S-40081-1) on the inside flange of the servo actuator. Lubricate seals with Dow Corning grease D-33, or equivalent.

3.7.4.3.2 Position seals (S-12546-435), O-rings (MS28775-436 and 2-273-N304) on rotary joint (359-61202-13). Install the rotary joint and seals in probe guide support. Lubricate seals with Dow Corning grease D-33, or equivalent.

3.7.4.3.3 Install bearing cone (99575) and cup (99100). Apply Lubri-Kote A-1040 CR, purchased from the Mealy Grease and Oil Co., Cleveland, Ohio, or equivalent to the bearing assembly to facilitate reassembly and pressing operation.

3.7.4.3.4 Install bearing retainer ring (359-40226-7) and lock in position by tightening the setscrews (M73AS420-16N).

3.7.4.3.5 Install the shim (359-40236-7) and bearing retainer (359-40211-7). Secure bearing retainer with bolts (M60FS820-26N).

NOTE

Insert a 0.005 inch feeler gage between the bearing retainer and the housing of servo actuator (359-61202-1). This dimension must be maintained to ensure sufficient clearance required to pre-load the bearing assemblies.

3.7.4.3.6 Tighten bolts (M60FS820-26N) by applying 95 to 105 foot-pounds torque to secure the bearing retainer and to pre-load the bearing assemblies.

3.7.4.3.7 Insert a 0.007 inch feeler gage between the servo actuator flange and probe guide support (359-40213-7). This dimension must be maintained through a 180-degree rotation of the servo actuator. Insert feeler gage at several points to insure proper clearance during rotation.

3.7.4.3.8 Install potentiometers (2-5989-3) as described in paragraph 3.7.2.2 and potentiometer (205989-4) as described in paragraph 3.7.2.3.

NOTE

Lubricate all seals installed in paragraphs 3.7.4.3.9 through 3.7.4.3.11 using Dow Corning grease D-33, or eaulvalent.

3.7.4.3.9 Install seals (2-275) on the flange of servo actuator (359-61202-1).

3.7.4.3.10 Install seal (2-169) on the inside diameter of roll drum (359-40205-7) and install the roll drum, aligning the Z-axis, over the flange of the servo actuator; at the same time, engage the roll-drum gear teeth with the pinion gear of gear boxes (359-30201).

3.7.4.3.11 Position dual element bellows assembly (359-31203-7) on the roll drum with seals (2-143 and 2-274) installed. Secure the bellows assembly and roll drum to the servo actuator using bolts (M60FS820-28N) and seals (NAS1598C8Y). Lubricate seals with Dow Corning grease D-33, or equivalent.

3.7.4.3.12 Install transducer support (359-40206-7) with parts as disassembled in accordance with paragraph 3.7.3.1.1 over the rod end of the servo actuator, aligning the Z-axis and keys (359-40220-7). Secure with pad (359-40222-7) and nut (NAS1021-620).

NOTE

Keys (359-40220-7) on the transducer support and keyways (359-40215-7) must be parallel to the direction of stroke and to each other. They must contact each other as shown in figure 1 on AMF DWG NO. 359-60201, Sheet 4 in Zone 8-F. No shake is permitted.

3.7.4.3.13 Position flexure ring (359-40307-7) on the roll drum, and secure in position using bolts (M60CR1018) and washers.

3.7.4.3.14 Install end cap (359-40209-7) at rod end of guide tube. Use a spanner wrench to secure the end cap to support transducer (359-40206-7).

3.7.5 Motor Assembly (359-61206-7, -8).

3.7.5.1 Removal.

3.7.5.1.1 Disconnect plug, P2- or P4-MDRO7-35-5020 at gear housing cover (359-40204). See AMF DWG NO. 359-62003.

3.7.5.1.2 Remove capscrews (1/4-28UNF-2 x 1-1/8 IN. LG) securing the gear housing cover to the probe guide support. Back-off the cover sufficiently to disconnect the electrical wire at servo valve (359-11002). Remove the cover and wire.

3.7.5.1.3 Remove and discard seal (2-278) at bottom edge of cover if damaged.

3.7.5.1.4 Back-off the coupling nut securing the hydraulic lines to the motor assembly. Catch hydraulic fluid in a one-quart container (see AMF DWG NO. 359-61204). Cap all open ports and lines.

3.7.5.1.5 Remove capscrews (M60CR420-12E) securing motor assembly to gear box (359-61206) as shown on AMF DWG NO. 359-60201. Remove the motor assembly.

3.7.5.2 Disassembly (see AMF DWG NO. 359-61206).

3.7.5.2.1 Cut lockwire and remove capscrews securing servo valve (359-11002) and valve assembly (359-31204) to the hydraulic motor.

3.7.5.2.2 Remove the valve; remove and discard O-rings (MS28775-010) if damaged.

3.7.5.3 Reassembly. Reassembly procedures for motors assembly (359-61206) are the reverse of the disassembly procedures described in paragraph 3.7.5.2 except for the following:

CAUTION

> Motor assembly (359-61206-7) rotates clockwise as viewed from the shaft end; be certain clockwise rotating valve assembly (359-31204-7) is installed to make up a -7 motor assembly. When reassembling counterclockwise rotating motor assembly (359-61206-8), install the 359-31204-8 valve assembly.

3.7.5.3.1 Lubricate O-rings with Dow Corning grease D-33, or equivalent.

3.7.5.3.2 Secure all lockwire in accordance with MS33540 requirements

3.7.5.4 Installation. Installation procedures for motor assembly (359-61206) are the reverse of the removal procedures described in paragraph 3.7.5.2 except for the following:

NOTE

Motor assembly (359-61206-7) rotates clockwise; the -8 motor assembly rotates counterclockwise. Ensure that the motor assemblies are installed in the positions shown on AMF DWG NO. 359-60201.

3.7.5.4.1 Lubricate O-rings with Dow Corning grease D-33, or equivalent.

3.7.6 Gear Box (359-30201).

3.7.6.1 Removal (see AMF DWG NO. 359-60201).

3.7.6.1.1 Remove applicable motor assembly (359-61206-7, or -8) to gain access to the gear box. Refer to paragraph 3.7.5.1 for removal procedures.

3.7.6.1.2 Remove screws and washers securing the gear box to probe guide support (359-40213). Remove the gear box.

3.7.6.1.3 Remove and discard O-ring (2-140) located on the inside diameter of ring seal (359-40227) if damaged.

3.7.6.2 Installation. The installation procedures for gear box (359-30301) are the reverse of the removal procedures described in paragraph 3.7.6.1 except for the following:

3.7.6.2.1 Lubricate O-ring (2-140) with Dow Corning grease D-33, or equivalent.

3.7.7. Ring Seal (359-40227-7).

3.7.7.1 Removal (see AMF DWG NO. 359-60201).

3.7.7.1.1 Remove components from roll drum in accordance with paragraph 3.7.3.1.1 then remove roll drum and dual seal in accordance with paragraphs 3.7.3.1.7 and 3.7.3.1.8.

3.7.7.1.2 Remove the screws securing the ring seal to probe ring support (359-40213). Remove the ring seal.

3.7.7.1.3 Remove and discard O-ring (2-140) located in the inside diameter of the ring seal if damaged.

3.7.7.2 Installation. The installation procedures for the ring seal are the reverse of the removal procedures described in paragraph 3.7.7.1 except for the following:

3.7.7.2.1 Lubricate O-ring and gasket with Dow Corning grease D-33, or equivalent.

3.7.8 Probe Guide Support and Guide Bearing (see AMF DWG NO. 359-60201).

3.7.8.1 Removal.

3.7.8.1.1 Actuate probe traverse servo actuator (359-61201) to position probe actuator assembly (359-60201) approximately 24-inches from its fully retracted position.

3.7.8.1.2 Remove bolts securing actuator rod bellows to adapter block and retract.

3.7.8.1.3 Remove bolts, cotter pin, and nuts securing the piston rod to cylinder adapter block (359-40117). See AMF DWG NO. 359-60004.

3.7.8.1.4 Actuate probe traverse servo actuator to retract the piston rod clear of the probe actuator assembly. De-energize the probe traverse servo actuator and probe actuator assembly.

WARNING

> Be certain all power to probe traverse servo actuator (359-61201) and probe actuator assembly (359-60201) is OFF. Failure to do so may result in injury to personnel and damage to the equipment.

3.7.8.1.5 Disconnect all electrical leads at the servo actuator and probe actuator assembly.

3.7.8.1.6 Release clamps and move electrical wiring clear of the actuator assembly.

3.7.8.1.7 Disconnect all hydraulic lines leading to the probe actuator assembly. Catch hydraulic fluid in a one-quart container.

3.7.8.1.8 Secure both lower two-leg slings from assembly 359-01003 around the probe actuator assembly and attach to the overhead hoist. Take up any slack in the sling.

3.7.8.1.9 Remove coupling nut securing potentiometer shaft to shaft attachment bracket (359-40121-7). See AMF DWG NO. 359-60004.

3.7.8.1.10 Manually retract the potentiometer shaft clear of the actuator assembly.

3.7.8.1.11 Remove capscrews, washers, and nuts securing upper half of bearing retainer blocks (359-40103) to the lower half.

NOTE

> Probe guide rails (359-40102-7) are pinned at one end to the upper half of the bearing retainer blocks. The opposite end is free to permit expansion and contraction caused by extreme changes in temperature. Remove only the two retainer blocks that are not pinned to the probe guide rail.

3.7.8.1.12 Remove the two forward bearing retainer blocks.

3.7.8.1.13 Actuate the overhead hoist to raise the probe guide support and probe guide rails clear of the support structure.

3.7.8.1.14 Remove shims (359-40108). Note the position, number, and total thickness of the shims to facilitate reinstallation.

3.7.8.1.15 Slide probe guide rails (359-40102) clear of the probe guide support.

3.7.8.1.16 Remove capscrews securing cover (359-40234) to the probe guide support. Remove the cover.

3.7.8.1.17 Remove defective bearing guide (359-30202).

3.7.8.2 Installation. The installation procedures for probe actuator support (359-60201) and guide bearings (359-30202) are the reverse of the removal procedures described in paragraph 3.7.8.1 except for the following:

NOTE

> Guide bearings (359-30202) must be replaced in pairs and line-bored after reassembly to maintain concentricity and parallelism between the centerline of the probe actuator assembly and and centerline of the probe guide rails as shown on AMF DWG NO. 359-60201, sheet 4.

3.7.9 Potentiometer, 43 Inch Stroke (20598).

3.7.9.1 Removal (see AMF DWG NO. 365-60004).

3.7.9.1.1 Actuate probe actuator (359-61201) to fully retracted position.

3.7.9.1.2 Disconnect electrical wiring at potentiometer (20598).

3.7.9.1.3 Remove the locknut and washer securing the shaft of the potentiometer to shaft attachment bracket (359-40121).

3.7.9.1.4 Retract the potentiometer shaft and remove the jam-nut and washer.

3.7.9.1.5 Remove the capscrews, washers and nuts, securing the potentiometer to the front, and rear supports. Remove the potentiometer and shims. Note the position, number and total thickness of shims (359-40120) to facilitate reinstallation.

3.7.9.2 Installation. The installation procedures for 43-inch stroke potentiometer (20598) are the reverse of the removal procedures described in paragraph 3.7.9.1 except for the following:

3.7.9.2.1 Install shims (359-40120) as required to maintain the potentiometer shaft stroke parallel to the probe stroke to within 0.015-inch TIR.

3.7.9.2.2 Connect electrical wiring to the potentiometer and adjust the potentiometer shaft as required to obtain a 0-inch indication on the system monitor.

3.7.9.2.3 Actuate servo actuator (359-61201) to the full-out position and check for a 42-inch indication on the system monitor panel to ensure proper function of the potentiometer. Refer to section II for operating procedures.

3.7.10 Probe Side Hydraulic Installation (359-61203).

3.7.10.1 Removal.

WARNING

> Be certain all power to probe traverse servo actuator (359-61201) and probe actuator hydraulic installation is off. Failure to do so may result in injury to personnel and damage to the equipment.

3.7.10.1.1 Remove the 43-inch stroke potentiometer (20598). Refer to paragraph 3.7.9.1 for removal procedures.

3.7.10.1.2 Disconnect plug (P1-MDRO7-125-5020) at the short shroud (see AMF DWG No. 359-62003).

3.7.10.1.3 Release clamps and move electrical wiring clear of the actuator hydraulic installation.

3.7.10.1.4 I emove 1-1/4-inch capscrews securing rear support (359-40118-7) and cover to hort shroud (359-41203). Remove the rear support (see AMF DWG NO. 359-612(3).

3.7.10.1.5 Remove the remaining 1-inch capscrews securing cover (359-41204) to the short shroud. Remove the cover.

3.7.10.1.6 Disconnect and remove electrical wiring at the J1 receptacle, pressure transducer, and servo valved (359-11004).

3.7.10.1.7 Disconnect 1/4-inch flexible drain line at bottom of short shroud. Catch hydraulic fluid in a suitable container.

3.7.10.1.8 Disconnect and remove the 1/4-inch flexible drain line at servo actuator (359-61201) and at the shroud connector.

3.7.10.1.9 Disconnect hydraulic hose, (MS28759-6) at elbows (AN833-16C). Release clamps securing outer flexible tubing surrounding the hydraulic hoses and remove each hose and outer tubing clear of the short shroud. Discard all seals if damaged.

3.7.10.1.10 Back off nut (AN818-4C) securing each end of the 1/4-inch diameter tubing and remove the tubing. Discard all seals if damaged.

3.7.10.1.11 Back off the checknut and remove each elbow (AN833-16C) at valves (359-31206-7). Discard all seals if damaged.

3.7.10.1.12 Remove capscrews securing the short shroud to long shroud (359-41202). Remove the short shroud end gaskets (359-41205-7) as a unit.

3.7.10.1.13 Disconnect the 1/2-inch diameter tubing at valves (359-31206-7). Catch hydraulic fluid in a one-quart container.

3.7.10.1.14 Remove capscrews securing mounting plate (359-41206-7) and pressure transducer to the servo actuator. Remove the mounting plate and transducer as a unit.

3.7.10.1.15 Remove the screws securing the transducer to the mounting plate. Remove the transducer.

3.7.10.1.16 Remove the capscrews securing each servo valve (359-11004) to valve assembly (359-31206-7). Remove the servo valves and discard O-rings (MS28875-014) if damaged.

3.7.10.1.17 Remove capscrews securing valve assemblies (359-31206-7) to the servo actuator. Remove the valve assemblies and discard O-rings (MS28875-014) if damaged.

3.7.10.1.18 Remove capscrews securing long shroud (359-41202-7) to the servo actuator. Remove the shroud and discard O-ring (2-269) if damaged.

3.7.10.1.19 Disconnect and remove the 1/2-inch diameter tubing at the servo actuator. Discard all seals if damaged.

3.7.10.2 Installation. Installation procedures for probe actuator hydraulic installation (359-61203) are the reverse of the removal procedures described in paragraph 3.7.10.1 except for the following:

3.7.10.2.1 Lubricate all seals with Dow Corning grease D-33, or equivalent.

3.7.10.2.2 During installation of the hydraulic tubing, apply 135 to 150 inch-pounds torque to secure the 1/4-inch diameter tubing; and 450 to 500 inch-pounds torque to secure the 1/2-inch diameter tubing.

3.7.10.2.3 Prior to installation of the short shroud, inspect gaskets (359-41205-7) for evidence of damage. If damaged, remove the gasket and thoroughly clean the mating surface on the short shroud. Install a replacement gasket using adhesive EC-1099 (see AMF DWG NO. 359-61203).

3.7.11 Probe X-LF Servo Actuator (359-61201).

3.7.11.1 Removal.

3.7.11.1.1 Remove 43-inch stroke potentiometer (20598). Refer to paragraph 3.7.9.1 for removal procedures.

3.7.11.1.2 Remove probe actuator hydraulic installation (359-61203). Refer to paragraph 3.7.10.1 for removal procedures.

3.7.11.1.3 Secure both lower 2-leg slings from assembly 359-01003 to servo actuators (359-61201) and to the overhead hoist. Take up any slack in the sling.

3.7.11.1.4 Remove capscrews and washers securing bellows assembly (359-312-7) to probe guide support (see AMF DWG NO. 359-60004).

3.7.11.1.5 Remove bolt (NAS464-16-47), cotter pin, and nut (AN320C16) securing the piston rod end to the probe guide support.

3.7.11.1.6 Remove and discard O-ring (2-260) located on the cylinder adapter block if damaged.

3.7.11.1.7 Remove capscrews, washers and nuts, securing the bracket sleeve (359-40115-400) to the lower half of cylinder mounting bracket (359-40115-7). Remove the bracket sleeve and front support (359-40119-7) as a unit.

NOTE

> The cylinder mounting bracket sleeve and lower half are matched marked and must be reinstalled accordingly.

3.7.11.1.8 Actuate the overhead hoist to remove the servo actuator and bellows assembly clear of the support structure.

3.7.11.1.9 Remove the capscrews and washers securing the bellows assembly to the servo actuator. Remove the bellows assembly and connector (359-61301-11) as a unit.

3.7.11.1.10 Remove and discard the O-rings located on the face plate of the bellows assembly if damaged.

3.7.11.2 Disassembly (see AMF DWG NO. 359-61201).

3.7.11.2.1 Remove lockwire and back off locknut (NAS509-24) and key securing the rod end to the piston rod.

3.7.11.2.2 Back off the rod end and remove the locknut and key.

3.7.11.2.3 Remove lockwire and screws securing drain cover (359-61201-13) to compensator rod (359-61201-9). Remove the drain cover.

3.7.11.2.4 Remove unit (359-61201-12) securing the compensator rod in position. Use a spanner wrench 359-60201T2 to remove the nut.

3.7.11.2.5 Remove compensator rod (359-61201-9) clear of the piston rod. Remove and discard O-ring (2-133-B318-7) packing (MS28774-243) and seal (MS28775-243) if damaged.

3.7.11.2.6 Remove piston rod (259-61201-8) clear of the cylinder barrel. Remove and discard seals (S12547-243) and packing (MS28775-242), seals (S12547-328) and packing (MS28776-329) if damaged.

3.7.11.2.7 Remove bearing (359-61201-11) at the piston rod end of the barrel. Remove shims (359-61201-14).

3.7.11.2.8 Remove packing (MS28775-243) and seals (MS28774-243), O-rings (2-243) located on the outside diameter of the bearing. Remove packing (MS28775-334) and seals (S12546-333) located on the inside diameter of the bearing. Discard all seals if damaged.

3.7.11.3 Reassembly. The reassembly procedures for servo actuator (359-61201) are the reverse of the disassembly procedures described in paragraph 3.7.11.2 except as follows:

3.7.11.3.1 Lubricate all seals with Dow Corning grease D-33, or equivalent.

3.7.11.3.2 Install shims (359-61201-14) to align the port holes in bearing (359-61201-11) and barrel (359-61201-7) with respect to the Z-axis of the barrel after bottoming within ±5 degrees (see AMF DWG NO. 359-61201).

3.7.11.3.3 Secure all lockwire in accordance with MS33440 requirements.

3.7.11.4 Installation. Installation procedures for the servo actuator are the reverse of the removal procedures described in paragraph 3.7.11.1 except for the following:

3.7.11.4.1 Apply 95 to 105 foot-pounds torque to the capscrews when securing the bracket sleeve to the lower half of cylinder mounting bracket (359-40115-7).

3.7.11.4.2 Lubricate all seals with Dow Corning grease D-33, or equivalent.

3.7.12 Drogue Mount and Transducers.

3.7.12.1 Removal (see AMF DWG NO. 359-60301).

WARNING

Be certain all power to the drogue mechanism is off. Failure to do so may result in injury to personnel and damage to the equipment.

3.7.12.1.1 Disconnect all electrical leads to the drogue mount (359-40316-7) and transducer (359-11008).

3.7.12.1.2 Remove the eight 1-1/4-inch capscrews and six 2-1/2 inch capscrews securing the single-load cell mounts to the vertical small motion ring. Do not remove the dowel pins located on the vertical small motion ring.

3.7.12.1.3 Remove the drogue mount and transducers clear of the support structure. Remove shims (359-40237). Note number and total thickness of shims at each load cell mount to facilitate reinstallation.

3.7.12.1.4 Back off the transducer locknut and rotate the single load cell mount (359-40314-7) clockwise until clear of the transducer. Remove the locknut. Note the position of each load cell mount to facilitate reinstallation.

3.7.12.1.5 Back off the locknut at the double load cell mount (359-40313-7) and rotate the transducer counterclockwise to remove.

3.7.12.1.6 Repeat steps 3.7.12.1.4 and 3.7.12.1.5 to remove the remaining transducers.

3.7.12.1.7 Remove the capscrews securing the double load cell mounts (359-40313-7) to the drogue mount. Remove each double load cell mount. Note the position of each load cell mount for reinstallation.

3.7.12.2 Installation. The installation procedures for the drogue mount and transducers are the reverse of the removal procedures described in paragraph 3.7.12.1 except for the following:

3.7.12.2.1 Secure single-load cell mounts (359-40314-7) to the vertical small motion ring with capscrews as shown on AMF DWG No. 359-60303.

3.7.12.2.2 Before tightening the locknuts, adjust each transducer as required to obtain the 8±0.001 inch gap between the vertical small motion ring (359-40305-7) and the drogue mount.

3.7.13 Vertical Small Motion Ring (359-40305-7).

3.7.13.1 Removal (see AMF DWG NO. 359-60303).

3.7.13.1.1 Remove drogue mount (359-40316-7) and transducers (359-11008) as a unit. Refer to paragraphs 3.7.12.1.1 through 3.7.12.1.4 for removal procedures.

3.7.13.1.2 Insert two 1/2 inch bolt-size eyebolts into any suitable tapped mounting holes in the vertical small motion ring and engage mounting hooks from the overhead hoist.

3.7.13.1.3 Disconnect and remove the potentiometer (598-6G). Refer to paragraph 3.7.15.

3.7.13.1.4 Disconnect vacuum lines at vertical servo actuators (359-61304-1).

3.7.13.1.5 Back off setscrews and remove vertical retainers (359-41352-7) at each end of the servo actuator. Use a spanner wrench (359-60303T2) to remove the retainers.

3.7.13.1.6 Remove plugs (359-41353-7 and -8). Note position of plugs to ensure proper reinstallation.

3.7.13.1.7 Repeat steps 3.7.13.1.3 through 3.7.13.1.6 at each of the remaining servo actuators.

3.7.13.1.8 Guide the vertical small motion ring clear of the horizontal small motion ring using the overhead hoist.

3.7.13.1.9 Remove and discard the O-rings located at each end of the vertical servo actuators (359-61304-1) if damaged.

3.7.13.1.10 Remove the bushings (359-40336-7).

3.7.13.2 Installation.

3.7.13.2.1 Install bracket (359-41305-7) on the servo actuator in the position shown on AMF DWG NO. 359-60303 before installing the vertical small motion ring (359-40305-7).

3.7.13.2.2 Coat threads of bushing (359-40336-7) with stud lock; and install the bushing.

3.7.13.2.3 Lubricate all O-rings with Dow Corning grease D-33, or equivalent, and install O-rings at each end of the servo actuators (359-61304-1).

3.7.13.2.4 Hoist the vertical small motion ring into position over the servo actuators.

3.7.13.2.5 Install plugs (359-41353-7 and -8) as shown on DWG NO. 359-60303.

3.7.13.2.6 Install vertical retainers (359-41352-7) at each end of the servo actuator. Do not tighten the retainers.

3.7.13.2.7 Manually move the vertical small motion ring to ensure a ±1/4-inch vertical motion. Adjust all the vertical retainers (359-41352-7) as required to obtain the ±1/4-inch movement.

3.7.13.2.8 Tighten the vertical retainers at each end of the servo actuator in the upper right-hand quadrant only. Be certain the ±1/4-inch vertical motion is maintained; if necessary readjust the vertical retainers in the upper right-hand quadrant.

3.7.13.2.9 Repeat step 3.7.13.2.8 to adjust the servo actuator in the upper left-hand quadrant, maintaining the ±1/4-inch deflection. Continue adjustments in the lower quadrants.

3.7.13.2.10 Connect all vacuum lines to the servo actuators.

3.7.13.2.11 Complete the installation of the potentiometer. Refer to paragraph 3.7.15.2

3.7.13.2.12 Install drogue mount (359-40316-7) and transducers (359-11008). Refer to paragraph 3.7.12.2.

3.7.14 Z-HF Servo Actuator (359-61304).

3.7.14.1 Removal (see AMF DWG NO. 359-61303).

3.7.14.1.1 Remove vertical small motion ring (359-40305-7), drogue mount (359-40316-7), and transducers to gain access to the vertical servo actuators (refer to paragraph 3.7.13.1).

3.7.14.1.2 Remove capscrews securing servo actuator (359-61304-1) to the horizontal small motion ring (359-60304-1). Remove the servo actuator. Note the position and direction of each servo actuator to ensure proper reinstallation.

3.7.14.1.3 Remove and discard O-rings located between the servo actuator and the horizontal small motion ring if damaged.

3.7.14.1.4 Remove capscrews and washers securing the bracket (359-41305-7) to the servo actuator housing and remove the bracket.

NOTE

Perform step 3.7.14.1.4 only if required to remove the servo actuator to which the bracket is attached.

3.7.14.2 Disassembly.

3.7.14.2.1 Remove the marman clamp and Permacel Teflon sealing tape used to seal the joint between the bellows assemblies (359-31304) and the servo actuator. Note thickness and number of turns when removing sealing tape to ensure proper reinstallation.

3.7.14.2.2 Back off and remove the bellows assembly. Remove and discard O-rings (2-148) if damaged.

3.7.14.2.3 Remove spring pin (MS171524) and bearing gland (359-61304-10) at each end of the actuator. Remove and discard O-rings (2-231) if damaged.

3.7.14.2.4 Slide piston rod (359-61304-8) and seal gland (359-61304-9) free of the actuator body.

3.7.14.2.5 Remove the seal gland and discard seals and packing if damaged.

3.7.14.2.6 Remove and discard seals and packing located on the piston rod if damaged.

3.7.14.2.7 Remove the remaining seal gland and discard all seals and packings if damaged.

3.7.14.3 Reassembly. The reassembly procedures are the reverse of the disassembly procedures described in paragraph 3.7.14.2 except for the following:

3.7.14.3.1 Lubricate all seals, O-rings and packings with Dow Corning grease D-33, or equivalent.

3.7.14.3.2 Install sealing tape and marman clamp as shown on DWG NO. 359-61304.

NOTE

Install Permacel Teflon sealing tape, wrapping a sufficient number of turns to obtain approximately a 3-3/4-inch diameter.

3.7.14.4 Installation. The installation procedures for the servo actuator are the reverse of the removal procedures described in paragraph 3.7.14.1 except for the following:

3.7.14.4.1 Lubricate all O-rings with Dow Corning grease D-33, or equivalent.

3.7.14.4.2 Install each actuator in its original position and direction as noted in paragraph 3.7.14.1.2.

3.7.14.4.3 Apply 375 ± 25 inch-pounds torque to the bolts securing the servo actuator to the horizontal small motion ring.

3.7.15 Z-HF Potentiometer (598-6G).

3.7.15.1 Removal (see AMF DWG NO. 359-61313).

WARNING

> Be certain all power to the drogue mechanism is off. Failure to do so may result in injury to personnel and damage to the equipment.

3.7.15.1.1 Disconnect the potentiometer at the J7 connector (see AMF DWG NO. 359-62003).

3.7.15.1.2. Cut lockwire and back off retainers (359-41310-7) securing the potentiometer shaft to the bracket (see AMF DWG NO. 359-61313).

3.7.15.1.3 Remove capscrews securing matched clamps (359-41304-7) and potentiometer to the vertical small motion ring. Remove the clamps and washer shims (AN960-610). Note number and thickness of shims to facilitate reinstallation.

3.7.15.1.4 Remove the potentiometer, retainer, belleville washer, potentiometer seat, and ball as a unit clear of the bracket (359-41305-7).

3.7.15.1.5 Remove the groove pin and ball (359-41308-7) to release the potentiometer seat, belleville washer, and retainer.

3.7.15.1.6 Remove capscrews and washers securing bracket (359-41305-7) to the servo actuator housing and remove the bracket.

3.7.15.2 Installation. The installation procedures are the reverse of the removal procedures described in paragraph 3.7.15.1 except for the following:

3.7.15.2.1 Install the potentiometer as shown on DWG NO. 359-61313. Tighten capscrews finger tight, and check movement of potentiometer by actuating the servo actuator (359-61304). Adjust the potentiometer as required to permit free movement of the shaft, and then secure the capscrews.

3.7.15.2.2 Adjust potentiometer electrically to read zero on the control panel.

3.7.16 Y-HF Actuator (359-61305).

3.7.16.1 Removal (see AMF DWG NO. 359-60303).

3.7.16.1.1 Remove drogue mount (359-40316-7) and transducers (359-11008) as a unit. Refer to paragraphs 3.7.15.1.1 through 3.7.15.1.4 for removal procedures.

3.7.16.1.2 Remove capscrews securing cover plate (359-40311) to the drogue pivot table and remove the cover plate.

3.7.16.1.3 Remove and discard the O-ring (359-40340-7) if damaged.

3.7.16.1.4 Remove the components of the horizontal hydraulic installation (359-61308) in the area of the servo actuator to be removed. (Refer to paragraph 3.7.2.4.)

3.7.16.1.5 Remove cylinder retainer (359-40325), using a spanner wrench 359-60301T1 (see AMF DWG NO. 359-61303).

3.7.16.1.6 Remove cylinder rings (359-40324-7 and -8).

NOTE

> The cylinder rings are match marked and must be reinstalled as a pair, and in their original position.

3.7.16.1.7 Remove shims (359-40333). Note number and total thickness of shims to ensure proper reassembly so as to obtain the required ±1/4-inch cylinder stroke.

3.7.16.1.8 Remove the nut and washer securing the servo actuator to the horizontal ring. Remove the servo actuator.

3.7.16.1.9 Remove and discard the two O-rings located on the inside diameter of the bellows assembly (359-31305-1) if damaged.

3.7.16.2 Disassembly.

3.7.16.2.1 Back off setscrew and remove bearing glands (359-61305-10) at each end of the servo actuator.

3.7.16.2.2 Remove piston rod (359-61305-8) and seal gland (359-61305-9) clear of barrel (359-61305-7). Remove and discard seals and packing from the piston rod if damaged.

3.7.16.2.3 Slide the seal gland free of the piston rod. Remove and discard seals and packings if damaged.

3.7.16.2.4 Remove the remaining seal gland (359-61305-9) from the barrel. Remove and discard seals and packings if damaged.

3.7.16.3 Reassembly. The reassembly procedures are the reverse of the disassembly procedures described in paragraph 3.7.16.2 except for the following:

3.7.16.3.1 Lubricate all seals and packings with Dow Corning grease D-33, or equivalent.

3.7.16.4 Installation. The installation procedures for the horizontal servo actuator are the reverse of the removal procedures described in paragraph 3.7.16.1 except for the following:

3.7.16.4.1 Lubricate all O-rings with Dow Corning grease D-33, or equivalent.

3.7.17 Horizontal Small Motion Ring (359-60304).

3.7.17.1 Removal (see AMF DWG NO. 359-60303).

3.7.17.1.1 Remove horizontal HF servo actuator in accordance with paragraph 3.7.16.1.

3.7.17.1.2 Install the bellows retainer compression tool (359-60303T2). See Special Tools Table for use and application. Compress bellows (359-31305) to a solid position against face of drogue pivot table (359-40303).

3.7.17.1.3 Remove retainers (359-40327 and 359-40334) with ball (MS19060-41). Note thickness and quantity of shims behind retainer (359-40334).

3.7.17.1.4 Slide horizontal ring (359-60304) to side of pivot table with machined clearance cut on trunnion support leg. This will cause horizontal ring to clear compressed bellows on opposite side. Ring may now be tipped up and disengaged from remaining bellows.

3.7.17.2 Reassembly. The reassembly procedures for the horizontal small motion ring are the reverse of these described in paragraph 3.7.17.1.

3.7.18. Vertical High Frequency Valve Assembly.

3.7.18.1 Removal (see AMF DWG NO. 359-61307). The following procedures are applicable for the vertical high frequency valve assembly (359-31322 and -31323; and high frequency servo valve (359-11001).

WARNING

> Be certain all power to the drogue mechanism is off. Failure to do so may result in injury to personnel and damage to the equipment.

3.7.18.1.1 Remove shoulder screws securing cover (359-40321-7) and gasket (359-40323-7). Remove the cover and gasket. Replace gasket if damaged.

3.7.18.1.2 Disconnect electrical leads to servo valve assembly (359-11001).

3.7.18.1.3 Back off the nut securing the tube (359-41385-7) to the tee (AN824-2C). Slide the tube into the valve assembly (359-31322-7) until clear of the tee (AN824-2C).

3.7.18.1.4 Remove self-locking screws manifold (359-41369-7) to the horizontal small ring (359-60304).

NOTE

> Do not remove the manifold (359-41369-7). Removing the manifold screws is necessary to permit the manifold and associated tubing to be moved in the direction away from the valve assembly being removed.

3.7.18.1.5 Remove the three 1-1/2-inch screws and one 2-inch screw securing the valve assembly to the horizontal ring. Remove the valve assembly, servo valve, and tube (359-41385-7) as a unit.

3.7.18.1.6 Remove the tube clear of the valve assembly. Remove and discard all tube packings and O-rings located on the valve assembly if damaged.

3.7.18.1.7 Remove and discard the O-rings located on the mounting face of the valve assembly if damaged.

3.7.18.1.8 Remove the three 1/2-inch screws securing the servo valve to the manifold. Remove the servo valve.

3.7.18.2 Installation. The installation procedures for the valve assembly and servo valve are the reverse of the removal procedures described in paragraph 3.7.16.4 except for the following:

3.7.18.2.1 Lubricate all O-rings and seals with Dow Corning D-33 or equivalent.

3.7.18.2.2 Apply 70 ± 5 inch-pounds torque when securing tube fittings.

3.7.19 Drogue Side Gimbal Servo Actuator (359-61303-1).

3.7.19.1 Removal (see AMF DWG. NO. 359-60301).

WARNING

Be certain that all power to the drogue mechanism is off. Failure to do so may result in injury to personnel and damage to the equipment.

3.7.19.1.1 Disconnect electrical leads to the servo actuator (see AMF DWG NO. 359-62003).

3.7.19.1.2 Disconnect hydraulic lines at the servo actuator (see AMF DWG NO. 359-61308).

WARNING -1

Removal of rod end connection between servo actuators and pivot table will allow table to fall forward on gimbal ball. Suitable support or brace must be attached prior to start of disassembly.

WARNING -2

> Two men are required to remove and support the servo actuator. Failure to observe this warning may result in injury to personnel and damage to the equipment.

3.7.19.1.3 Remove the shoulder screw, shims, and nut securing the rod end of servo actuator (359-6030301) to the drogue pivot table. Note the number and total thickness of the shims to facilitate reinstallation.

NOTE

> During reinstallation, the rod end bearing (359-31307) must be centered to 0.004 ± 0.001 inch maximum clearance within the pivot table bracket.

3.7.19.1.4 Remove the shoulder screw, nut, and bearing securing the blind end of the servo actuator. Remove the servo actuator.

3.7.19.2 Disassembly (see AMF DWG NO. 359-61303).

3.7.19.2.1 Remove end fitting (MS33656-4) and rod end connector (item 14). Remove and discard O-ring (2-26-B318-7) if damaged.

3.7.19.2.2 Back off the connector (359-61301-11). Remove and discard the O-ring (2-25-B318-7) and packing (MS28774-4) if damaged.

3.7.19.2.3 Remove the four capscrews securing dual-element bellows assembly (359-31303-7) to rod end cap (item 10). Remove and discard O-rings if damaged.

3.7.19.2.4 Cut lockwire and back off jam nut (NAS509-14) and rod end lock, (NAS559-6). See Special Tools Table. Remove rod end bearing (359-31307).

3.7.19.2.5 Remove the dual-element bellows assembly, spacer (item 12) and rod end lock and jam nut clear of the piston rod (item 9).

3.7.19.2.6 Remove bolts (MS20074-04-05) and washers (AN960C416) securing plate (item 15).

3.7.19.2.7 Remove piston guide (item 11). Remove and discard O-ring, (MS28775-129) and packing (MS28774-129); the seals (S-12546-214), and O-rings (MS28775-125). Discard seals if damaged.

3.7.19.2.8 Cut lockwire and back off locknut (item 13) to remove rod end cap (item 10) and discard O-rings (2-234-B318 and MS28775-234) and packing (MS28774-234) if damaged. Remove locknut (item 13).

3.7.19.2.9 Slide piston rod (item 9) clear of barrel (item 8). Remove and discard seals (S-12547-145) and O-rings (MS28775-144) if damaged.

3.7.19.2.10 Remove connector (item 16). Remove and discard O-ring (2-25-B318-7) and packing (MS28778-4) if damaged.

3.7.19.2.11 Cut lockwire and back off locknut (item 13) to remove piston end cap (item 7). Remove the locknut.

3.7.19.2.12 Remove and discard O-rings (2-234-B318-7) and (MS28775-234) and packing (MS28774-234) if damaged.

3.7.19.3 Reassembly. The reassembly procedures for the drogue gimbal servo actuator are the reverse of those described in paragraph 3.7.19.2 except as follows:

3.7.19.3.1 Lubricate all vacuum seals with Dow Corning grease D-33, or equivalent.

3.7.19.3.2 Secure all lockwire in accordance with MS33540 requirements.

3.7.19.4 Installation. The installation procedures for the servo actuator are the reverse of the procedures described in paragraph 3.7.19.1.

3.7.20 Drogue Z and Y-LF Servo Actuators.

3.7.20.1 Removal (see AMF DWG NO. 359-60301).

3.7.20.1.1 Move the probe mechanism to the fully retracted position and lower the drogue vertical mechanism to its bottom position.

WARNING

> Be certain all power to the probe and drogue mechanism is off. Failure to do so may result in injury to personnel and damage to the equipment.

3.7.20.1.2 Disconnect all electrical leads to the drogue mechanism.

3.7.20.1.3 Secure both lower 2-legs from 359-01003 slings to assembly shown on 359-60303 consisting of the drogue mount, horizontal and vertical small motion ring, and drogue pivot table to the overhead hoist. Take up any slack in the sling.

3.7.20.1.4 Disconnect gimbal actuators in accordance with paragraph 3.7.19.1.

3.7.20.1.5 Disconnect all hydraulic lines leading to the drogue mechanism (see AMF DWG NO. 359-61008 and 359-61308).

3.7.20.1.6 Remove the capscrews and shims securing pivot frame (359-40307-7) to the horizontal servo actuator. Note the number and thickness of shims (359-40317) to facilitate reinstallation (see AMF DWG NO. 359-60301). Secure gimbal yoke (359-40306) and pivot frame to avoid inadvertant motion and possible damage.

3.7.20.1.7 Remove bolts from retainer (359-40308) and remove assembly (359-60303) with hoist.

CAUTION

> Exercise care during hoisting operation to prevent damage to the equipment. Be certain all electrical and hydraulic lines have been disconnected.

3.7.20.1.8 Secure one of lower 2-leg of the 359-01003 slings to the lifting eyes on each vertical servo actuator (359-61302-1) using shackles and to the overhead hoist.

3.7.20.1.9 Remove the nut and washer securing the shaft of potentiometer (205989-2) to shaft bracket (359-40328-7).

3.7.20.1.10 Remove the capscrews and washers securing potentiometer cylinder to the mounting plates. Remove the potentiometer.

3.7.20.1.11 Remove shims (359-40120-10). Note the number and total thickness of shims to facilitate reinstallation of the potentiometer.

3.7.20.1.12 Remove the capscrews and washers securing mounting brackets (359-40330-7, 359-40329-7, and 359-40328-7). Remove mounting brackets and shims (359-40120). Note number and total thickness of shims to facilitate reinstallation.

3.7.20.1.13 Disconnect hydraulic lines (359-61008) leading to the low frequency horizontal and vertical hydraulic installation (359-61309-1, -2 and 359-61310-1, -2). See AMF DWG NO. 359-61312.

3.7.20.1.14 Disconnect all Teflon tubing at the horizontal and vertical acutators. Remove tubing between the hydraulic installations (359-61309-1 and -2).

3.7.20.1.15 Remove the capscrews securing the rack supports (359-40359-7) and rack assemblies (359-40363-7) to the top of the base (see AMF DWG NO. 359-60004).

3.7.20.1.16 Raise the rack support and rack assembly sufficiently to permit the unit to be pivoted about the pinion (359-40360-7). When clear of the base structure, draw the rack support and rack downwards until free of the pinion and remove.

3.7.20.1.17 Support the torque tube (359-40353-7) and remove the capscrews and dowels securing the pillow blocks (359-40347-7) to the base plates (359-40346-7) attached to each vertical actuator. Remove the torque tube and associated components.

3.7.20.1.18 Remove the pillow blocks (359-40347-7) from each end of the torque tube and remove the bearings (359-40362 7 and -8).

3.7.20.1.19 Remove the screws securing the plates (359-40352-7) and rollers (359-40349) to the support plates (359-40348). Remove the plates (359-40352-7) and rollers.

3.7.20.1.20 Remove the retainers (359-40357-7) and slide the bearings (359-40362-10) free of the roller shaft.

3.7.20.1.21 Remove the end support plate (359-40348-7), bearing (359-40362-9) and slide the bushing (359-40350-7) free of the torque tube.

3.7.20.1.22 Remove the pinion (359-40360-7) and spacer (359-40355-7).

3.7.20.1.23 Remove the inside support plate (359-40348-7) and bearing (359-40362-9). Remove the thrust bearing (T-200-2B).

3.7.20.1.24 Remove bolts and washers securing flange rod base (359-41368) of each vertical actuator to support structure.

3.7.20.1.25 Remove capscrews and washers securing upper bracket (365-40107-7) to the support structure column. Remove shims (359-40112). Note number and total thickness of shims for reinstallation.

3.7.20.1.26 Actuate the overhead hoist to remove the vertical and horizontal servo actuators clear of the support structure and onto a suitable work area. Remove shims (359-40116). Note number and total thickness of shims for reinstallation.

3.7.20.1.27 Remove capscrews securing shroud (359-41358) to the manifold block (see AMF DWG NO. 359-61309). Remove the shroud.

3.7.20.1.28 Remove six capscrews securing manifold block (359-41354) and eight capscrews securing pipe connectors (359-41355-7) to the servo actuator. Remove the manifold block, pipe connectors, and components as a unit.

NOTE

Disassembly procedures for the horizontal low frequency hydraulic installation are contained in paragraph 3.7.23.1.

3.7.20.1.29 Remove and discard the O-rings and packings at each pipe connector if damaged.

3.7.20.1.30 Remove capscrews securing shroud (359-41365-7) to the manifold plate (see AMF DWG NO. 359-61310). Remove the shroud.

3.7.20.1.31 Remove four capscrews securing manifold plate (359-41362-7) to the vertical servo actuator. Remove the manifold plate and components (see AMF DWG NO. 359-61312).

NOTE

Disassembly procedures for the low frequency vertical hyrdaulic assembly are contained in paragraph 3.7.24.1.

3.7.20.1.32 Remove the capscrews securing the bellows assembly (359-31314-7) to the housing supports (359-41314-7, -8 and -9).

3.7.20.1.33 Remove capscrews plugging tapped holes in tapered dowels securing ends of the horizontal piston rods to the housing supports (359-41314-7, -8, and -9).

3.7.20.1.34 Slide the vertical servo actuator and housing supports clear of the horizontal servo actuators, using both 2-leg slings and the overhead hoist. Repeat procedure to remove the remaining vertical servo actuator.

NOTE

When separating the servo actuators, the horizontal servo actuators may be supported on wooden blocks of sufficient height to permit the vertical servos to just clear ground level.

3.7.20.1.35 To complete the disassembly of the horizontal servo actuator, refer to paragraph 3.7.21.1 Disassembly procedures for the vertical servo actuator are contained in paragraph 3.7.22.

3.7.20.2 Installation. The installation procedure for the drogue low-frequency horizontal and vertical servo actuators are the reverse of the removal procedures described in paragraph 3.7.20 except for the following:

3.7.20.2.1 Lubricate all seals with Dow Corning grease D-33, or equivalent.

3.7.20.2.2 When securing tube fittings, apply torque as follows: 3/8 DIA tubing, 285 ± 15 inch-pounds; 1/4 DIA tubing, 142.5 + 7.5 inch-pounds.

3.7.20.2.3 Prior to installation of shroud (359-41358-7), inspect gasket (359-41359-7) for damage. Replace gasket as required (see AMF DWG NO. 359-61309, Note 2).

3.7.21 Drogue Horizontal Side Actuator (359-61301-1, -2)

3.7.21.1 Disassembly.

3.7.21.1.1 Remove the capscrews and nuts securing traverse assembly (359-60302-1) to the mounting brackets on the horizontal servo actuators (359-61301-1 and -2).

3.7.21.1.2 Remove shims (359-40318). Note the number and total thickness of the shims to facilitate reinstallation.

3.7.21.1.3 Remove adapters (359-41356-7). Discard O-rings and packings (see AMF DWG NO. 359-61312) if damaged.

3.7.21.1.4 Remove capscrews securing bellows assembly (359-31314-7) to the barrel of the horizontal servo actuator.

3.7.21.1.5 Remove the bellows assembly at each end of the piston rod. Remove and discard O-rings (2-171 and 2-174) if damaged.

3.7.21.1.6 Remove connectors (item 11, 359-61301) at each end of the actuator barrel.

NOTE

Four connectors (item 11) are installed on actuator (359-61301-2); only two connectors are used on the -1 actuator.

3.7.21.1.7 Remove O-rings (2-25-B318-7) located on the bearing surface of each connector. Remove packing (MS28778-4). Discard seals if damaged.

3.7.21.1.8 Remove capscrews (3/8-24 x 2-1/2 IN. LG) and washers (AN960C616) securing the seal gland at each end of the actuator barrel (item 7). Remove the seal gland.

3.7.21.1.9 Remove and discard four seals (S-12546-445) and packings (MS28775-446) located on the inside diameter of the seal glands if damaged.

3.7.21.1.10 Remove packing (2-274-B318-7), O-ring (8-272-N300-9), and packing (2-272-N304-7) located on the bearing surfaces of the seal gland. Discard seals if damaged.

3.7.21.1.11 Slide piston rod (item 8) clear of actuator barrel, (item 7).

3.7.21.1.12 Remove and discard seals (S40055) and packings (MS28775-455) located at the center of piston rod (item 8) if damaged.

3.7.21.2 Reassembly. The reassembly procedures for the drogue horizontal servo actuator are the reverse of those described in paragraph 2.7.21.1 except for the following:

3.7.21.2.1 Lubricate all vacuum seals with Dow Corning grease D-33, or equivalent.

3.7.21.2.2 During reassembly of seal glands (items 13, 14 and 15) apply 525 inch-pounds torque to the capscrews removed in paragraph 3.7.21.1.8.

3.7.22 Drogue Vertical Side Actuator (359-61302-1)

3.7.22.1 Disassembly (see AMF DWG NO. 359-61312).

3.7.22.1.1 Remove eyebolts (30) at upper end of the piston rod.

3.7.22.1.2 Remove the four capscrews securing bellows assembly (359-31315) to upper bracket (359-40107). Remove the upper bracket and bearing rod (359-41367) as a unit.

3.7.22.1.3 Remove capscrews securing bellows assembly (359-31315) to the barrel of the actuator. Remove the bellows assembly and discard O-rings (2-175 and 2-273) if damaged.

3.7.22.1.4 Remove capscrews securing rod base flange (359-41368-7) to the piston rod of the vertical actuator.

3.7.22.1.5 Remove the capscrews securing bellows assembly (359-31316-7) to the rod base flange and the barrel of the actuator. Remove the rod base flange and bellows assembly.

3.7.22.1.6 Remove and discard O-rings at each end of the bellows assembly if damaged.

3.7.22.1.7 Remove center shoulder screws, washers and nuts securing the linkage (359-41315) and slide blocks (359-41321) to the actuator barrel. Remove the slide blocks.

3.7.22.1.8 Remove shoulder screws securing the links to both housing supports (359-41314) and remove each link (359-41315).

4.7.22.1.9 Slide each housing support (359-41314-7 and -9) free of the servo actuator.

4.7.22.1.10 Back off each connector (359-61301-11) located on the rod end bearings. Remove and discard the packing and O-rings (see AMF DWG NO. 359-61302) if damaged.

3.7.22.1.11 Remove capscrews securing the rod end bearings (359-61302-13) and the base plate (359-40346-7) to the barrel (359-61302-8). Remove the base plate (see AMF DWG NO. 359-60004), rod end bearings, and discard all O-rings and packings if damaged.

4.7.22.1.12 Remove the barrel clear of the piston rod (359-61302-7).

CAUTION

Exercise care when separating the barrel and piston rod so as not to score or otherwise mar the chrome plated surface of the piston rod.

3.7.22.2 Reassembly. The reassembly procedures for the vertical servo actuator are the reverse of the disassembly procedures described in paragraph 3.7.22.1 except for the following:

3.7.22.2.1 Lubricate all seals with Dow Corning grease D-33, or equivalent.

3.7.22.2.2 Installation procedures for the servo actuator are contained in paragraph 3.7.20.2.

3.7.23 Horizontal Low Frequency Hydraulic Installation (359-61309-1, -2).

3.7.23.1 Disassembly.

3.7.23.1.1 Remove pipe connectors (359-41355-7) and discard the internal O-rings and packings if damaged.

3.7.23.1.2 Remove the adapter tubes (359-41356-7) and discard the packings and O-rings if damaged.

3.7.23.1.3 Remove capscrews securing hose adapters (359-41357-7) to the manifold block. Remove and discard the packings and O-rings if damaged.

3.7.23.1.4 Remove capscrews and washers securing servo valve (359-11004) to the valve assembly.

3.7.23.1.5 Remove the capscrews securing the valve assembly (359-31311-7) to the manifold block and remove the valve assembly. Remove and discard the O-ring located at the base of the valve assembly if damaged.

NOTE

> The procedures described in steps 3.7.23.1.6 through 3.7.23.1.9 apply to the horizontal low frequency hydraulic installation, AMF PART NO. 359-61309-2 only.

3.7.23.1.6 Back off the sleeve nuts securing the 1/4-inch diameter tubing to the transducer and to the manifold block. Remove tubing and discard all packings and O-rings if damaged.

3.7.23.1.7 Back off the check nut securing the 90-degree elbows to the transducer and remove the elbows. Discard all packings and O-rings if damaged.

3.7.23.1.8 Remove capscrews securing mounting plate (359-41360-7) to manifold block. Remove the mounting plate and transducer as a unit.

3.7.23.1.9 Remove the capscrews securing the transducer to the mounting plate and remove the transducer.

3.7.23.2 Reassembly. The reassembly procedures for the horizontal low frequency hydraulic installation are the reverse of the disassembly procedures described in paragraph 3.7.23.1 except for the following:

3.7.23.2.1 Lubricate all seals with Dow Corning grease D-33, or equivalent.

3.7.23.2.2 When securing 1/4-inch diameter tube fittings, apply 142.5 ± 7.5 inch-pounds torque to the coupling nuts.

3.7.23.2.3 Installation procedures for the horizontal low frequency hydraulic installation are contained in paragraph 3.7.20.2.

3.7.24 Low Frequency Vertical Hydraulic Assembly (359-61310-1, -2).

3.7.24.1 Disassembly.

3.7.24.1.1 Remove the capscrews securing the servo valve (359-11004) to the valve assembly and remove the servo valve. Discard the servo valve packing.

3.7.24.1.2 Back off the flared tube nut securing the 90-degree elbow to the valve assembly. Remove the elbow and discard the packing and O-rings if damaged.

3.7.24.1.3 Remove capscrews securing valve assembly (359-31312-7) to manifold plate. Remove the valve assembly and discard all packings located at the base of the valve assembly.

3.7.24.1.4 Back off the coupling nuts and disconnect all 1/4-inch diameter tubing at the manifold plate and pressure transducer. Remove tubing and discard O-rings if damaged.

NOTE

The procedures described in paragraphs 3.7.24.1.5 through 3.7.24.1.7 apply to the low frequency vertical hydraulic assembly, AMF PART NO. 359-61310-1 only.

3.7.24.1.5 Back off the flared tube nut and remove elbow (AN833-4C).

3.7.24.1.6 Remove the capscrews securing the mounting block (359-41363-7) and pressure transducer to the manifold plate. Remove the mounting block and transducer as a unit.

3.7.24.1.7 Remove the capscrews securing the pressure transducer to the mounting block and remove the transducer.

3.7.24.2 Reassembly. The reassembly procedures for the low frequency vertical hydraulic assembly are the reverse of the disassembly procedures described in paragraph 3.7.24 except for the following:

3.7.24.2.1 Lubricate all seals with Dow Corning grease D-33, or equivalent.

3.7.24.2.2 When securing 1/4-inch diameter tubing, apply 142.5 ± 7.5 inch-pounds torque to the coupling nuts.

3.7.24.2.3 Installation procedures for the low frequency vertical hydraulic assembly are contained in paragraph 3.7.20.2.

3.7.25 Horizontal High Frequency Hydraulic Installation (359-61308).

3.7.25.1 Disassembly (see AMF DWG NO. 359-61308).

NOTE

The disassembly procedures contained in this paragraph are complete only to the extent necessary to provide access for removal of the horizontal high frequency servo actuators (359-60303) as described in paragraph 3.7.16.4.

3.7.25.1.1 Back off slide tubes (359-41392-7 and 359-41393-7) from valve assembly (359-31309-7).

3.7.25.1.2 Slide each slide tube into the tube manifold (359-41389-7) until the threaded end of each slide tube is clear of the valve assembly.

3.7.25.1.3 Remove capscrews (M38CR1032-7E) securing the valve assembly (359-31309-7) to the relief valve adapter. Remove the valve assembly and attached servo valve (359-11001). Discard O-ring (MS28775-012) if damaged.

3.7.25.1.4 Remove O-rings (MS28778-2, and -8). Discard O-rings if damaged.

3.7.25.1.5 Disconnect tubing at relief valve adapter (359-41351).

3.7.25.1.6 Remove the capscrews securing the relief valve adapter to servo actuator (359-61305). Remove the relief valve, GLYD ring and O-rings. Discard seals if damaged.

3.7.25.1.7 Back off the locknuts securing the hydraulic tubing and elbows at each tube manifold assembly (359-41389-7). Be certain all hydraulic lines are clear of manifold. Discard all seals if damaged.

3.7.25.1.8 Back off slide tubes (359-41392-8 and 359-41393-8) from the valve assembly and slide each slide tube into the tube manifold (359-31389-7).

3.7.25.1.9 Remove the screws and washers securing the manifold bracket (359-41303-7) to the horizontal small ring assembly (359-60304).

3.7.25.1.10 Remove the manifold bracket, tube manifold, and slide tubes as a unit.

3.7.25.2 Reassembly. The reassembly procedures for the horizontal high frequency hydraulic installation are the reverse of the disassembly procedures described in paragraph 3.7.25.1 except for the following:

3.7.25.2.1 Lubricate all seals with Dow Corning grease D-33, or equivalent.

3.7.25.2.2 Apply 475 ± 25 inch-pounds torque when securing all 1/2-inch diameter tubing.

3.8 STORAGE.

3.8.1 This section contains procedures for dismantling and storing the ADTD for an indefinite period of time, under ambient environmental conditions with up to 100% humidity.

3.8.2 In preparing the ADTD for storage the major components of the system are removed and stored intact. Fixed wiring and piping may be left attached. However, care must be taken to protect and seal these items as defined in paragraph 3.8.7. The components involved for storage are as follows:

3.8.2.1 General assembly with seismic mass.

3.8.2.2 Shock mounts.

3.8.2.3 Hydraulic power pack.

3.8.2.4 Vacuum pump systems (12 Torr and 0.01 Torr).

3.8.2.5 Accumulator racks.

3.8.2.6 Control Console Assembly.

3.8.2.7 Amplifier terminal.

3.8.2.8 Electrical cables, hydraulic and vacuum piping, and fittings.

3.8.3 Before dismantling the ADTD, consideration should be given to the length of time the system will be in storage. If the system is to be operated within three months, the operational hydraulic fluid, Military Specification MIL-H-5606 may be retained in the test fixture, hydraulic power pack and associated piping. If the system is to be stored for more than three months, the hydraulic fluid, MIL-H-5606 should be removed and replaced with a preservative hydraulic fluid conforming to Military Specification MIL-H-6083.

3.8.4 General Assembly with Seismic Mass.

3.8.4.1 Preparation. Retract all general assembly actuators by performing the following steps:

3.8.4.1.1 Place all nine SYSTEM MONITOR panel switches to POSITION.

3.8.4.1.2 Turn all SYSTEM MONITOR panel POSITION controls counterclockwise until the meters indicate zero.

3.8.4.1.3 Perform system shutdown procedures given in section II.

3.8.4.2 Removal of Pressure and Return Penetration Plate Assemblies (AMF DWG NO. 359-61010 and 359-61011).

3.8.4.2.1 Disconnect the two quick disconnect couplings from the fixed accumulator lines or return piping outside chamber. Cap coupling ends with clear plastic closures.

3.8.4.2.2 Remove four screws and washers attaching retainer plate to adapter.

3.8.4.2.3 Pull vacuum shroud with adapter and interior hydraulic lines attached through the penetration from inside the chamber. Use care in feeding the exterior hydraulic hoses with couplings through the clearance hole in the retainer plate. Retain the adapter O-ring seal.

3.8.4.2.4 Remove the retainer plate from the chamber flange by removing 12 screws, washers and nuts. Retain hardware and O-ring seal.

3.8.4.2.5 Secure retainer plate to adapter with four screws and washers with adapter seal installed.

3.8.4.2.6 Replace blind flange (NASA provided) on chamber opening with "O" seal and twelve screws, washers and nuts.

3.8.4.3 Removal of Vacuum Penetration Plate Assembly (AMF DWG NO. 359-61012).

3.8.4.3.1 Disconnect three hose assemblies at exterior vacuum lines. (Vacuum system should be aired prior to disconnection.)

3.8.4.3.2 Plug or cap hose end fittings and tape securely.

3.8.4.3.3 Remove four screws securing retainer to adapter.

3.8.4.3.4 Pull disconnected vacuum hose with adapter attached through penetration from inside chamber. Retain "O" seal.

3.8.4.3.5 Remove retainer plate from chamber flange by removing four screws, washers and nuts. Retain hardware and "O" seals.

3.8.4.3.6 Secure retainer to adapter with four screws with "O" seals installed.

3.8.4.3.7 Plug ports in retainer plate with clear plastic closures.

3.8.4.3.8 Replace blind flange (NASA provided) on chamber opening with "O" seals etc.

3.8.4.3.9 Carefully withdraw all hydraulic and vacuum lines with penetration assemblies and drape over manifolds avoiding sharp bends. Secure penetration assemblies to support structure by lockwire through bolt holes in retainer plates. Wrape penetration assemblies in cushioning material to avoid damage to sealing surfaces.

3.8.4.4 <u>Removal of General Assembly Electrical Components</u>.

3.8.4.4.1 Disconnect electrical cables W1 through W9 from chamber interior side of penetration plate (VS-103). See AMF DWG NO. 359-62001.

3.8.4.4.2 Disconnect electrical cables (W40 through W48) from chamber exterior of penetration plate (VS-103). See AMF DWG NO. 359-62001.

3.8.4.4.3 Disconnect electrical cables W10, W11, W30, and W31) from chamber interior side of penetration plate (VS-104). See AMF DWG NO. 359-62001.

3.8.4.4.4 Remove the penetration plates (AMF DWG NO. 359-62513) by removing the twelve bolts, nuts and washers. Retain the mounting hardware. Place the mounting bolts back into the penetration plate mounting holes and secure with the washers and nuts.

3.8.4.4.5 Install a blank plate to close the holes left by the removal of penetration plates (VS-103 and VS-104).

3.8.4.4.6 Remove hardware securing seismic mass to the shock mounts.

3.8.4.5 Removal of General Assembly Seismic Mass.

3.8.4.5.1 Attach lifting slings (359-01003) to seismic mass at lifting lugs. Insure shackle bolts are tight. Install spreader bar and rotate key lugs to top position to lock in place.

3.8.4.5.2 Take up slack in lifting sling.

NOTE

Gross weight of general assembly is 54,000 lbs.

3.8.4.5.3 Remove hardware securing shock mounts to seismic mass.

3.8.4.5.4 Lift general assembly clear of shock mounts.

CAUTION

Take up strain or sling slowly observing any shift in position due to CG location. If necessary re-lower the general assembly and adjust lugs of lower slings around eyelets at spreader bar to compensate.

3.8.4.5.5 Remove general assembly from chamber, using care to avoid damage to adjacent equipment or protruding portions of the general assembly. Guy ropes may be attached to the seismic mass at the lifting lugs to assist in controlling lateral motions when lifting and lowering.

3.8.5 Shock Mounts.

3.8.5.1 Remove hardware securing the four shock mounts to the lunar plane beam supports.

3.8.5.2 Remove shock mounts from the test chamber and enclose them in polyethylene bags or equivalent.

3.8.6 Hydraulic Power Pack

3.8.6.1 Perform system shutdown procedures given in section II.

NOTE

> The hydraulic power pack is a portable wheeled unit which may be towed to any suitable location for storage. Internal storage facilities are provided for hydraulic hoses and electrical cables.

3.8.6.2 Disconnect the self-sealing quick-disconnect couplings for the pressure and return lines. Store within the power pack enclosure. Cap couplings with clean plastic caps.

3.8.6.3 Disconnect the electrical power and control wiring. Reel and store within power pack enclosure. Cap electrical connectors with plastic caps.

NOTE

> No special wrapping is required for the power pack. A dust cover of polyethylene, or equivalent may be used.

3.8.7 Accumulator Racks.

3.8.7.1 Perform system shutdown procedures given in section II.

WARNING

> Prior to performing any work on the accumulator racks, the accumulator valves must be closed to prevent a sudden release of hydraulic fluid under high pressure, which may cause injury to personnel.

3.8.7.2 Turn the valve handwheels at the lower part of the accumulator rack (AMF DWG NO. 359-61009) to the fully clockwise position to shut-off the accumulators.

3.8.7.3 Remove clamp and seal rings from hydraulic piping. Retain all clamps, seal rings and piping.

3.8.7.4 Close the hydraulic pipe openings with clean plastic caps.

3.8.7.5 Remove mounting hardware and place in a polyethylene bag, or equivalent. Attach bag to the accumulator rack frame.

3.8.7.6 Enclose accumulator rack in a polyethylene bag.

3.8.8 Vacuum Pump Systems (12 Torr and 0.01 Torr).

NOTE

> Each system is composed of a power pack and a drain system. The power pack is located as shown in AMF DWG NO. 359-61006. The drain system is located in a pit under the test chamber.

3.8.8.1 Perform system shutdown procedures given in section II.

3.8.8.2 Remove fittings and seals from vacuum piping from both power pack and drain system. Enclose fittings and seals in a polyethylene bag and attach bag to the power pack.

3.8.8.3 Close all shut off valves and disconnect all cooling water, gas inleak, and valve air supply lines. Close all openings with clear plastic closures.

3.8.8.4 Open both drain system drain-cocks and vent valves to remove all condensed liquids.

3.8.8.5 Remove drain systems from pit.

3.8.8.6 Disconnect thermocouple vacuum gage cables and remote power and control wiring and secure on power pack stand.

3.8.8.7 Enclose complete power pack in heat sealed poly bag. Dolly casters should not be included within bag to facilitate maneuvering cart.

3.8.8.8 Enclose the drain system in a heat-sealed polyethylene bag.

3.8.8.9 If vacuum system is installed in MSC Bldg. 13, Steps 3.8.8.1, 3.8.8.2 and 3.8.8.8 are necessary. Disconnect main suction lines to vacuum penetration plate at the drain system inlet. Prepare system for storage by enclosing entire pumping and drain system in assembled condition on cart.

3.8.9 <u>Control Console Assembly.</u>

NOTE

> Due to the location and size of the control console it may be desirable to disassemble each enclosure frame. These procedures outline this method for storage.

3.8.9.1 Perform system shutdown procedures given in section II.

3.8.9.2 Disconnect inter-cabinet wiring from terminal boards located in the rear of the cabinets. Coil wire ends, and tie in place inside cabinets.

3.8.9.3 Disconnect wiring from computer and test device in test chamber. Coil wire ends. Wrap ends in cushioning material and seal in polyethylene bags or equivalent.

3.8.9.4 Separate the enclosure frames by removing the attaching hardware. Bag hardware and attach to the appropriate enclosure frame.

3.8.9.5 Remove the desks from enclosure frames 4 and 5 if desired. Attach parts to outside of cabinet for storage.

3.8.9.6 Secure 30 units of activated desiccant, conforming to Military Specification MIL-D-3464, to the interior of each cabinet. A humidity indicator, conforming to Military Standard MS20003 should also be included.

3.8.9.7 Enclose the cabinet in a polyethylene bag and heat seal.

3.8.10 Amplifier Terminal.

3.8.10.1 Perform system shutdown procedures given in section II.

3.8.10.2 Disconnect incoming cables at terminal boards. Remove fittings at cabinet top and pull cable clear of terminal.

3.8.10.3 Coil wire ends of cable. Wrap in cushioning material and seal in polyethylene bags or equivalent.

3.8.10.4 Secure 32 units of activated desiccant, conforming to Military Specification MIL-D-3464, to the interior of the cabinet. A humidity indicator, conforming to Military Standard MS20003 should also be included.

3.8.10.5 Enclose the cabinet in a polyethylene bag and heat seal.

3.8.11 Transmission Cables, Piping and Fittings.

3.8.11.1 The ends of cables, piping and fittings, which are not removed for storage, should be covered with plastic plugs or caps to prevent the entry of dirt, oil or moisture. Where this is not practicable, the ends should be wrapped in cushioning material and sealed in polyethylene bags, or equivalent.

3.8.11.2 Loose electrical cables should be coiled and the connector ends closed with plastic plugs or caps.

3.9 DRAINING AND REFILLING HYDRAULIC SYSTEM.

3.9.1 Draining.

3.9.1.1 Shut down system.

3.9.1.2 Disconnect hoses at the ADTD manifold connection and drain fluid into a clean container.

NOTE

There is approximately 52 gallons of hydraulic fluid in the system exclusive of the hydraulic power pack.

3.9.2 Refilling.

3.9.2.1 The system is filled by running the hydraulic power pack at reduced pressure (less than 500 psi) so as not to collapse the filters in the servo valves.

3.9.2.2 Pump hydraulic fluid back into system through a 10 micron filter. This procedure should be performed axis by axis. Exercise each axis through its full stroke as it is being filled. This will fill and bleed axis.

3.9.2.3 Add any additional hydraulic fluid, as required to replace loss due to draining and refilling.