AD729 902

HIGH-GAIN, LONG-PERIOD SEISMOGRAPH STATION INSTRUMENTATION

VOLUME I

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY

of

COLUMBIA UNIVERSITY

31 MARCH 1971

SPONSORED BY

ADVANCED RESEARCH PROJECTS AGENCY

ARPA Order No. 1513

2

UNCLASSIFIED

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
Lamont-Doherty Geological Observatory Columbia University Palisades, NY 10964	UNCLASSIFIED 2b. GROUP

3. REPORT TITLE

High-Gain, Long-Period Seismograph Station Instrumentation, Volume I

4. DESCRIPTIVE NOTES (Type of report and inclusive dates)

Scientific......Interim

5. AUTHOR(S) (First name, middle initial, last name)

Dr. Lynn Sykes

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
31 March 1971	240	13

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
F44620-70-C-0038	
b. PROJECT NO. AO 1513	
c. 62701D	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) AFOSR - TR - 71 - 2372
d.	

10. DISTRIBUTION STATEMENT

Approved for public release;
distribution unlimited.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
TECH, OTHER	AF Office of Scientific Research (NPG) 1400 Wilson Boulevard Arlington, VA 22209

13. ABSTRACT

Five high-gain, long-period seismograph stations are being installed, operated, and evaluated at sites in Alaska, Australia, Israel, Spain, and Thailand. Details of these installations are given in a series of five Technical Reports each entitled "High-Gain, Long Period Seismograph Systems Installation Report." These instruments are capable of operating at magnifications greater than 500,000 at periods of 35 to 45 seconds. The purpose of this report is to describe the instruments in detail, present a parts list, and present technical drawings and operation manuals for the major components.

DD FORM 1473

UNCLASSIFIED

Security Classification

HIGH-GAIN, LONG-PERIOD SEISMOGRAPH STATION

INSTRUMENTATION

VOLUME I

LAMONT-DOHERTY GEOLOGICAL OBSERVATORY

of

COLUMBIA UNIVERSITY

31 MARCH 1971

SPONSORED BY

ADVANCED RESEARCH PROJECTS AGENCY

ARPA Order No. 1513

2

ARPA Order Number:	1513
Program Code Number:	OF10
Contractor:	Columbia University
Effective date of contract:	1 February 1970
Contract Expiration date:	31 January 1971
Amount of contract:	$ 942,578.00
Contract Number:	F44620-70-C-0038
Principal investigator:	Lynn R. Sykes, 914-359-2900
Program director:	Peter L. Ward, 914-359-2900
Project scientist:	William Best, 202-OX4-5456
Title of work:	Long-Period Seismological Research Program

The following persons have contributed significantly to the design, construction, and/or installation of this equipment:

George Choy

Merrill Connor

Shannon Cory

Fred England

George Hade

Tracy Johnson

Keith McCamy

Andrew Murphy

Paul Pomeroy (Now at University of Michigan, Ann Arbor)

John Rynn

John Savino

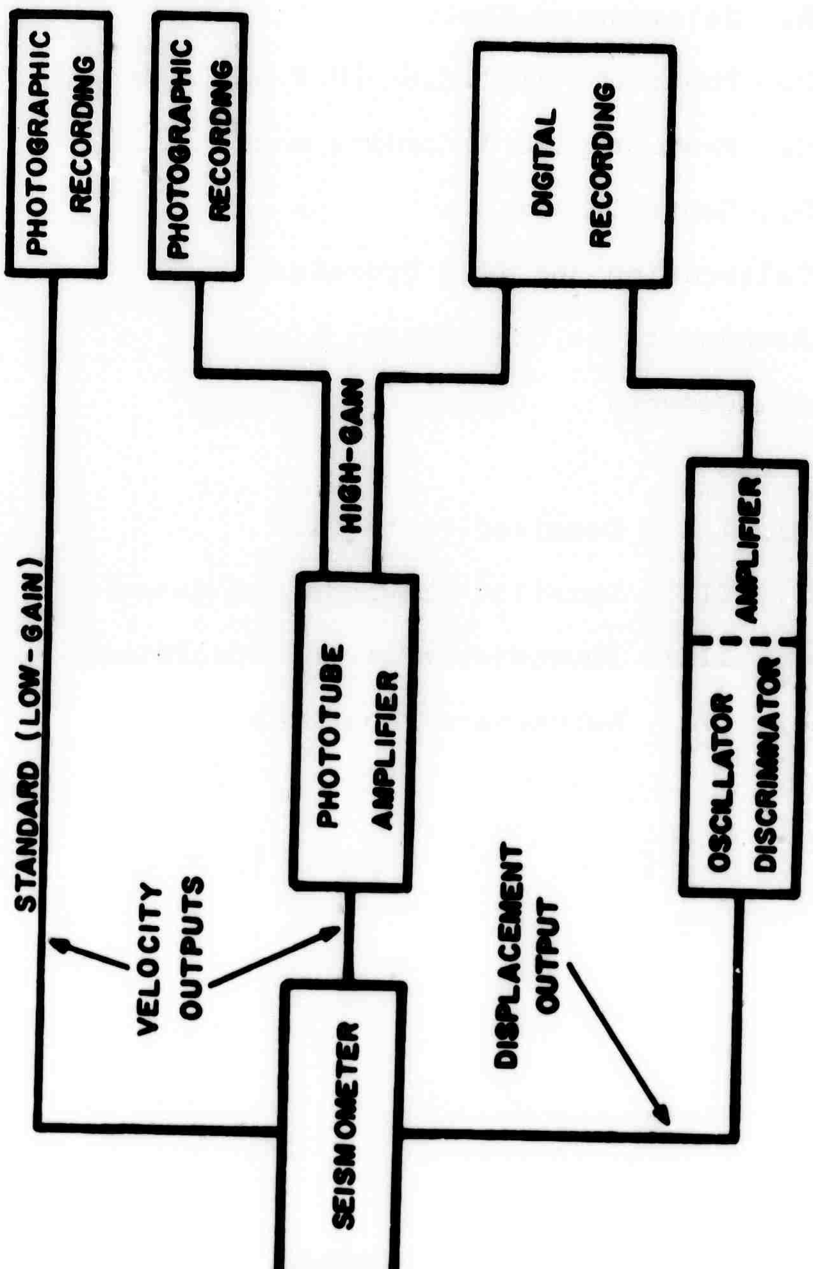
Marc Sbar

Peter Ward

Preceding page blank

TABLE OF CONTENTS

Figure 1: Block diagram of high-gain, broad-band, long-period seismograph system.



INTRODUCTION

Five high-gain, long-period seismograph stations are being installed, operated, and evaluated at sites in Alaska, Australia, Israel, Spain, and Thailand. Details of these installations are given in a series of five Technical Reports each entitled "High-Gain, Long-Period Seismograph Systems Installation Report". These instruments are capable of operating at magnifications greater than 500,000 at periods of 35 to 45 seconds. The purpose of this report is to describe the instruments in detail, present a parts list, and present technical drawings and operation manuals for the major components.

I: GENERAL DESCRIPTION OF THE INSTRUMENTATION

Each high-gain, long-period seismograph station consists of a three-component seismograph system as shown in Figures 1 and 2. The design is based on the development of a similar system (Pomeroy et al., 1969) that has been in operation since the fall of 1968 at the Lamont-Doherty Geological Observatory's Ogdensburg Mine Observatory in New Jersey (Major et al., 1964). Modifications, as outlined below, were made to the basic instruments to obtain increased sensitivity of the seismometers for the observation of long period seismic waves (Oliver, 1959) and small teleseisms (Molnar et al., 1969; Pomeroy et al., 1969), and to reduce the thermal and mechanical noise of the seismograph system (Melton, 1966; Savino, 1970; Savino and Hade, 1970; Sutton, 1962; Trott, 1965, 1966). Typical component values and system gains are given in Table I.

The seismometers, a Geotech Model S-11 vertical and two Geotech Model S-12 horizontals, have their natural periods set at approximately 30 seconds. Each seismometer has two velocity transducers, each of the moving coil-fixed magnet type, and was modified to include a Sprengnether displacement transducer system. One velocity transducer output is loosely coupled to a Kinemetrics Model LG-1 galvanometer of 100 seconds natural period. The position of a light beam reflected by this galvanometer is converted to volts, amplified and filtered using a Geotech Model 5240B phototube amplifier and a Geotech Model 14486 power supply. The filtered output from the phototube amplifier (P.T.A.) system is recorded photographically on a Sprengnether HR-6007 three-drum recorder using a Geotech Model G-10 recording galvanometer with natural period of 0.3 seconds. Magnifications in excess of 500,000 at periods of 35 to 45 seconds can be attained, and so this output is designated "high-gain" (Figure 3). The P.T.A. output is also recorded on magnetic tape using an Astrodata digital data acquisition system. This digital system has a dynamic range of over 90db, but the overall system dynamic range is limited by the photo-

Figure 2: Detailed diagram of the high-gain, broad-band, long-period seismograph system. This diagram is given on the last page of the report.

tube amplifiers to about 70db. The second velocity transducer is loosely coupled to a Kinemetrics Model LG-1 galvanometer of 100 seconds natural period and recorded photographically on a second Sprengnether three-drum recorder. Kinemetrics Model LG-1 MOD galvanometers with natural periods of 7 seconds are provided as band rejection filters (Pomeroy and Sutton, 1960) at stations where the short period (6 to 8 second) microseism level is observed to be exceptionally high. This standard or "low-gain" output (Figure 3) has a magnification of up to 8000 at periods of 25 to 35 seconds.

Modifications were made to the boom of each seismometer to accomodate Sprengnether Models VC202H and VC202V displacement transducer systems. Signals from the displacement transducers are detected and amplified by the Sprengnether Model VCT201BA oscillator-discriminator units and recorded digitally on the Astrodata system.

The high sensitivity of the seismograph systems is possible because of several design features. The "high-gain" passband has been shaped to correlate with a natural low in the earth noise spectrum (Figure 4). This spectrum is based on the earth noise studies of Savino (1970) who showed that a very stable and pronounced minimum, or window, exists between 30 and 40 seconds at Ogdensburg. At periods longer than 40 seconds, the displacement spectrum of earth noise increases at 12 to 14 db/octave.

TABLE I

High-Gain Seismograph System:

Resistors:	Seismometer	r_s	=	560 ohms
	Phototube Amplifier	r_g	=	500 ohms
		R	=	12K ohms
		S	=	6K ohms
	L-Pad Attenuator	R	=	200K ohms
		S	=	120 ohms
	Recording Galvanometer	r_g	=	68 ohms

System Gain: 120,000

Damping:	Z_{seis}	=	1	Z_{gal}	=	1
	$N\text{-}S_{seis}$	=	1.2	$N\text{-}S_{gal}$	=	1
	$E\text{-}W_{seis}$	=	1.2	$E\text{-}W_{gal}$	=	1

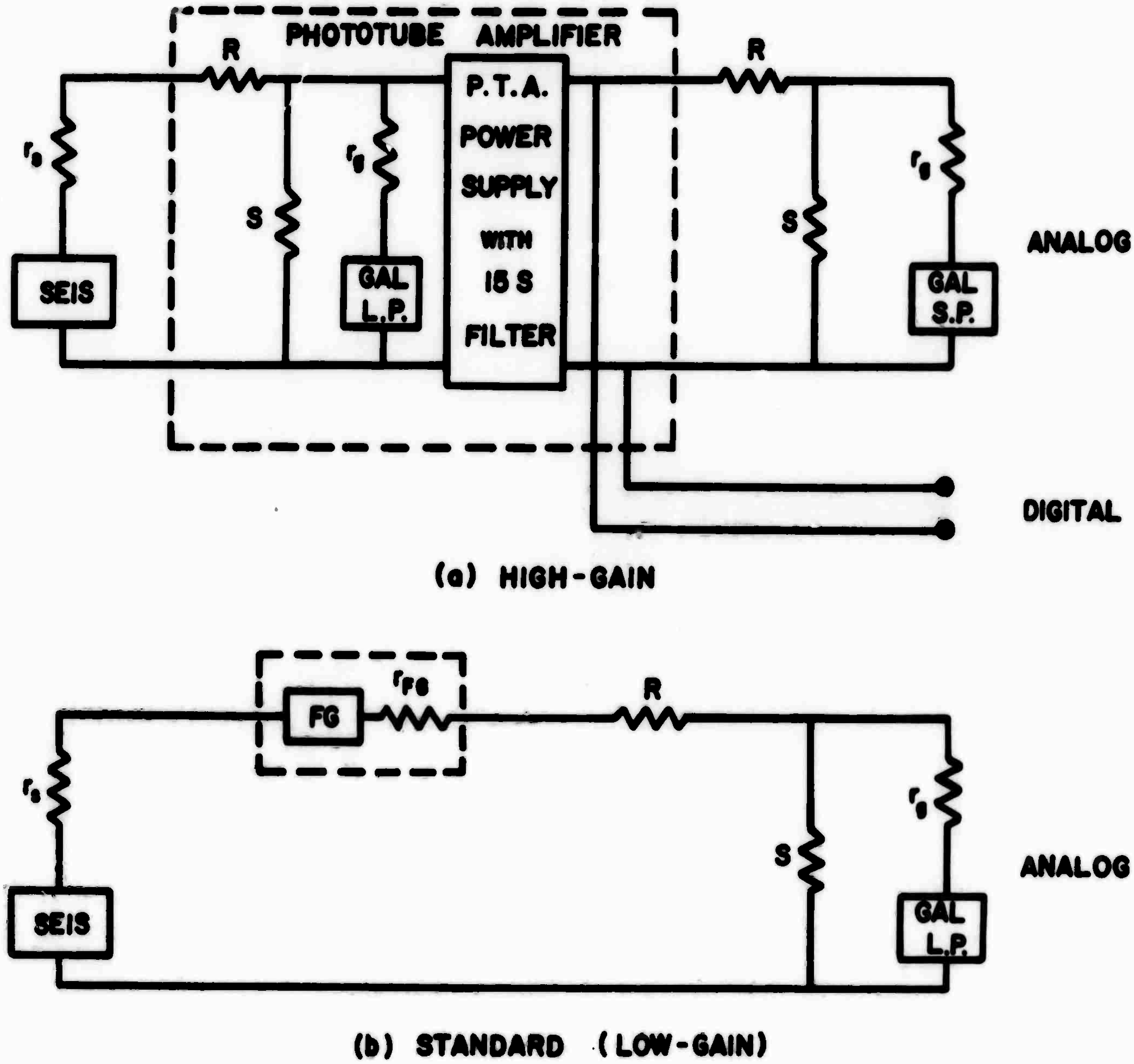
<u>Standard (Low-Gain) Seismograph System</u>:

Resistors:	Seismometer	r_s	=	560 ohms
	Filter Galvanometer	r_{fg}	=	500 ohms
	L-Pad Attenuator	R	=	6K ohms
		S	=	6K ohms
	Recording Galvanometer	r_g	=	500 ohms

System Gain: 5,800

Damping:	Z_{seis}	= 1		Z_{gal}	= 1	
	$N\text{-}S_{seis}$	= 1.2		$N\text{-}S_{gal}$	= 1	
	$E\text{-}W_{seis}$	= 1.2		$E\text{-}W_{gal}$	= 1	

Figure 3: Circuit diagrams of seismograph systems. Boxes marked SEIS represent seismometer; GAL L.P., long-period (Tg = 100 sec) galvanometer; GAL S.P., short-period (Tg = 0.3 sec) galvanometer; FG, filter galvanometer; R,S,r_s,r_g, and r_{FG} are lumped circuit resistances.

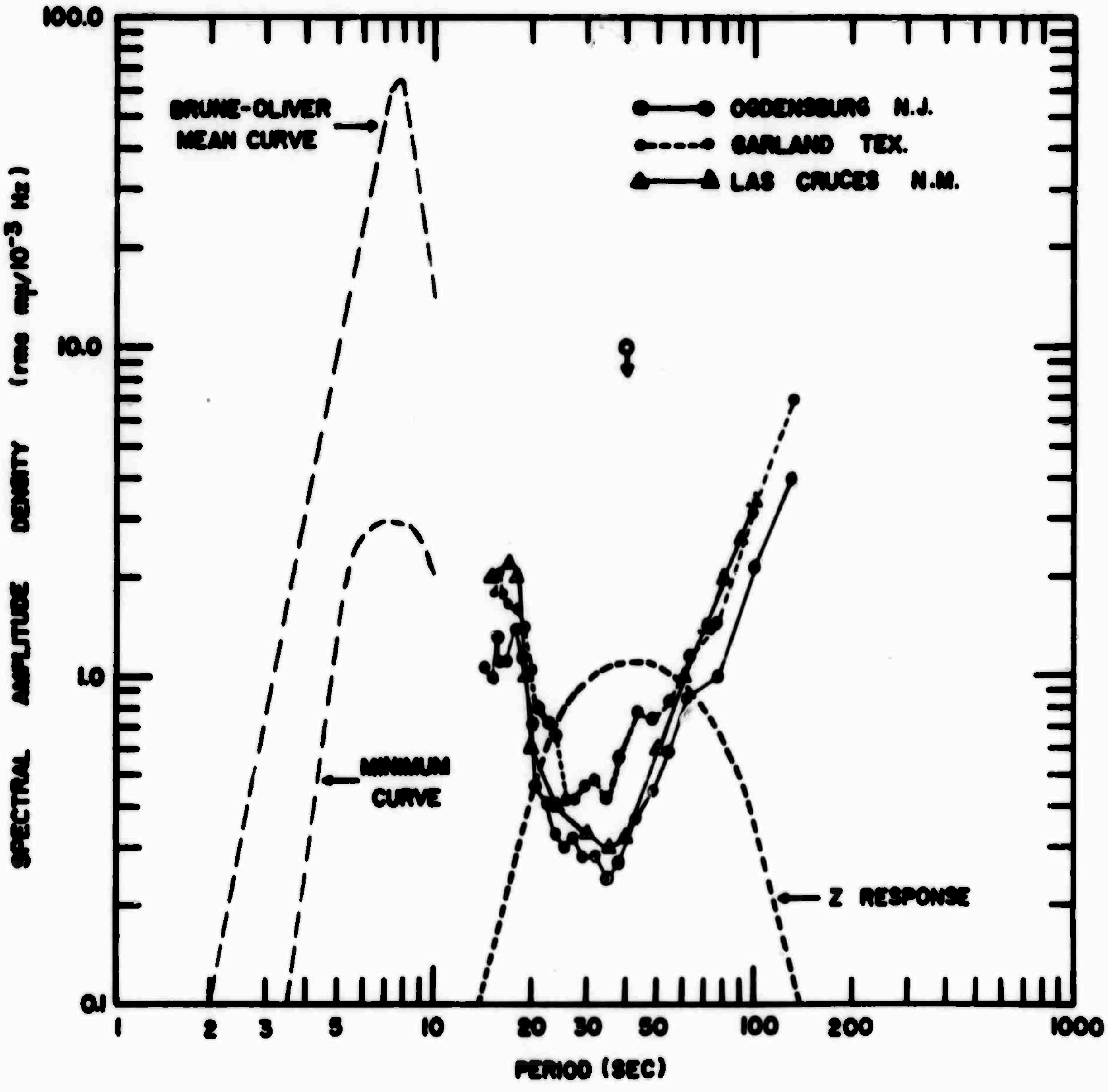


Data from a few sites in the U.S.A. (Figure 4) and from a high-gain station in Chad (Abeche), Africa, show the existence of a similar noise minimum. The short period (6 to 8 second) microseisms are electronically filtered by a Geotech Model 6824-15S filter which is part of the P.T.A. power supply.

Environmental sources of noise were minimized by encapsulating each seismometer in a pre-stressed steel tank with a hemispherical top. Each instrument tank is filled with argon. By means of this rigid environmental control, each seismometer is isolated from changes in temperature and atmospheric pressure. In addition, these tanks are placed in a vault sealed from external environmental variations by a series of ship-type bulkhead doors.

Data are recorded in both analog and digital format. The analog data are derived from the velocity transducers of the vertical, north-south and east-west components, and consist of six photographic records per day (15 mm per minute time base) comprising three component records each of high (P.T.A.) and low (standard) gain data. The digital tape data consists of three channels of high-gain velocity data digitized at a rate of one sample per second and three channels of displacement data digitized at a rate of one sample per five seconds. At this sampling rate, a tape lasts approximately two weeks. Up to nine

Figure 4: A comparison of the shape and level of spectrum of earth noise observed at Ogdensburg, New Jersey (Savino, 1970), Garland, Texas, and Las Cruces, New Mexico (Trott, 1965). The spectral amplitude densities were based on data for vertical seismometers. The data from Ogdensburg represent the lowest level in the earth noise spectrum of the high-gain, broad-band, long-period seismograph system installed at this site. The Brune-Oliver (1959) mean and minimum curves are shown for comparison. The displacement response of the high-gain vertical seismograph is shaped to correlate as closely as possible to the inverse of the earth noise spectrum.



additional channels of data can be easily written on the tape if desired.

Provision is made to calibrate the system, test seismometer boom and galvanometer mirror positions, and to center the booms and mirrors, all remotely from a control console external to the seismometer vault. Time signals for the photographic recorders are provided either from the Astrodata digital data acquisition system or from the WWSSN system clock when this high-gain system is installed adjacent to a WWSSN station.

II: DETAILED DESCRIPTION OF THE INSTRUMENTATION

The detailed description of the instrumentation will be subdivided into sections according to the major divisions of the station as shown in Figure 2. Where applicable, Lamont-Doherty Geological Observatory four-digit part numbers of the components are given (e.g. #1100) according to the listings in Appendix I of this report. Details of cabling for this seismograph system are given in Table II.

Prior to the pouring of the concrete piers and subsequent instrument installation in the seismometer-P.T.A. chamber and recording building, all excavation and building construction was completed. The installation included the emplacement of the ship-type bulkhead doors (#5100) and cable conduits (#5101) in the concrete bulkheads of the seismometer-P.T.A. chamber.

A: SEISMOMETER VAULT

The seismometer vault, generally with minimum dimensions of 15 feet by 7 feet by 7 feet, houses the three seismometers (#1200 and #1300) in their respective pressure tanks (#1100). The five seismometer vaults are constructed in three different settings: (a) Charters Towers, Australia - in an existing tunnel between two bulkhead doors, (b) Fairbanks, Alaska; Eilat, Israel; Toledo, Spain - at the end of a tunnel enclosed by one bulkhead door, and (c) Chiang Mai, Thailand - in a specially constructed reinforced poured concrete building, which proved to be airtight, enclosed by one bulkhead door.

At all sites the area that was to become the seismometer vault floor was carefully excavated to bedrock so that no large slabs of rock supported by sand or large-grain pebbles existed. The cement floor was poured after all loose rocks were removed and the rock surface thoroughly cleaned. A two parts sand - one part cement mixture, with no reinforcing or aggregate, was used. A good bond between the pier and the bedrock was ensured by careful plastering or brushing of the cement onto the clean rock surface. The seismometer enclosures were placed directly on the floor in order to avoid the possibility of thermal stresses acting on the sides of the commonly used seismometer pier.

TABLE II

CABLE DETAILS

Description		Cable Type
N-S Velocity Low Gain Signal	Seismo to Photorec	2CS
E-W Velocity Low Gain Signal	Seismo to Photorec	2CS
Z Velocity Low Gain Signal	Seismo to Photorec	2CS
N-S Velocity High Gain Signal	Seismo to P.T.A.	2CS
E-W Velocity High Gain Signal	Seismo to P.T.A.	2CS
Z Velocity High Gain Signal	Seismo to P.T.A.	2CS
N-S Primary Calibration	Seismo to Console	2CS
E-W Primary Calibration	Seismo to Console	2CS
Z Primary Calibration	Seismo to Console	2CS
N-S Secondary Calibration	Seismo to Console	2CS
E-W Secondary Calibration	Seismo to Console	2CS
Z Secondary Calibration	Seismo to Console	2CS
N-S Velocity High Gain Signal	P.T.A. to Photorec	2CST
E-W Velocity High Gain Signal	P.T.A. to Photorec	2CST
Z Velocity High Gain Signal	P.T.A. to Photorec	2CST
N-S Velocity High Gain Signal	P.T.A. to Digital	2CST
E-W Velocity High Gain Signal	P.T.A. to Digital	2CST
Z Velocity High Gain Signal	P.T.A. to Digital	2CST
N-S Displacement Signal/ Boom Center Motor	Seismo to Console	2CST
E-W Displacement Signal/ Boom Center Motor	Seismo to Console	2CST

TABLE II - Cont'd.

Description			Cable Type
Z	Displacement Signal/ Boom Center Motor	Seismo to Console	2CST
N-S	Displacement Signal	Console to Digital	2CST
E-W	Displacement Signal	Console to Digital	2CST
Z	Displacement Signal	Console to Digital	2CST
N-S	PTA Gal Centering Monitor	P.T.A. to Console	2CST
E-W	PTA Gal Centering Monitor	P.T.A. to Console	2CST
Z	PTA Gal Centering Monitor	P.T.A. to Console	2CST
N-S	PTA Gal Centering Motor	Console to P.T.A.	2CST
E-W	PTA Gal Centering Motor	Console to P.T.A.	2CST
Z	PTA Gal Centering Motor	Console to P.T.A.	2CST
N-S	Boom Centering Motor	Console to Seismo	2CST
E-W	Boom Centering Motor	Console to Seismo	2CST
Z	Boom Centering Motor	Console to Seismo	2CST
N-S	Displacement Transducer Power Supply	P.T.A. to Seismo	3CST
E-W	Displacement Transducer Power Supply	P.T.A. to Seismo	3CST
Z	Displacement Transducer Power Supply	P.T.A. to Seismo	3CST
3	Spare Cables	Seismo to Console	2CST
3	Spare Cables	Seismo to Console	2CS
3	Spare Cables	Seismo to P.T.A.	3CST

TABLE II - Cont'd.

Notes: (1) 2CS -- 2 Conductor Solid (#18 Wire)(#5150)

2CST -- 2 Conductor Stranded (#16 Wire) (#5160)

3CST -- 3 Conductor Stranded (#16 Wire) (#5170)

All Cables with Milar Shield and Separate Earth Conductor

(2) Abbreviations for End Positions of Cable Runs:

Seismo -- Seismometer Vault

P.T.A. -- P.T.A. Room

Photorec -- Recording Room (Photographic Recording)

Console -- Control Console in Control Room

Digital -- Astrodata Digital Acquisition System in Control Room

(3) All 110V Cables are #10-3 Wire Plastic Jacket Cable (#5180)

Each pressure tank (#1100) consists of a hemispherical top, a right-circular cylindrical bottom and mating flanges on the top and bottom that provide a metal to metal seal after compressing a 1/4 inch thick 60 durometer neoprene gasket that forms the interface seal. A lifting eye is welded on the top-center of each hemisphere. Signal cable entrances into the tank enclosures are seven one inch pipe couplings welded to the side of the cylindrical bottom. A nut assembly is welded to the inside center of the cylindrical bottom to be used with the prestresser (#8201). Six 1/4 inch thick steel gussets are spaced at 60° intervals around the bottom flange for additional support. To facilitate the removal of the tank top without seriously disturbing the instrument inside, a handwinch (#1111) is provided together with either an eye bolt (#7023) with roof bolt anchor (#7024) attached to the vault roof above the center of each tank or a metal tripod (#1115). An airtight seal between the tank top and bottom is made by clamping the flanges together with twelve equally spaced "C" clamps (#1109) and twelve steel clamping plates (#1110). A thin coating of vacuum grease (#1113) is placed on both sides of the neoprene gasket before clamping.

Before anchoring the tanks, each bottom was prestressed with the prestressing fixture (#8201) by distorting the base into a dome approximately 3/8 inch high at the center. Each tank area was cleaned and the bottom surface was roughened. Using a tank base template, drill guide (#8202) and guide pins (#8204), six 1 3/8 inch diameter holes were drilled through the pier to a depth of at least 4 inches into the bedrock whenever possible. Using the setting fixture (#8205), the steel hold-down studs (#1106) and roof-bolt anchors (#1105) were set in the holes. The tank bottom was placed on the pier on a domed bed of fine grained mortar (#7206) and anchored down. The prestresser was released a small amount until mortar, excess water and entrapped air were extruded from under the tank bottom on all sides. Thus no air voids were left between the tank base and the pier. The prestresser remained in place until the mortar had set (from six to twenty-four hours).

The Geotech long-period seismometers, two horizontal (#1300) and one vertical (#1200), were adjusted to a 30 second operating period. Each seismometer has two velocity transducer (signal) coils and two calibration coils wound to have resistances of 560 ohms each and 2 ohms each, respectively. The calibration coils are simply wound on the outside of the signal coils. The four ends of each coil assembly (#1202, #1307), that is, two signal coil ends and to calibration coil ends, are long enough (approximately 25 inches) to extend beyond the hinge point of the seismometer boom. These fine wires are insulated from the point where they leave the coil assembly back to the hinge and are mounted in synthane cable holders (#1208-1, #1208-2) attached to the seismometer boom. The excess wire at the hinge point is coiled to minimize any restoring force on the boom and the ends are mechanically clamped between copper blocks in the terminal blocks (#1207, #1305). One terminal block per coil assembly assures that a positive electrical and mechanical connection is formed between these wires and the solid wires going to the P.T.A., recording galvanometers and the control console. Since there is only one mechanical connection between each coil and the P.T.A. (high-gain) or recording galvanometer (low-gain), nearly all thermal noise-generating solder joints are eliminated.

Since the adjustment of the boom position with pendulum periods of 30 seconds is extremely delicate, the seismometer leveling mechanism must be very sensitive. Remote boom position sensing and boom position adjustment are necessary because the seismometers are sealed in the tanks and in the vaults. For these reasons, several additions and modifications were made to the seismometers. The use of low RPM, low voltage DC motors in place of high torque AC motors allowed for greater control. In addition, the low DC voltage is necessary since humidity conditions may cause extreme "cross-talk" that results with the use of 110V AC power. The vertical seismometer incorporates a Geotech Model 1007S remote centering assembly (#1201) with its standard 500 RPM 110V AC motor replaced by a 10 RPM 12V DC motor (#1203). This modification was most satisfactory since the extra mass of the DC motor to the rear of the hinge point helped compensate for the added mass of the center capacitor plate of the displacement transducer (#1204) in front of the hinge point.

The remote leveling devices provided by the manufacturer for the horizontal seismometers proved inadequate for the unique leveling needs demanded by the high-gain system. The W.F. Sprengnether Co. designed and built a leg assembly for the horizontal seismometers (#1302) that uses a motor driven wedge to microscopically adjust the seismometer level. The unit, attached to the underside of the seismometer base with no drilling or base modifications necessary, is bolted to the base using the existing leveling leg holes and two (1/2 - 32) brass bolts. One of the legs, which the unit replaces, is again used with the unit for initial leveling. The Sprengnether unit can be leveled (1) manually, by screwing the manual adjust leg in and out of the unit and (2) electromechanically, by gently wedging the remaining leg toward or away from the pier. The backlash in the system is minimal and the contact areas of the wedge in compression are constant. Micron positioning of the pendulum (boom) is easily and quickly done even at extended pendulum periods of 60 to 90 seconds. This leveling unit is rather massive and attaching it to the seismometer base tilts the seismometer relative to the pier. The third leg of the seismometer, that is used for period adjustment is lengthened by a brass bushing (#1301) to equal the amount the seismometer was raised as a result of attaching the leveling unit.

To remotely monitor the boom position, Sprengnether Models VC202V and VC202H, variable-capacitance, displacement transducers (#1204, #1303 respectively) were mounted to the seismometers. Fixtures to mount the transducer hardware without disassembling or drilling the instruments were provided by the manufacturer . On the vertical seismometer, the displacement transducer mounting plate (#1205) was modified to serve as a cable guide and cable clamp (#1205-1, #1205-2). The total range of the seismometer boom motion (20 mm) was reduced to about 6 mm to improve the signal-to-noise ratio, linearity and sensitivity of the displacement transducer. Sprengnether Model VC201BA oscillator-discriminator units (#1206) with a power consumption of 0.5 watts per unit, are used to detect the three displacement signals. One such unit is placed inside each pressure tank adjacent to the seismometer and is connected to the capacitor plates by short coaxial cables. These cables must be clamped to prevent mechanical motion that may induce apparent signals. The displacement transducers thus play the dual role of monitoring the seismometer boom position and detecting earth motions over the very broad period range from about 10 seconds (limited by the sampling rate of the digital recorder) to DC.

The moment arms, centers of gravity and centers of oscillation were accurately determined for one vertical seismometer and one horizontal seismometer by the manufacturer. These values were used for the other seismometers. Extreme care was taken in placing the seismometers in the tanks with their respective axes aligned as close as possible to the north-south or east-west direction, which had been surveyed to an accuracy of $\pm 0.5^{\circ}$ by sun or star sightings and transferred to the pier floor and pressure tank flanges. The axis of the vertical seismometer was orientated either north-south or east-west. Following the emplacement of the seismometers, all electrical connections and cabling were completed and checked and then coded and logged. Each pair of signal and calibration cables from the same coil assembly were potted in Scotchcast (#7002) using the small potting mold (#8208) and sealed with a one inch compression fitting (#1112) into a pipe coupling in the tank bottom. The boom centering motor power enters the pressure tank through a watertight bulkhead assembly (#1103) with a pipe adapter (#1101). A similar bulkhead connector is also used for the cables carrying power to, and signal from, the oscillator-discriminator unit. A pressure valve (#1102) is sealed in another pipe coupling to facilitate venting of the tank. Pipe plugs (#1104) sealed the two remaining pipe couplings in each tank. A schematic diagram indicating the positions of all the above cables in each pressure tank is shown in Figure 5. All connectors in the pipe couplings were completely sealed with Glyptal sealant (#7009). Outside the tanks, the cables were rigidly attached to either the seismometer pier or a cable trellis on the seismometer vault wall. All cables were then potted and passed through cable conduits in the bulkhead between the seismometer vault and the P.T.A. room (as described in Section II B).

Before encapsulating the instruments inside their respective tanks, argon gas was bubbled into the sealed seismometer cover through a brass vent pipe (#1209) to purge damp air and replace the air with a medium that would not support thermal convection. A balloon (#1210) was placed over the brass vent pipe to hold the gas inside the seismometer while allowing the seismometer enclosure to breathe. Several packets of dessicant (#6001) were placed inside each seismometer as well as inside each pressure tank. The calibration procedures

A - High-Gain Signal

B - Primary Calibration

C - Secondary Calibration

D - Low-Gain Signal

CODING OF CONNECTORS

Marsh Marine A (MMA)

		#1103-1	#1103-2	
Boom	(+12V	Lead 1	Lead	White
Center	(-12V	2		Green
Not	(	3		Blue
Used	(	4		Yellow
	(	5		Brown
	(	6		Orange

Marsh Marine B (MMB)

		#1103-1	#1103-2	
D.T.	(+12V	Lead 1	Lead	White
Power	(-12V	2		Green
Supply	(Com	3		Blue
D.T.	(Shield	4		Yellow
Signal	(Signal	5		Brown
	(Ground	6		Orange

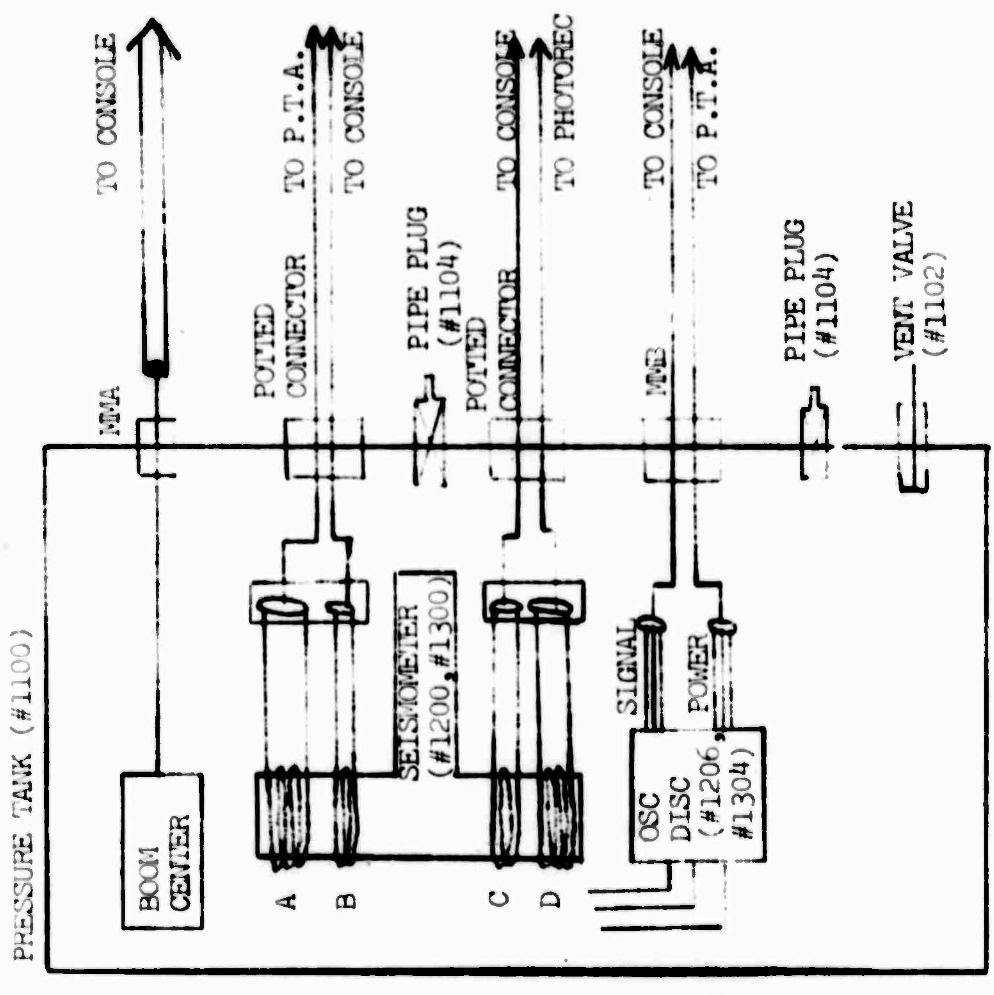


Figure 5: Schematic diagram indicating the positions of signal and calibration cables through the pipe couplings of the seismometer pressure tank.

and determination of instrument parameters are discussed in Section III.

B: PHOTOTUBE AMPLIFIER (P.T.A.) ROOM

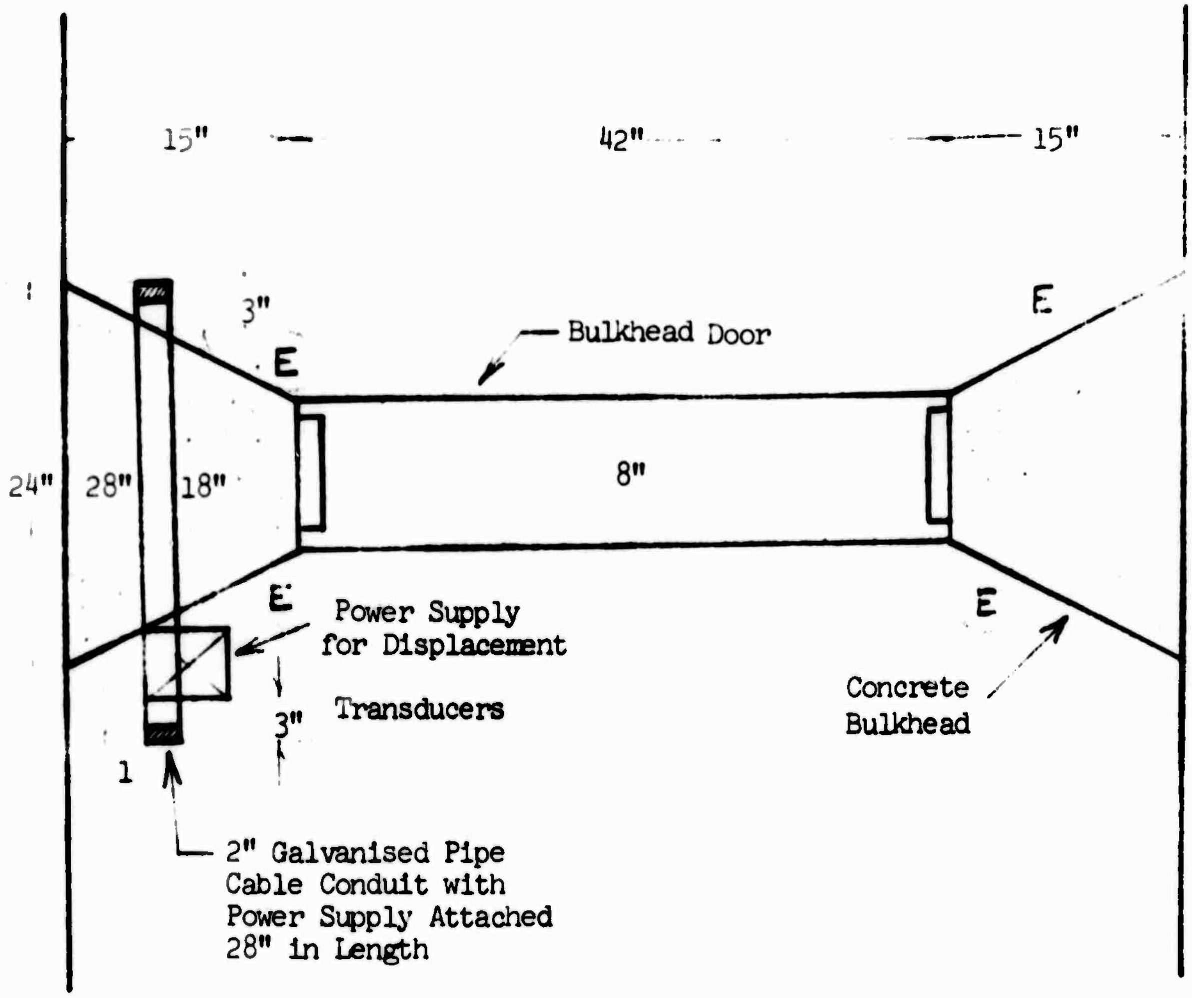
The P.T.A. room, generally with minimum dimensions of 6 feet by 7 feet by 7 feet, houses the phototube amplifiers (#2100), their power supplies (#2200) and the displacement transducers power supply (#2300). This room is sealed from both the seismometer vault and the outside environment by ship-type bulkhead doors (#5100). All cables enter and leave this room through the potted cable conduits (#5101, #8206). Each phototube amplifier consists of a Kinemetrics Model LG-1 100 second galvanometer (#2103), beam splitter, light source and phototube deck. The galvanometer is electromechanically adjusted to center the light on the beam splitter using a DC motor-driven adjustable galvanometer base (#2101, #2102, #2104). This adjustment and subsequent monitoring of the motion are carried out remotely from the control console (#3200). The P.T.A.'s are placed on a concrete pier generally less than four inches high. The three solid state Geotech Model 14486 power supplies are placed on a separate bench and each contains two fixed Geotech Model 6824-15S plug-in active filters (#2201), one for the high-gain signal to the photographic recorders and the other for the high-gain signal to the digital recorder. The response of this band pass filter, with a low cut at 200 seconds, a high cut at 30 seconds, and a 40db notch at 6 seconds, is shown in Appendix 2 (#2201). A quad box (#2400 - #2403) distributes the 110V AC power in this room to the P.T.A.'s and displacement transducer power supplies.

All exposed surfaces of the concrete bulkheads are sealed with epoxy paint (#7005) (Figure 6). The 2 inch galvanized pipe cable conduits (#5101) are cemented into the bulkheads. All signal, calibration and centering motor cables are potted using the large potting mold (#5105). A complete airtight seal is made by firmly clamping the molded cables and brass coupling (#8206) inside a length of rubber hose (#5106). The 110V AC power cable enters the P.T.A. room through a 2 inch pipe cap with a 3/4 inch compression fitting attached (#5103). The open ends of the cable conduits are protected with 2 inch pipe protectors (#5104) to prevent chafing of the cables. All unused cable conduits are sealed with 2 inch pipe caps (#5102, #7008).

C: PHOTOGRAPHIC RECORDING ROOM

The photographic recording room houses long and short period galvanometers (#4201, #4302) and two Sprengnether Model HR-6007 three-drum photographic recorders (#4100) for the analog recording of the high-

Figure 6: Schematic diagram indicating the position of cable conduits in the concrete bulkheads.



NOTES:

1. Five Cable Conduits in Same Vertical Plane with 6" Centers
2. 1 28 Inch Cable Conduit and 4 24 Inch Cable Conduits in Bulkhead Between Seismometer Vault and P.T.A. Room
3. 5 24 Inch Cable Conduits Between P.T.A. Room and Tunnel

E Exposed Concrete Surfaces Coated with Epoxy gain and standard (low-gain) velocity outputs. Concrete galvanometer piers ranging in height from 24 inches to 42 inches were constructed. All cables enter the room through 2 inch galvanized pipe conduits (#5101) which are sealed to be light-tight (#7003).

The three high-gain recording galvanometers, Geotech Model G-10 0.3 second galvanometers (#4302), are rigidly mounted on individual brass assemblies (#4300) each with its own leveling legs. The three assemblies are placed on a single aluminium plate with leveling legs (#4304). A resistive network (L-pad attenuator, Figure 3 a) for each galvanometer is mounted on a terminal strip (#3275) attached to the brass assembly. Signal cables terminate in the terminal strip, and short pigtails connect the attenuator network to the galvanometer input terminals.

Each standard recording galvanometer, a Kinemetrics Model LG-1 100 second galvanometer (#4201), is encapsulated in an airtight cylindrical brass enclosure (#4200) to eliminate the effects of humidity, pressure variations and air currents on the galvanometer. The standard precision leveling screws were removed and the body of the galvanometer rigidly attached to the enclosure base plate (#4200). New leveling legs (#4200) are attached to the base plate. An air and moisture tight seal between the cylindrical cover and the base plate is made with a neoprene rubber O-ring. The signal cables, which are potted in Scotchcast (#7027), enter the galvanometer through a right-angle pipe coupling with a compression fitting (#4200) attached to the underside of the base plate to preserve the air and moisture tight seal. The resistive network (L-pad attenuator, Figure 3 (b), #4203) for suitable damping and signal voltage levels is attached directly to the galvanometer at the lower binding post and the other resistor is spot-welded to a piece of copper wire that is attached to the upper binding post. The filter galvanometers, Kinemetrics Model LG-1 MOD (Tg = 7 seconds) (#4350) are tightly coupled to their respective seismometers (Figure 3 b) and are placed adjacent to each standard (long period) recording galvanometer.

Each three-drum recorder is placed on an adjustable metal bench (#4103) such that the cylindrical lens of the recorder is at a distance of approximately one meter from the galvanometer mirror. The recorder is level in two planes. Adjustment of the metal bench allows the recorder lens to be brought to the proper horizontal level compatible to the galvanometer mirror and light source. With the galvanometer level and unclamped, the light spot is adjusted by the galvanometer zero adjustment until the reflected light is centered horizontally on the recorder aperture. The recorder light source is

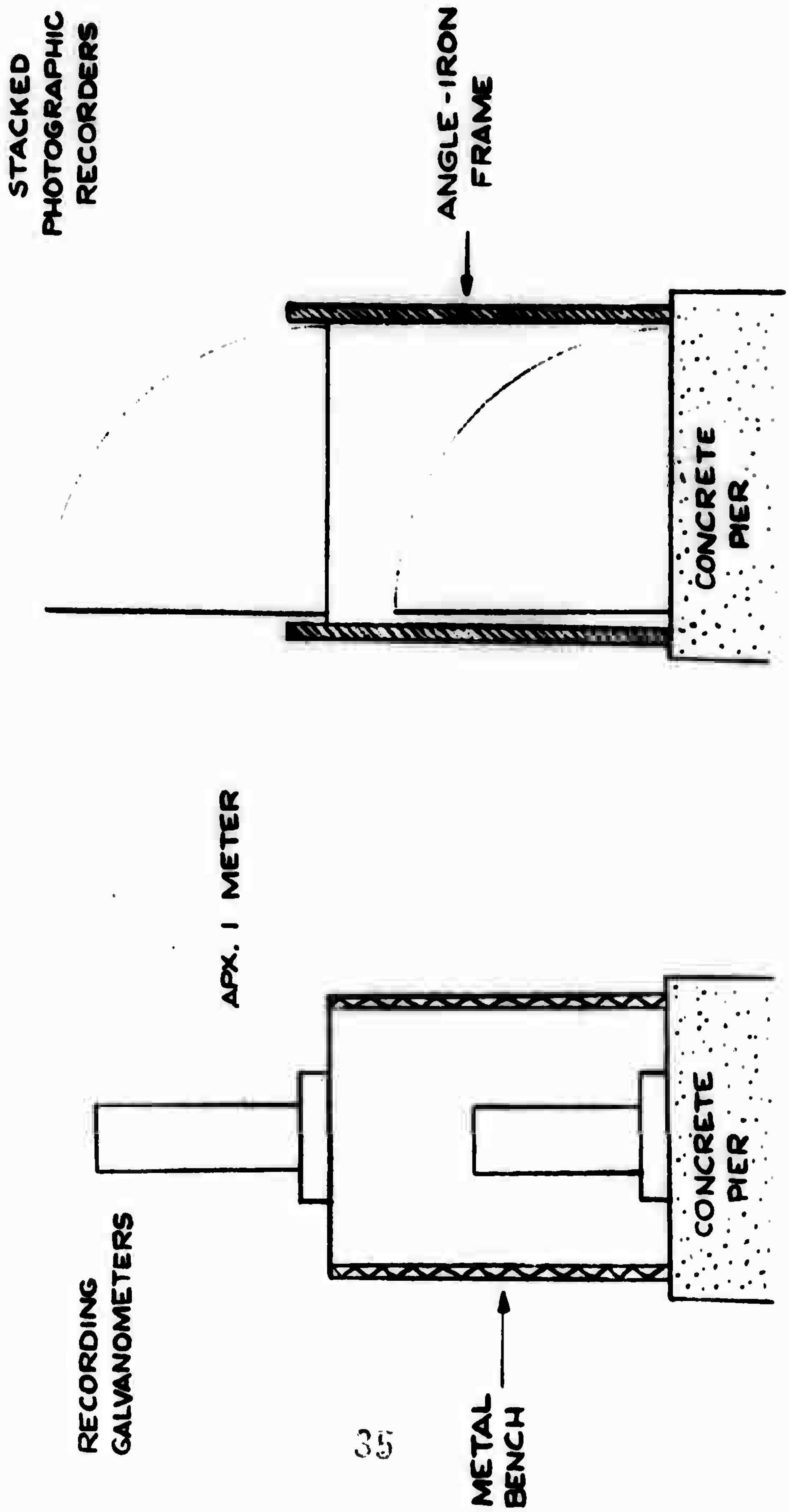


Figure 7: Schematic diagram showing stacked recording galvanometers and photographic recorders.

then adjusted vertically until the image is centered on the aperture of the recorder. A good spot on the photographic paper is obtained by setting the adjustable focus galvanometer lenses, the light intensity (lamp current) and the cylindrical lens focusing adjustment. Time mark amplitudes are set with the recorder time mark deflector control.

At several sites it is necessary to stack the recording galvanometers and photographic recorders because space is limited. A metal bench is placed on a concrete galvanometer pier and the galvanometers are located on both the pier and the metal bench. The two photographic recorders are attached to each other by angle-iron brackets (#4101) and the combination placed on a concrete pier. This mounting procedure is shown in Figure 7. Adjustments of the galvanometers and recorders are carried out in the same manner as described above.

The developing and processing of the photographic records is performed at each site. Processing trays (#4111), photographic paper (#6004), chemicals (#6002, #6003) and a record canister (#4105) are provided for each installation. All developing and processing is carried out in a room outside the photographic recording room. At those sites where the L.D.G.O. system has been installed next to a WWSSN station, the WWSSN dark room facilities are used.

Where high humidities are common, a Westinghouse Model ENJ2S dehumidifier (#4400) is installed in the photographic recorder room.

D: CONTROL ROOM

The control room houses the power distribution panel for the system (#3424), the control console (#3200-3215), the Astrodata digital data acquisition system (#3100) and metal cabinets for parts (#3500, #3501). Input to the distribution panel is either 110V 60 Hz or 240V 50Hz (local power). Power then passes through a 20 amp circuit breaker (#3420, #3421), a Topaz Model 051T25ST transformer (#3410-1, #3410-2) and two line filters (#3411) at which point 110 volts is fed to the rear panel connectors on the control console (#3207, #3278, #3279). The transformer, circuit breaker, line filters and a three-pin 30 amp receptacle (#3422) and socket (#3423) are mounted on a sheet of marine plywood (#3424) anchored to one wall of the control room.

The control console contains equipment for power regulation, calibration and remote centering of the seismic system. A voltage regulator (#3270) and the system groung point (#3281) are located in the bottom of the console. A Simpson Model 1349 segmental voltmeter (#3272) for monitoring the system line voltage (nominally 110V) and the system fuses (#3273, #3274) are mounted on a 5 inch panel (#3213). A drawer (#3204) is provided for instruction manuals. The Wavetek Model 112B oscillator (#3240) and Hewlett-Packard Model 419A null voltmeter (#3250) are provided for use during calibration and maintenance. These two instruments are normally located on an enclosed shelf (#3211) behind a swinging door (#3206).

The calibration panel (#3230) contains a digital current meter and circuitry to provide positive or negative calibration pulses or steps from a stable DC source (mercury battery). The Wavetek oscillator can also be connected to this panel by using the external input jacks. The calibration output signal can be attached to a calibration coil on each seismometer or to the coils of two or three seismometers by means of a patch panel.

The boom position monitor and control panel (#3220) contains a meter, switches and a power supply for remotely detecting the position of the seismometer booms and P.T.A. galvanometer mirrors and for leveling the seismometers or rotating the P.T.A. galvanometer base. A choice of 115V or 220V power input is given and an output is provided to power the calibration panel.

Time signals for the records are taken from the digital data acquisition system. An auxiliary slave time relay (#3102) is installed in the digital unit for this purpose. A radio receiver (#3218) and antenna (#3219) are installed in the control room and outside the tunnel, respectively, to determine time corrections. For those installations at a WWSSN station however, time signals for the photographic records and radio signals for the time corrections are taken from the WWSSN time console. To minimize any effects of tampering with the timing system of the WWSSN console, a 24 volt relay with a 500 ohm coil is placed in parallel with the time mark deflectors of the U.S.C.G.S. system (Figures 8 and 9). The 24 volt 2 second duration pulses that give time mark deflections to the U.S.C.G.S. recorders also actuate the relay. The relay contact closures, in turn, switch the time mark deflectors of the Sprengnether recorders (#4100). The WWSSN radio signal is wired directly to a speaker panel (#3215) in the control console.

The Digital Data Acquisition System has 15 channels (nine A-type and six B-type channels) available for analog data input. Only six channels (three A-type and three B-type) are used in normal operation. The A-type channels contain velocity data and the B-type channels contain displacement data. Each channel input has a low-frequency filter; type A channels a bandpass filter and type B channels a low-pass filter (Appendix 2, #3100). A solid state multiplexer sequentially selects the type A and type B filter outputs and transfers them to an analog-to-digital converter. The 14-bit-plus sign digitized output is integrated and then formatted for output to a Cipher Data Products Model 100 tape recorder. The magnetic tape format consists of a sequence of 18-bit words recorded at 556 BPI on 7-track IBM-compatable 1/2 inch computer tape. Each record consists of four words of header time data, 1998 words of seismic data and a record gap. The seismic data is composed of the outputs of the three velocity channels (high gain outputs from the P.T.A.'s) digitized at a rate of one sample per second, and the outputs of the three displacement transducers, digitized at rates of one sample per five seconds. Included in the unit is a crystal-controlled digital clock and remote time display panel. The general theory of operation and tape format of the digital system are described in Appendix 2 (#3100). A Weston digital multimeter (#3103) is included for testing and calibrating the digital system.

A Westinghouse Model ENJ2S dehumidifier (#3600) is usually installed in the control room. Station line voltage (either 110V or 240V) or system voltage (110V) can be monitored by the Rustrak recorder (#3413).

An Exide Uninterruptable Power Supply consisting

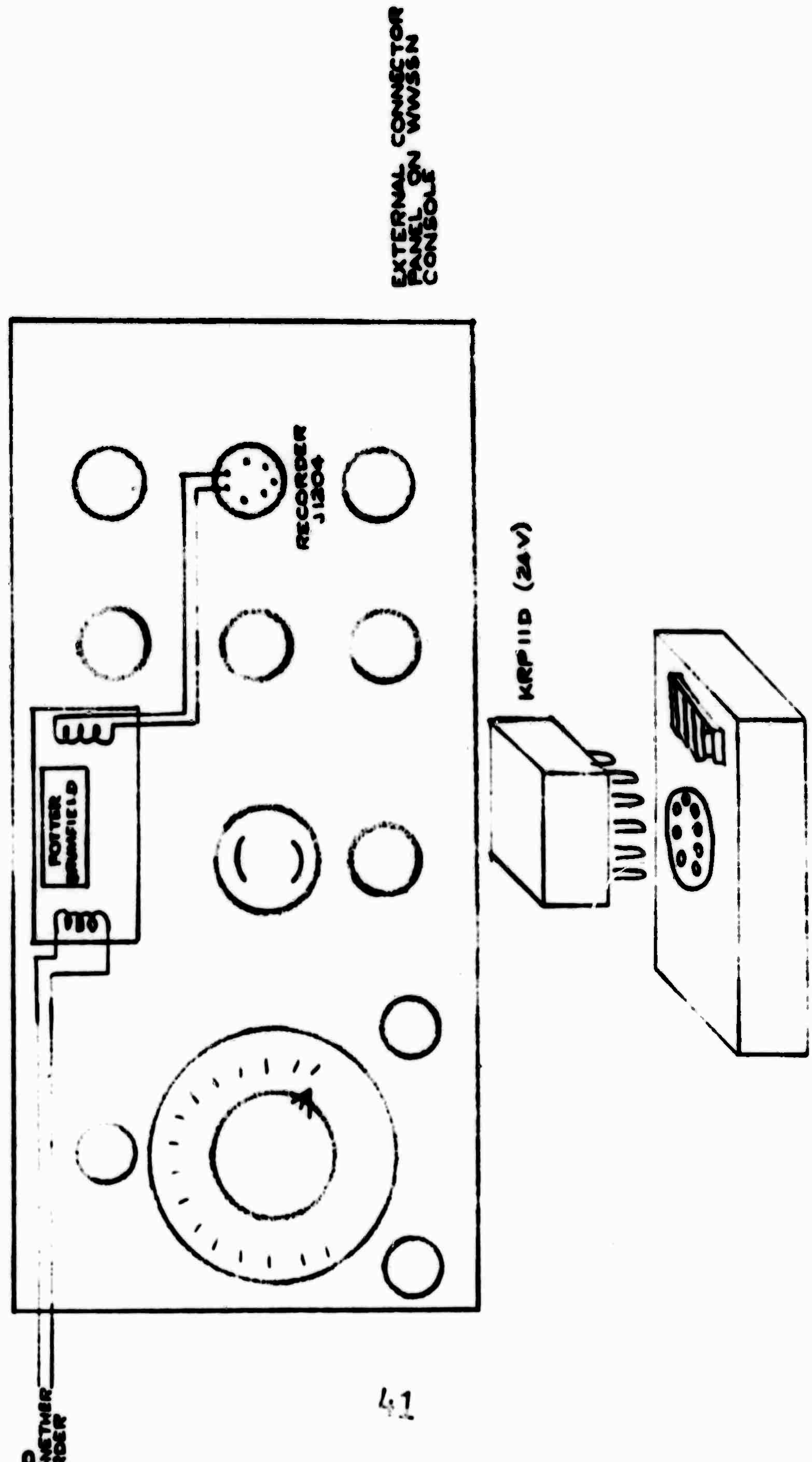


Figure 8: Time relay for high-gain system added to WWSSN console.

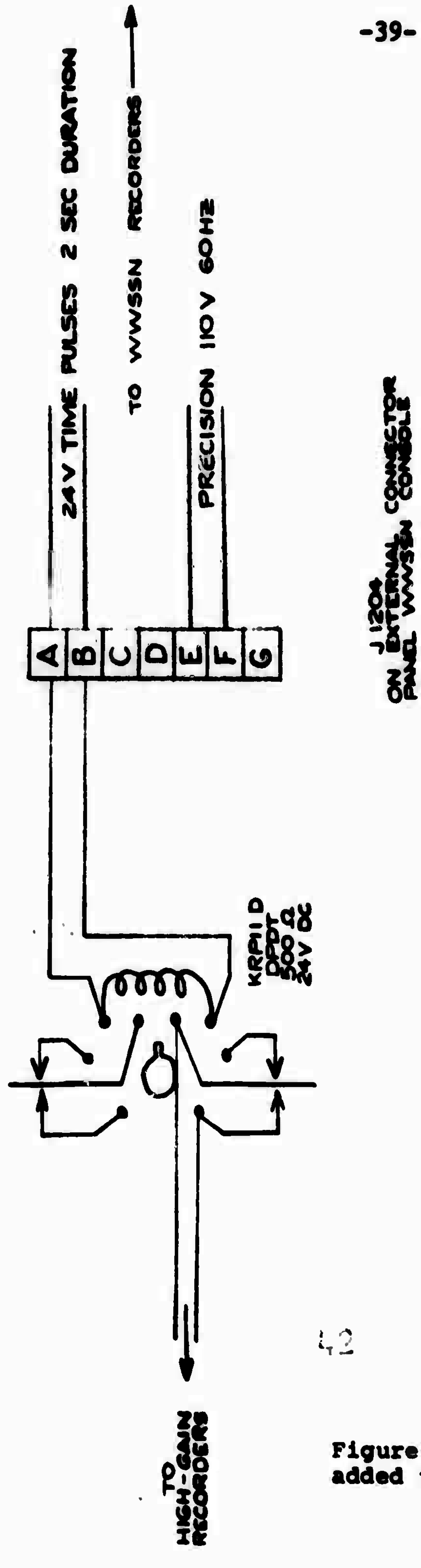


Figure 9: Wiring diagram for time relay added to WWSSN console.

of battery charger (#3800), batteries (#3802 and #3803) and static inverter (#3801), is being installed at each station sometime during the first year of operation.

III: CALIBRATION AND TEST PROCEDURES

The following determinations are usually carried out during installation:

(a) Measurement of flux densities of seismometer magnets

(b) Measurement of the resistances of the seismometer signal and calibration coils

(c) Measurement of the resistances of the standard (low gain) velocity output signal cable, primary calibration cable and secondary calibration cable

(d) Free periods of the seismometers

(e) Seismometer free period versus boom position (linearity check)

(f) Critical damping resistance (CDRX) of each seismometer signal coil

(g) Electromechanical constants (G values) of each seismometer signal and calibration coil

(h) Free periods of the P.T.A., high gain recording, standard recording and filter galvanometers

(i) CDRX of the P.T.A. and standard recording galvanometers

(j) Current sensitivities of all galvanometers

(k) Calibration and polarity check of each output

(l) Noise checks of individual components and complete system

(m) Frequency response of each velocity output

(n) Phase response of each velocity output

(o) Absolute calibration of displacement transducer (linearity and sensitivity).

Values for specific instruments are given in the station installation reports.

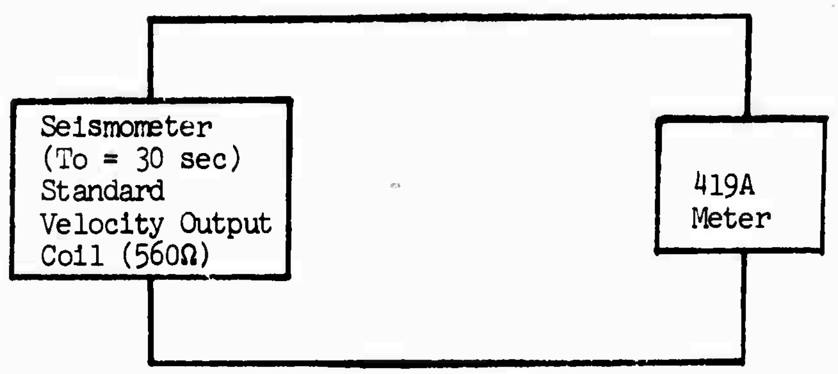
The flux densities of all magnets (after regaussing) are measured with a General Electric Model 416X33 gaussmeter (#8001) placed in a plexiglass holder (#8002). A probe positioning guide locates the gaussmeter in exactly the same part of the flux field each reading thereby eliminating variations in the readings due to different observers techniques. The vertical seismometer frame was found to be slightly magnetic and measurements are therefore taken before and after attaching the magnets to the frame.

All coil and cable resistances are measured with an RCA Voltohmyst meter (#3414). The values are tabulated according to particular instruments in the station reports.

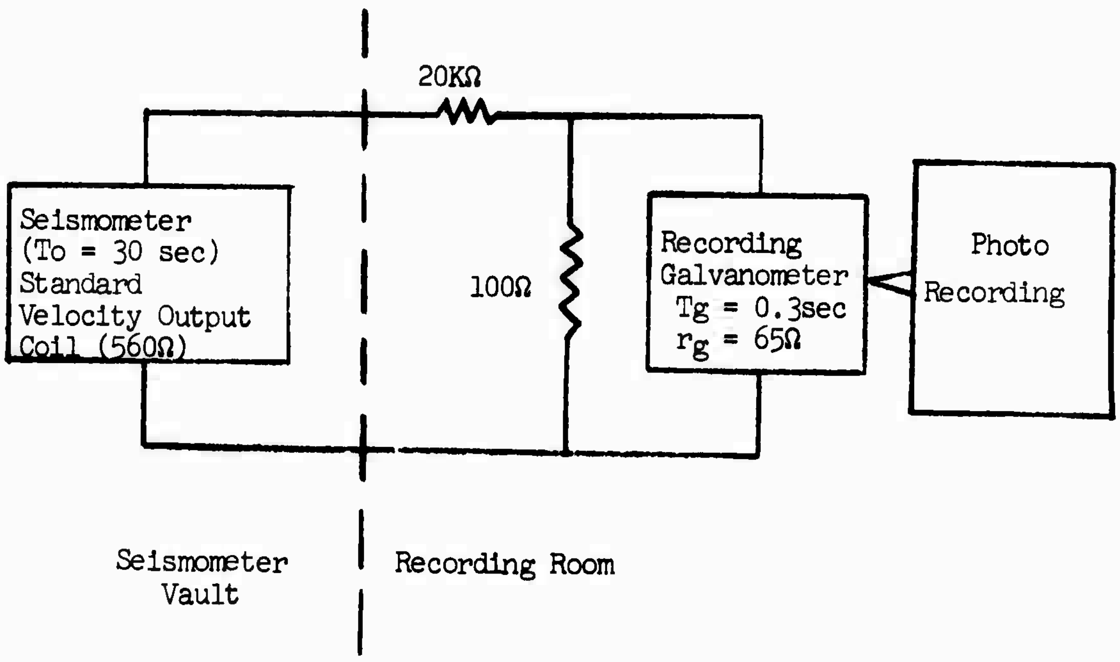
The seismometer free periods are measured after each instrument has been leveled and adjusted for a near-zero boom position. While adjusting the seismometer to the predetermined value, a Hewlett-Packard Model 419A Null Voltmeter (#3250) is corrected across the standard velocity output coil to monitor the boom oscillations, and the period determined with a stop watch (#8007) (Figure 10 a). When the free period is as close to 30 seconds as can be determined by the above method, a record of the exact value is then obtained by photographically recording decaying oscillations. For this, the seismometer is loosely coupled to a short period (Tg = 0.3 seconds) recording galvanometer (#4302) with an appropriate L-pad resistive network (Figure 10 b) and then pulsed.

The period versus boom position test is performed on each seismometer with the displacement transducer capacitance plates removed, so that the full 20 mm movement of the boom can be utilized. No test point should vary by more than ±10% from the average. With the horizontal seismometer, a substantial period adjustment must be made in order to adjust the boom position. This effect results from the position of the new adjustment legs (#1302) relative to the long axis of the boom.

The CDRX of each signal coil is determined using the circuit of Figure 11. The pulsing circuit is extended into the recording room to facilitate observation. A pulse is remotely applied to one calibration



(a) Circuit for Seismometer Free Period Adjustment



(b) Circuit for Recording Seismometer Free Period

Figure 10: Circuits for the determination of the free period of a seismometer.

coil (using the calibration panel on the control console) and the resulting deflections are observed on the null voltmeter and recorded photographically. The decade resistance box (#8006) is adjusted to give zero overshot. Following the same procedure, the resistance necessary for a damping factor of approximately 0.7 (5% overshoot) is determined and the seismometer is then left to operate in this underdamped condition.

The electromechanical constants, G values, for all signal and calibration coils are determined using the circuit in Figure 12. This method follows a variation of the standard "weight-lift" calibration procedure. The seismometer is initially centered to give a zero output using the displacement transducer as monitor. A 200 mgm calibration mass is attached to the seismometer mass thereby applying a constant force that results in a deflection from zero. For the horizontal seismometers, this mass forms part of the catenary suspension (#1212), whereas for the vertical seismometers, the calibration mass is placed directly on the seismometer mass at the center of oscillation. Current, adjusted by the decade resistance box, is passed through one calibration coil, returning the seismometer boom to its original zero and equalizing the applied force. The value of G, which is simply force per unit current, is calculated as follows:

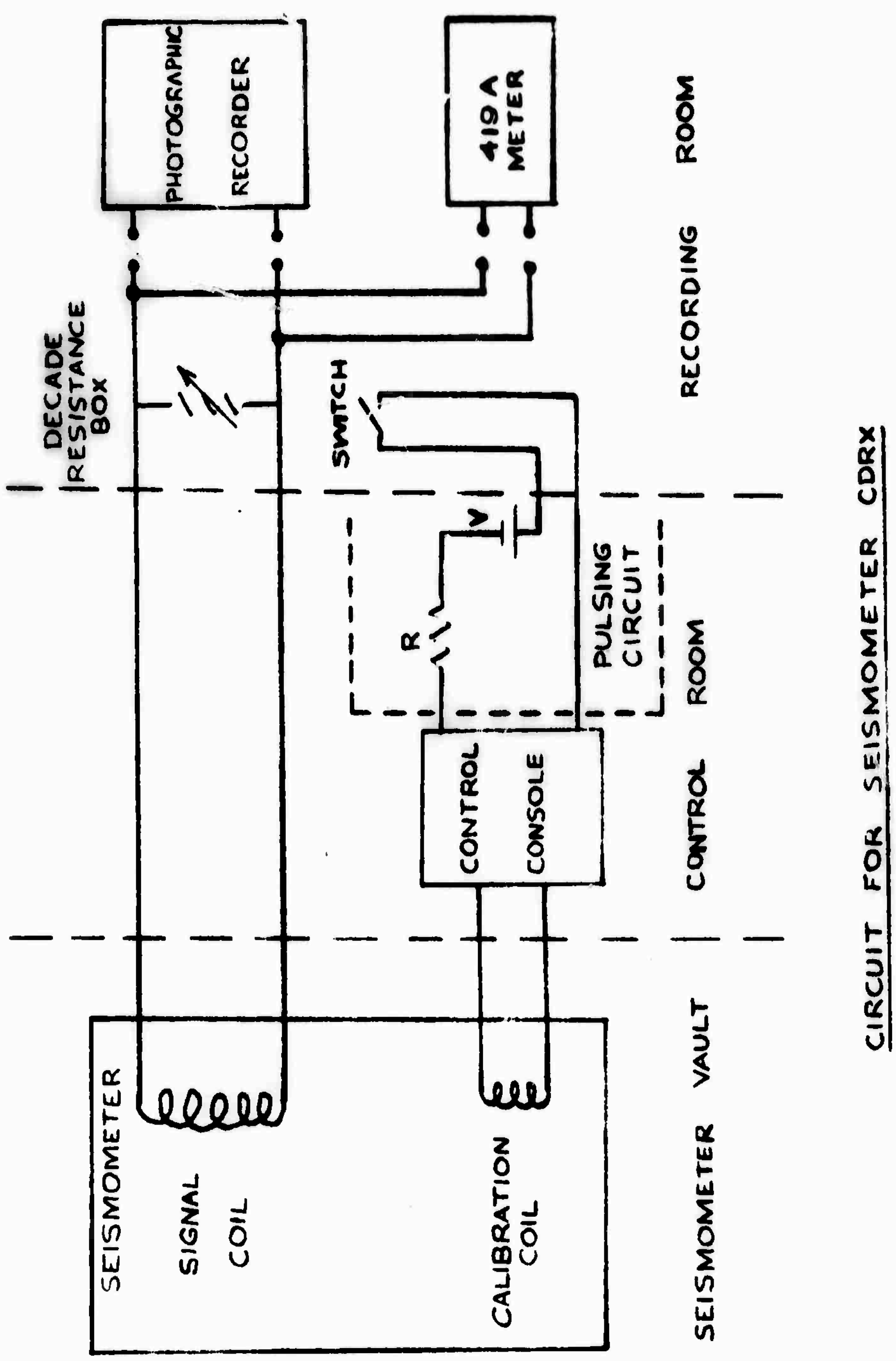


Figure 11: Circuit for the determination of the critical damping resistance (CDRX) of a seismometer.

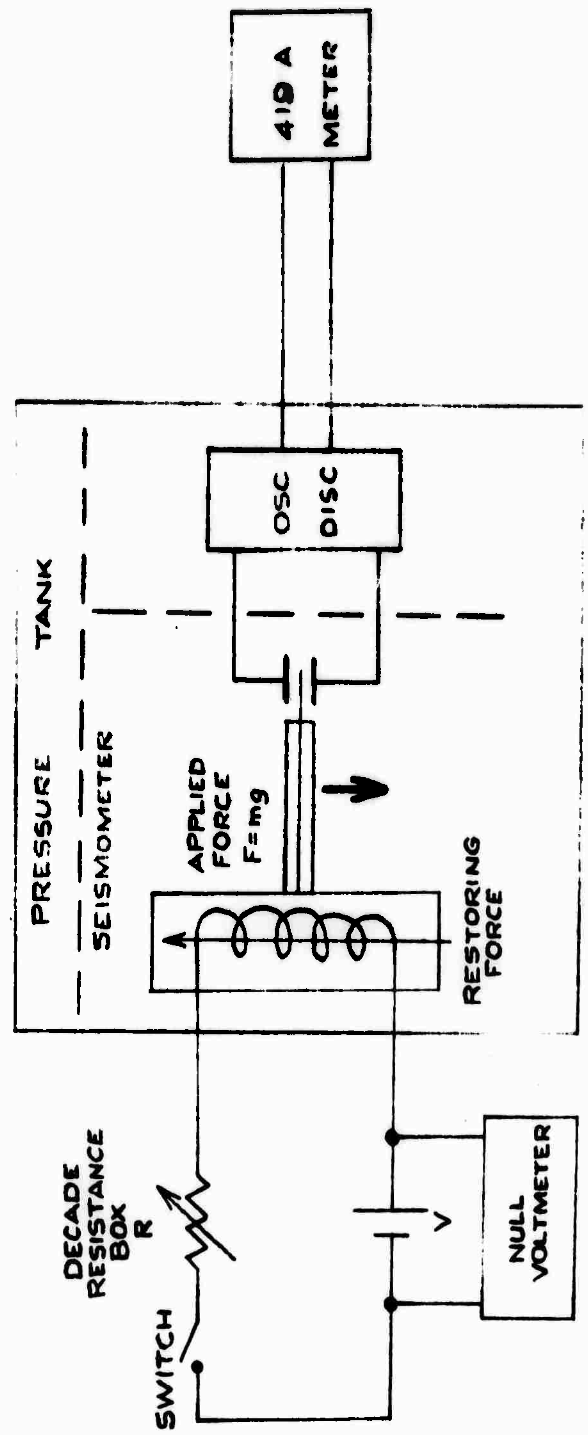


Figure 12: Circuit for the determination of electromechanical constants (G values) for seismometer signal and calibration coils.

$$G = \frac{\text{applied force in newtons}}{\text{restoring current in amperes}}$$

$$= \frac{mg}{i} \text{ newtons amp}^{-1}$$

where: m = effective mass of applied weight (kgm) (100 mgm for horizontal; 200 mgm for vertical)

i = Current through calibration coil (amp)

g = acceleration due to gravity

$= 9.8 \text{ m sec}^{-2}$

For the circuit elements used (Figure 9) this reduces to

$$G = \frac{mgR}{V} \text{ newtons amp}^{-1}$$

where: $R = (R^1 + r)$ ohms

R^1 = resistance as measured on decade resistance box (ohms)

r = resistance of particular seismometer signal or calibration coil (ohms)

V = DC voltage as measured on null voltmeter

This calibration procedure is performed with each seismometer set to a free period of approximately 15 seconds.

The free periods, critical damping resistance and damping coefficients of all galvanometers are determined in a similar manner to those for the seismo meters. The circuits are shown in Figure 13. On the long-period galvanometers, the damping factor of 0.7 (CDRX = 3000 ohms) is set by adjusting the magnetic shunt lock screw. The current sensitivity (amperes per mm deflection at 1 meter) of each long-period (Tg = 100 seconds) and short-period (Tg = 0.3 seconds) galvanometer is calculated from a photographic record of the application of a constant current (step function). This step function is applied directly to the respective galvanometer with the long period and short period resistive networks (#4202, #4303, respectively).

Using the complete system, a calibration pulse is applied to each coil to determine relative magnifications and polarities. A schematic diagram indicating correct polarity on the photographic records is shown in Figure 14.

The noise levels of several parts of the system are determined from photographic recordings. The following tests are performed:

(a) Input to high gain recording galvanometer (Tg = 0.3 sec) shorted

(b) Dummy galvanometer in place of the 100 second P.T.A. galvanometer. The P.T.A. is connected to the 0.3 seconds recording galvanometer. This test enables the determination of the best noise level of the P.T.A. electronics and power supply (including the 15-S filter) since the seismometer and P.T.A. 100 second galvano-

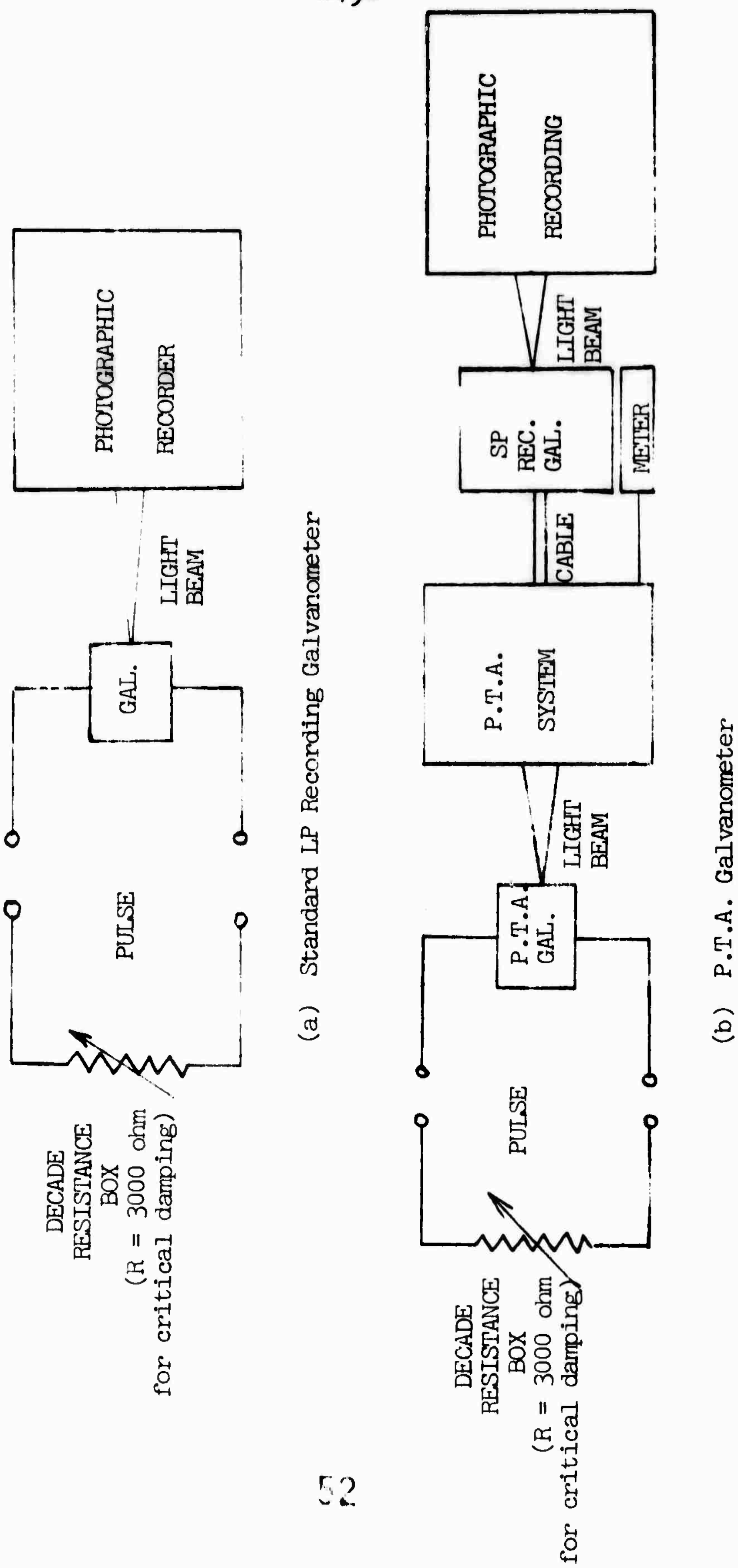


Figure 13: Circuits for the determinations of free period, critical damping resistance (CDRX) and damping coefficient for the long-period (Tg = 100 sec) galvanometer.

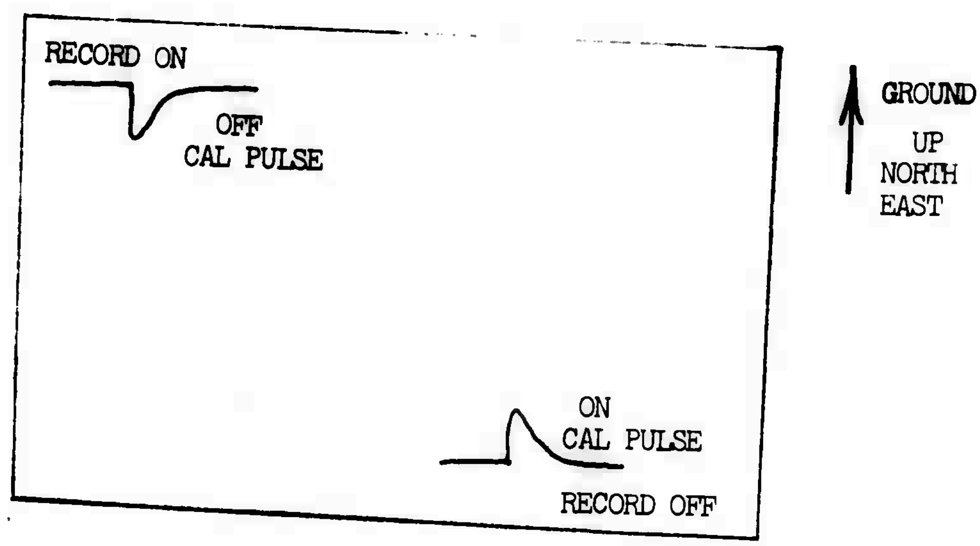


Figure 14: Schematic diagram indicating calibration pulse polarities and ground motion directions on a photographic record.

meter are replaced by a stable light beam incident on the beam splitter.

(c) Open circuit input to P.T.A. galvanometer. This would show worst possible noise level of the electronic plus galvanometer part of the high-gain system

(d) Open circuit input to standard recording galvanometer (Tg = 100 seconds). This enables the worst noise level of the 100 second galvanometer to be determined.

Frequency responses can be determined for the complete seismograph system. A steady-state calibration method consisting of driving the seismometer with a known steady-state sinusoidal motion and recording the outputs from the P.T.A. and standard galvanometer systems on photographic paper is used (Miller, 1963). The primary calibration coils of each seismometer are connected in series to the Wavetek Model 112B oscillator (#3240), which generates a constant amplitude sine wave at periods varying from 10 seconds to 250 seconds. This method of applying a force directly to the seismometer mass by passing a current through a coil corresponds to a force applied to the mass through the seismometer frame by earth movements, as both cause relative acceleration of this inertially stable mass (Geotech Technical Report No. 67-35). The response is expressed in terms of the amplitude measurement on the photographic record as a function of the amplitude of the earth displacement at various frequencies. Since the recorded amplitude can be thought of in terms of earth acceleration, earth displacement can be referenced by a double integration with respect to time. The record amplitude of each frequency plotted against the frequency or period gives an acceleration response curve. By multiplying each point on this curve by ω and ω^2 the velocity and displacement response curves, respectively, are obtained. Thus, in the MKS system:

$$\ddot{y} = \frac{Gi}{m} \text{ meters sec}^{-2}$$

where: $\ddot{y}$ = seismometer frame acceleration due to earth motion or, in the case of a frequency response, the constant amplitude acceleration of the simple harmonic driving force (in meters sec^{-2})

G = motor constant of the calibration coil (in newtons $amperes^{-1}$)

i = current in calibration coil (in amperes)

m = effective mass of the seismometer (in kilograms)

and integrating twice with respect to time

$$y = \frac{Gi}{\omega^2 m} \text{ meters}$$

where: $\omega = 2\pi f$, (in radians sec^{-1}) where f is the frequency of the motion

y = displacement amplitude of the earth vibration (in meters).

The dynamic magnification, M, of the seismograph system is then given by

$$M = \frac{\text{record amplitude}}{\text{displacement amplitude of the earth vibration}}$$

$$= \frac{y_r}{y}$$

$$= \frac{y_r \omega^{r} m}{Gi}$$

The dynamic magnification, M (or record amplitude/ ground displacement) can then be plotted against frequency (or period).

The phase response of the seismograph system, (in radians) is given as

$$\phi = \frac{2\pi t}{T}$$

where: t = time difference between the same phase of the input current and the output record in seconds

T = period in seconds

A plot of ϕ versus T yields the phase response curve.

The absolute calibration of the displacement transducer system is determined in terms of the sensitivity (mV per micron of ground displacement) and linearity. Using the micrometer mount assembly (#1211), the boom is mechanically moved increments of 0.05 mm at the center of oscillation and the resulting DC voltage outputs are observed on the null voltmeter (#3250). The sensitivity is defined as

$$\text{Sensitivity} \angle \frac{\text{DC voltage output}}{\text{boom position increments}}$$

With the 6 mm displacement as used in this system, the displacement response was found to be linear over the whole range.

IV: AMENDMENTS TO THE SYSTEM

During the installation of the Australian station (in the summer of 1970), it became obvious that the prestressing fixture (#8201) (refer to Section IIA) used to distort the tank bottom into a shallow dome was distorting the plane described by the top surface of the flange as well as the circular shape of this flange. Because of the distortion of the plane of the top surface of the flange, unwanted stresses and strains were induced in the base cylinder when the more rigid hemispherical top was clamped to the distorted flange. The relief of these stresses and the new physical shape into which the base was squeezed have two serious effects: (a) they cause "curing" noise, during which the cylinder relives its internal stresses, and (b) they cause a change in the parameters of the seismometer (e.g. period and boom position). It is impossible to allow for these problems during encapsulation and, therefore, when the seismometer is enclosed and sealed, subsequent random period and boom position of the instrument are incurred.

A new prestresser (#8201-MOD) has been designed and built to correct for this non-uniform prestressing of the base. Whereas the original prestresser concentrates the forces at three points on the base, up at the center and down at each end of a diametral line inside the tank cylinder, the new prestresser again concentrates a central force upward on the bottom but distributes a uniform downward load on the inner periphory of the tank bottom. With this uniform loading the cylinder will not be distorted and the bending moment forces of the base on the sides will be uniform and minimal.

ACKNOWLEDGEMENTS

We wish to thank Dr. Bryan Isacks of the Lamont-Doherty Geological Observatory and Dr. John P. Webb of the University of Queensland for critically reading the manuscript. This manuscript was principally prepared by Jack Rynn and Peter Ward with assistance from the other personnel working on this project as listed at the beginning of this report.

REFERENCES

Major, M.W., G.H. Sutton, J. Oliver, and R. Metsger (1964). On elastic strain of the earth in the period range 5 seconds to 100 hours, Bull. Seism. Soc. Am., 54, 295-346.

Melton, B.S. (1966). The long-period seismograph - its usefulness and its development, Geotech Div. Tech. Ret. 66-82, 35p.

Miller, H.J., S.J. (1963). Calibration of long-period seismographs at thirteen stations throughout the world, Scientific Report No. 24, prepared for Advanced Research Projects Agency, Vela Uniform, Bedford, Massachusetts.

Molnar, P., J. Savino, L.R. Sykes, R.C. Liebermann, G. Hade, and P.W. Pomeroy (1969). Small earthquakes and explosions in western North America recorded by new High-gain, long-period seismographs, Nature, 229, 1268-1273.

Oliver, J. (1959). Long earthquake waves, Scientific American, 200, 131-143.

Pomeroy, P.W., and G.H. Sutton (1960). The use of galvanometers as band-rejection filters in electromagnetic seismographs, Bull. Seism. Soc. Am., 50, 135-151.

Pomeroy, P.W., G. Hade, J. Savino, and R. Chander (1969). Preliminary results from high-gain, wide-band, long-period electromagnetic seismograph systems, J. Geophys. Res., 74, 3295-3298.

Savino, J. (1970). Long-period earth noise and the detection of and discrimination between earthquakes and underground explosions, ARPA Conference on Nuclear Test Detection, Woods Hole, Massachusetts, in press.

Savino, J., and G. Hade (1970). Long-period (15-150 sec) seismic noise observations at the Ogdensburg Mine Observatory, EOS Trans. Am. Geophys. Union, 51, 363.

Sutton, G.H. (1962). Note on long-period noise in seismographs, J. Geophys. Res., 67, 2082-2084.

Teledyne Inc. (1967). Measurement of earth vibrations with a seismometer, Geotech Div. Tech. Rept. 67-35, 17 p.

Trott, W. (1965). Investigation of noise in long-period seismographs, Geotech. Div. Tech. Rept. 65-91, 78 p.

Trott, W. (1966). Experimental investigation of thermal noise, Geotech. Div. Tech. Rept. 66-90, 39 p.

BLANK PAGE

DETAILED PARTS LIST

APPENDIX I contains the detailed parts list of the system. The drawings and parts list are arranged by four part numbers. The first digit (thousands digit) signifies the location or overall classification of the part according to the following scheme:

1 Seismometer Vault
2 Phototube Amplifier Room
3 Control Room
4 Photographic Recording Room
5 Pressure Door Assembly and Cabling
6 Expendable Supplies, General
7 Expendable Supplies, Used for Installation
8 Special Tools Needed for Installation
9 Recommended Spare Parts

The parts list consists of major assemblies as purchased for or built by Lamont-Doherty Geological Observatory. The detailed drawings and manuals are given in APPENDIX II if the column labeled "DETAILED DRAWING" is marked as follows:

X Denotes drawing included and arranged in order of part number

M Denotes manufacturer's instruction manual is available

MA Denotes manufacturer's instruction manual and any modifications to it are included in APPENDIX II.

L.D.G.O. PART NUMBER	DESCRIPTION	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
	PRESSURE VALVE ASSEMBLY				
1100	Pressure Tank and Gasket	[illegible]	X	Phoenix	[illegible]
1101	Pipe Adapter for Marsh Marine Connector	6	X	Lamont	
1102	Pressure Valve Pipe Adapter	3	X	Lamont	
1102-1	Pressure Valve Screw	3	X	Lamont	
1103-1	Watertite Bulkhead Connector (Individual Leads)	6		Vector	[illegible]
1103-2	Mating Bulkhead Connector	6		Vector	[illegible]
1103-3	Plastic Locking Sleeve	6		Vector	71-390
1104	Pipe Plug, 1"	18		Phoenix	
1105	Roof Bolt Anchor, 3/4"	18			
1106	Rolled Thread Steel Threaded Rod, 3/4" x 10				
	(Cut to desired lengths on site)	18			
1107	Nut, 3/4" x 10	18			
1108	Washer, 3/4"	18			

L.D.G.O. PART NUMBER	DESCRIPTION PRESSURE TANK ASSEMBLY (Continued)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
1109	"C" Clamp, 1 1/2" Heavy Duty	36		Armstrong	
1110	Steel Clamping Plate, 2" x 2" x 3/8"	36		Lamont	
1111	Handwinch	1		Luggall	1000-15
1112	Compression Fitting, 1"	6		Crouse-Hinds	CGR 397
1113	Celvacene Heavy Vacuum Grease	1 lb.		C.V.C.	269-352-22
1115	Tripod for Handwinch	1	x	Lamont	
1116	Brass shims, 0.030" thick by 0.5" by 3"	18		Lamont	

L.D.G.O. PART NUMBER	DESCRIPTION VERTICAL SEISMOMETER	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
1200	Vertical Seismometer - Long Period	1	NA	Geotech	J-11
1201	Remote Centering Assembly, Less Motor 1203	1		Geotech	1057 C
1202	Coil Assembly 25" Leaders on Signal and Calibration	2		Geotech	15940
1203	10 RPM 12VDC Motor	1		Hayden	K5331-P2-53
1204	Displacement Transducer	1		Sprengnether	VCT 202V
1205	Mounting Plate, for 1204	1	X	Lamont	
1205-1	Wire Clamp, for 1204	1	X	Lamont	
1205-2	Wire Clamp, for 1204	1	X	Lamont	
1206	Displacement Transducer Oscillator Discriminator	1	NA	Sprengnether	VCT 201EA
1207	Terminal Block	2	X	Lamont	
1208-1	Cable Holder	2	X	Lamont	
1208-2	Cable Holder	5	X	Lamont	
1209	Vent Pipe, 2" x 1/4" Brass, for 1200	1	X	Lamont	

L.D.G.O. PART NUMBER	DESCRIPTION VERTICAL SEISMOMETER (Continued)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
1210	Balloon	1			
1211	Micrometer Mount Assembly	1	X	Lamont	
1212	Seismometer Calibration Equipment (Including Catenary Suspension)	1		Geotech	

L.D.G.O. PART NUMBER	DESCRIPTION HORIZONTAL SEISMOMETER	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
1300	Horizontal Seismometer - Long Period	2	NA	Geotech	S-12
1301	Leg Adapter	2	X	Lamont	
1302	Remote Centering Assembly	2	NA	Sprengnether	S-5013 M
1303	Displacement Transducer	2		Sprengnether	VCT 202 H
1305	Terminal Block	4	X	Lamont	
1306	Terminal Base Plate	2	X	Lamont	
1307	Coil Assembly 25" Leaders on Signal and Calibration Coils	4		Geotech	15940
1308	Modified Leg, for 1302	2	X	Lamont	
	Note: L.D.G.O. part numbers 1206, 1208-1, 1208-2, 1209, 1210, 1211, 1212 also used for both vertical and horizontal seismometers (double quantity for latter)				

L.D.G.O. PART NUMBER	DESCRIPTION PHOTOTUBE AMPLIFIER ROOM	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
2100	Phototube Amplifier with turntable base	3	MA	Geotech	5240B
2101	Motor, 12VDC, for 2100	3		Hayden	K5352PZ
2102	Mounting Plate, for 2101	3	X	Lamont	
2103	Galvanometer, 100 sec, Fixed Focus, 500ohm Coil, CDRX 500-3000 ohm	3	MA	Kinemetrics	LG-1
2104	P.T.A. Modification Kit - Optional for GFE	3		Geotech	28660
2105	Washer, 1/4" for P.T.A. Lamp Mounts	12			
2200	P.T.A. Power Supply	3	MA	Geotech	14486
2201	Filter, Band Pass, for 2200	6	X	Geotech	6824-15S
2202	P.T.A. Power Supply Pin	12			
2300	Displacement Transducer Power Supply	1	MA	Powermate	UN1-164
2301	Mounting Plate, for 2300	1	X	Lamont	
2302	Mounting Clamp, for 2301	1	X	Lamont	

L.D.G.O. PART NUMBER	DESCRIPTION PHOTOTUBE AMPLIFIER ROOM (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
2303	Power Output Plate, for 2300	1	X	Lamont	
2400	Quad Box - 4" Square	1		Universal	52171
2401	Duplex Receptacle	2		Bryant	5252
2402	Box Cover - 4" Square	1		Universal	R58
2403	Compression Fitting, 3/4"	1		Crouse-Hinds	C6B 296
2500	P.T.A. Power Supply Bench: Marine Ply.5'x2'	1			
2501	Backing Board for Cables: Pineboard 5'x2'	1			

L.D.G.O. PART NUMBER	DESCRIPTION CONTROL ROOM	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
3100	Digital Data Acquisition System	1	M	Astrodata	
3101	Connector for Signal Input, for 3100	20		Amphenol	MS3106A145-2P AN3057-6AW/B
3102	Auxilary Slave Time Relay, for 3100	1	X	Lamont	
3103	Digital Multimeter	1		Weston	1240
3200	Relay Rack, Solid Bottom, Tapped 10-32	1	X	Premier	PRXA-70-24
3201	Side Panel, Light Gray	2		Premier	FL-70-24
3202	Castor, 3"	1 set		Premier	CA-5
3203	Blower	1		Premier	PMB-5-150
3204	Drawer	1		Premier	D1916
3205	Shelf	1		Premier	RD5-319-22
3206	Side Hinged Panel	1		Premier	SHP-819
3207	Rear Panel - Power Distribution	1	X	Premier	FP-719
3208	Louvered Panel	1		Premier	FPL-2919

L.D.G.O. PART NUMBER	DESCRIPTION CONTROL ROOM (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
3209	Rear Door	1		Premier	CD-33
3210	Chassis Support	1 pr.		Premier	CSA-24
3211	Shelf	1		Premier	S-22-24
3212	Panel, 7"	2		Premier	ARP-719
3213	Panel, 5"	1	X	Premier	ARP-519
3214	Panel, 5"	1		Premier	ARP-519
3215	Speaker Panel	1	X	Premier	SRP-819
3216	Speaker	1		Utah	VBJCW
3217	Volume Control L-Pad Attenuator, 4 ohm	1		Centralab	WL4
3218	Radio Receiver	1	M	Specific Products	WVTR-A1
3219	Antenna	1		Specific Products	AK-8
3220	Boom Position Monitor and Control	1	X	OAS	70-026

L.D.G.O. PART NUMBER	DESCRIPTION CONTROL ROOM (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
3230	Calibration Panel	1	X	OAS	70-026
3240	Triggered VCG Signal Generator	1	M	Wavetek	112B
3250	Null Voltmeter	1	M	Hewlett-Pack-ard	419A
3270	Voltage Regulator	1	X	Wanlass	VVR-1500
3271	Switch, DPDT 6 Amp (On/Off)	1		Arrow Hart	81024GB
3272	Segmental Voltmeter (110V-130V)	1		Simpson	1349
3273	Fuse Holder	2		Bussman	HPC
3274	Fuse, 10 Amp, 15 Amp	2		Fusetron	FNM
3275	Terminal Strip	8		Buchanan	
3276	Metal Trough, 4"x4"x2'	1		Keystone	KEW442
3277	Closing Plate, 4"x4", for 3276	2		Keystone	KFCP40
3278	3 Wire Twist Lock Recptacle	4		Bryant	7328-G
3279	3 Wire Twist Lock Plug	4		Bryant	[illegible]96S

L.D.G.O. PART NUMBER	DESCRIPTION	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
	CONTROL ROOM (Con't.)				
3280	Compression Cable Connector, 3/4"	12		Crouse-Hinds	CGB 2[illegible]
3281	Grounding Lug	6		Burndy	KPA4C
3282	Cable Connector	6		Romex	
3299	Power Distribution Strip	1		Premier	OB-170
3410-1	Transformer 60Hz 120V/120V	1	MA	Topaz	0511T25ST
3410-2	Transformer 50 Hz 240V/120V	1	MA	Topaz	051T25ST-8274
3411	Line Filter	2		Sprague	Filterall 3
3412	Utility Box and Cover, 6"x6"x4"	1			
3413	Line Voltage Recorder	1		Rustrak	2186
3414	Voltonmyst Meter	1	M	RCA	WV-500B
3420	Power Distribution Box and Switch	1		Westinghouse	CFB
3421	Circuit Breaker, 20 AMP	1		Westinghouse	EB2020
3422	3 Pin Receptacle, 30 Amp	1		Crouse-Hinds	ARE3373
3423	3 Pin Socket, 30 Amp	1		Crouse-Hinds	APJ3373

L.D.G.O. PART NUMBER	DESCRIPTION	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
3424	Power Distribution Panel (mounted components on 4' x 2' x 3" Marine Ply.)	1	x	Lamont	
3425	Stainless steel rod, 1/2" x 13, for 3424	3 ft.		Lamont	
3500	Metal cabinet for parts	1			
3501	Metal drawers for parts	1			
3600	Dehumidifier	1	MA	Westinghouse	ENJ25
3700	Casement door	3		Any	
3800	Battery charger	1	MA	Exide	US-50-1-6
3801	Static inverter	1		Exide	
3802	Batteries. 6V	20	MA	Exide	
3803	Battery rack	1	MA		

L.D.G.O. PART NUMBER	DESCRIPTION RECORDER ROOM	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
4100	Photographic Recorder - 3 Drum	2	MA	Sprengnether	HR-6007
4101	Bracket for Stacking Recorders - Optional	1		Lamont	
4103	Metal Bench, Movable, for 4100	2	X	Lamont	
4104	Safelight - Red Filters	3		Kodak	
4105	Canister for Photographic Records	1		Lamont	
4106	Timber Bench, for 6004 and 6005	1			
4107	Quad Box - 4" Square	1		Universal	52171
4108	Duplex Receptacle	2		Bryant	5252
4109	Box Cover - 4" Square	1		Universal	R58
4110	Compression Fitting, 3/4"	1		Crouse-Hinds	CGB 296
4111	Tray for Record Developing, Fixing and Washing of Photographic Records	3		Leedal	110-021-HW
4200	Long Period Galvanometer Assembly	3	X	Lamont	

L.D.G.O. PART NUMBER	DESCRIPTION	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
4201	Long period galvanometer, 100 sec, adjustable focus, CDRX 1000-3500 ohm	3	M	Kinemetrics	LG-1
4202	L.P. galvanometer resistive network-for calibration	1	X	Lamont	
4203	L.P. galvanometer L-Pad attenuation	6	X	Lamont	
4300	Short period galvanometer assembly	3	X	Lamont	
4301	Base for use with stacked photo recorders optional	1		Lamont	
4302	Short period galvanometer 0.3 sec	3		Geotech	G-10
4303	S.P. galvanometer resistive network-for calibration	3	X	Lamont	
4304	S.P. galvanometers base (2'6" x 10" x 3/4" aluminum plate)	1		Lamont	
4350	Filter galvanometer, 7 sec - optional	3		Kinemetrics	LG-1 MOD
4400	Dehumidifier (same as 3600)	1	MA	Westing-house	ENJ25

L.D.G.O. PART NUMBER	DESCRIPTION PRESSURE DOOR ASSEMBLY AND CABLING	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
5100	Bulkhead Door, Modified	3	X	Lamont (Dupont mfg.)	
5101	Cable conduit 2" Galvanized Pipe with Threaded				
	Ends: 28" Length	1			
	24" Length	9			
	16" Length	5			
	8" Length	8			
	4" Length	2			
5102	Pipe Cap 2"	5			
5103	2" Pipe Cap with 3/4" Compression Fitting	3	X	Lamont	
5104	Pipe Protector 2"	15			
5105	Brass Coupling 2" Associated with 8206	6		Lamont	
5106	Rubber Hose 2 5/16" x 3' (cut to desired lengths at site) associated with 8206	1			

L.D.G.O. PART NUMBER	DESCRIPTION PRESSURE DOOR ASSEMBLY AND CABLING (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
5107	Hose Clamp, 2 5/16" Associated with 8206	20			
5150	Cable Conductor, 2x18 Gauge Solid, Mylar Foil Shield	2000'*		Saxton	
5160	Cable Conductor, 2x16 Gauge Stranded, Mylar Foil Shield	5000'*		Saxton	
5170	Cable Conductor, 3x16 Gauge Stranded, Mylar Foil Shield	500'*		Saxton	
5180	Cable, #10-3 Conductor Wire, Plastic Jacket	250'*			
	* Quantity may vary to fit specific installation.				

L.D.G.O. PART NUMBER	DESCRIPTION EXPENDABLE SUPPLIES, GENERAL	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
6001	Dessicant - Silica Gel, for Seismometers	72		Fisher	1-952-7
6002	Acid Fixer, One Gallon Size (24 per case)	10*		Kodak	
6003	Dektol Developer, One Gallon Size (24 per case)	5*		Kodak	D72
6004	Linagraph Paper, Spec. 1258, Type 480, 92cmx30cm, 50 sheets per package	25*		Kodak	480
6006	Magnetic Tape, 1600BPI, Type K	26*		Ampex	874-278652
6007	Freon TF, 1 Qt. Tin	3		Moore	
6008	Cotton Buds, 1 Box	1		Johnson & Johnson	
6009	Inhibisol, 12 Cans per carton	1ctn.		Amerace-Esna	
	* Denotes per year.				

L.D.G.O. PART NUMBER	DESCRIPTION EXPENDABLE SUPPLIES, INSTALLATION	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
7001	Mold Release, Release Agent	2		Miller-Stephenson	1328
7002	Scotch Cast, Electric Resin #4, Size A	30		3M	
7003	Duxseal, 1 lb. Pkg.	7		Johnsmanville	
7004	Silastic RTV 732	2		Dow Corning	
7005	Hydro-Pox Epoxy Paint, 1 Gal.	10		Enterprise	
7006	White Lead, 1 Lb. Tin	1		National Lead	
7007	Never Seez, 1 Lb. Tin	1		Never Seez	
7008	Ribbon Dope Thread Sealant, 1/2"	10		Permacel	P-412
7009	Glyptal, 1 Pt. Tin	2		General Electric	7815 Black
7010	Electrical Tape, 3/4"	12		3M	
7011	Electrical Tape, 3/8"	6		3M	
7012	. ilar Tape, 1"	12			
7013	Paint Brush, 4"	6			

L.D.G.O. PART NUMBER	DESCRIPTION EXPENDABLE SUPPLIES, INSTALLATION (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
7014	Paint Brush, 2"	6			
7015	Acid Brush	15			
7016	Wire Brush	4			
7017	Foxtail Brush	1			
7018	Assorted Resistors, 10ohm - 30 M ohm, 1/2 Watt	1 pkg.		IRC	
7019	Pliobond, 4 oz. bottle	1			
7020	Strip-X Wire Stripper, 4 oz. bottle	1			
7021	Carbon Tetrachloride, 4 oz. bottle	1			
7022	Lables, Numerical and Alphabetical	25			
7023	Eye Bolt, 6"x1/2"	3			
7024	Roof Bolt Anchor, for 7023	3			
7025	Coil Dope, 4 oz. bottle	1			
7026	Mortar Mix, 45 lb. bag	8		Sakrete	

L.D.G.O. PART NUMBER	DESCRIPTION EXPENDABLE SUPPLIES, INSTALLATION (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
7027	Plastic Tubing, 3/8" Bore (for Potting Cable in Street "L" in 4200)	10'			
7028	Rubber Sheet, 2'x2'x1/8" (For Wire Potting Mould)	1			
7029	Lubriplate, 4 oz. bottle	2			

L.D.G.O. PART NUMBER	DESCRIPTION SPECIAL TOOLS FOR INSTALLATION	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
8001	Gaussmeter	1		General Electric	416X33
8002	Gaussmeter Holder	1	X	Lamont	
8003	Cross Test Level	1		Starrett	136
8004	Cross Test Level	1		Starrett	134
8005	Rotary Impact Hammer	1		Black and Decker	5055
8005-1	Carbide Bit for 8005, 1 3/8" x 15 5/8"	4		Black and Decker	62673
8005-2	Carbide Bit for 8005, 7/8" x 6"	2		Black and Decker	
8006	Decade Resistance Box	2		Heathkit	
8007	Stopwatch	1		Minerva	

L.D.G.O. PART NUMBER	DESCRIPTION SPECIAL TOOLS FOR INSTALLATION (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
8008	Torque Wrench, 250 Ft. Lb., 1/2" Drive	1			STW3RCF
8010	Soldering Iron and Stand	1		Weller	
8011	Solder - Resin Core, 1 Lb. Pkg.	4			
8012	Steel Tape, 100 ft.	1		Starrett	
8013	Hole Saw and Mandril, 1 7/8"	2		Black and Decker	
8014	Power Drill, 1/2"	1		Black and Decker	
8015	Oscilloscope, Portable AC/DC	1		Tektronix	422
8016	Taps - 1/2", 3/4", 1", 1"NPT 3/8 NPT	1 set			
8017	Dies - 1/2", 3/4"	1 set			
8018	Pipe Die - 2"	1			
8019	Micrometer, metric	1		Starrett	263M

L.D.G.O. PART NUMBER	DESCRIPTION SPECIAL TOOLS FOR INSTALLATION (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
8020	Vernier Calipers	1			
8021	Dymo Marker	1			
8022	Dymo Tape	4			
8023	Drill Index	1			
8025	Flashlight, with Red Filter	1		Eveready	
8026	Captains Lantern	1		Eveready	
8027	Socket Set - 1/2" Drive	1			
8028	Universal Socket Driver - 1/2",3/4"	1 ea.			
8029	Brace - Speed Wrench	1			
8030	3/4 Drive Sockets - 1 1/8", 1 1/2", 3/4"	1 ea.			
8031	Ratchet	1			
8032	Tap, 2-56	2			
8033	Electrical crimping tool and terminal set	1			

L.D.G.O. PART NUMBER	DESCRIPTION SPECIAL TOOLS FOR INSTALLATION (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
8034	Head Lamp, Adjustable	2			
8035	Wire Clamp Set	1		Panduit	
8036	Allen Wrenches, 1 set	1			
8037	Chart Recorder, dual channel 10"	1		Esterline-Angus	E 11025
8038	Hygrothermograph	1		Bendix	
8039	Microbarograph	1		Bendix	
8040	Electronic Microbarograph	1		Lamont	
8041	Air Bulb Blower	1			
8042	Tuning Wand	5			
8043	Tap and Die Set	1			
8044	Power Supply, 0-30V	1		Hewlett-Packard	6215A

L.D.G.O. PART NUMBER	DESCRIPTION	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
8045	Autotransformer, 240V-110V/110V	1		Signal Trans	
8046	Pipe wrench (either 14" or 16")	1			
8100	Installation team tool box	1			
8201	Tank prestresser	1	X	Lamont	
8201 (mod)	Modified tank prestresser (see text: section IV)	1	X	Lamont	
8202	Drill guide	1	X	Lamont	
8203	Centering pin	2	X	Lamont	
8204	Guide pin	3	X	Lamont	
8205	Setting fixture	1	X	Lamont	
8206	Wire insulator assembly, associated with 5100 and 5105, 5106, 5107	1	X	Lamont	
8207	Wire potting mold, 2 3/8", associated with 5100 and 8106	1	X	Lamont	

L.D.G.O. PART NUMBER	DESCRIPTION SPECIAL TOOLS FOR INSTALLATION (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
8208	Wire Potting Mold, 7/8", assoicated with 1101	2	X	Lamont	

L.D.G.O. PART NUMBER	DESCRIPTION	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
8045	Autotransformer, 240V-110V/110V	1		Signal Trans	
8046	Pipe wrench (either 14" or 16")	1			
8100	Installation team tool box	1			
8201	Tank prestresser	1	X	Lamont	
8201 (mod)	Modified tank prestresser (see text: section IV)	1	X	Lamont	
8202	Drill guide	1	X	Lamont	
8203	Centering pin	2	X	Lamont	
8204	Guide pin	3	X	Lamont	
8205	Setting fixture	1	X	Lamont	
8206	Wire insulator assembly, associated with 5100 and 5105, 5106, 5107	1	X	Lamont	
8207	Wire potting mold, 2 3/8", associated with 5100 and 8106	1	X	Lamont	

L.D.G.O. PART NUMBER	DESCRIPTION SPECIAL TOOLS FOR INSTALLATION (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
8208	Wire Potting Mold, 7/8", assoicated with 1101	2	X	Lamont	

L.D.G.O. PART NUMBER	DESCRIPTION RECOMMENDED SPARE PARTS	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
9000	Gasket for 1100	1			
9001	Pipe Adapter for Marsh-Marine Connector (1101)	1		Phoenix	1006-D-5386
9002	O-ring for valve screw 1002-2	4			
9003	Water-tite Bulkhead connector (individual leads) (1103-1)	1		Vector	XSK6BCL-GP
9004	Mating Bulkhead connector (1103-2)	1		Vector	RM"S"6SFS
9005	"C" Clamp, 1 1/2" Heavy duty (1109)	2		Armstrong	
9006	Steel clamping plate, 2"x2"x3/8" (1101)	12		Lamont	
9007	Seismometer coil assembly (1202, 1307)	1		Geotech	15940
9008	Motor, for 1302	1			
9009	Printed circuit board for Displacement Transducer Oscillator Discriminator Unit	1		Sprengnether	
9010	Vacuum Tubes, for 2100 and 2200	10			12AT7

L.D.G.O. PART NUMBER	DESCRIPTION RECOMMENDED SPARE PARTS (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
9011	Exciter Lamps, for 2100	4			
9012	Motor, for 2101	1		Hayden	
9013	Fuses, sloblow, 3A, 1/2A, for 2200	4 boxes			
9014	Bulb, for 2200	4		RCA	5582
9015	Photocells (matched pair), for 2100	2			
9016	Galvanometer, for 2103 and 4201	1		Kinemetrics	LG-1
9017	LG-1 Galvanometer Repair Kit, for 2103 & 4201	2		Kinemetrics	
9018	Coil-Mirror Assembly, for 2103 & 4201	2		Kinemetrics	
9019	Filter, Band Pass, for 2201	2		Geotech	6824-15S
9020	Bulb, for 3100	10			
9021	Relay, for 3102	1			
9022	Displacement Transducer Power Supply, for 2300	1		Powermate	UN1-164
9023	Circuit Breaker, 20A, for 3421	1			

L.D.G.O. PART NUMBER	DESCRIPTION RECOMMENDED SPARE PARTS (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
9024	Line Filter, for 3411	2		Sprague	Filterall 3
9025	Battery (4.2V) for 3230	12		Mallory	
9026	Fuse, 15A, for 3200	10			
9027	Bulb, #12 6V, for 4100	12			
9028	Lenses, for 4100	3		Sprengnether	
9029	Plastic Hold-Down Strips, for 4100	3		Sprengenther	
9030	Light Sources, for 4100	1		Sprengnether	
9031	Motor, for 4100	1		Bodine	
9032	Glass, for 4200	6		Lamont	
9033	Galvanometer, for 4302	1		Geotech	G-10
9034	Galvanometer, Filter, for 4350	1		Kinemetrics	LG-1 MOD
9035	Battery (1.4V) for 4202 and 4303	2		Mallory	"D" Cell
9036	Battery (1.5V), for 8025	24		Eveready	"D" Cell

L.D.G.O. PART NUMBER	DESCRIPTION RECOMMENDED SPARE PARTS (Con't.)	QUANTITY PER STATION	DETAILED DRAWING	MANUFACTURER	MANUFACTURER'S PART NUMBER
9037	Battery for 8026	4		Eveready	509
9038	Compression fitting, 3/4", for Quad Box	2		Crouse-Hinds	
9039	Bolt, 5/16"x24 Brass	12			
9040	Washer, 5/16" Brass	12			
9041	Duplex Receptacle	2		Bryant	S252
9042	3Wire Twist Lock Plug and Receptacle (3278 & 3279)	1		Bryant	9328-G, 996S
9043	Relay for WWSSN Console (24V DPST)	2		Sigma	

L.D.G.O. PART NUMBER	RECOMMENDED SPARE PARTS LIST AT EACH STATION DATA LOGGER #7104500100	QUANTITY PER STATION	SPARE QUANTITY PER STA.	MANUFACTURER	MANUFACTURER'S PART NUMBER
9101	Universal counter	1	1	Astrodata	27000
9102	(-) to 1C level shifter	1	1	Astrodata	27004
9103	Power driver	3	1	Astrodata	27011
9104	16 channel multiplexer	1	1	Astrodata	27017
9105	"D" flip flop	4	1	Astrodata	27041
9106	26 inverter buffers	4	1	Astrodata	27103
9107	10, 4-way nands	3	1	Astrodata	27104
9108	Decodes, 4 to 16 and 3 to 8	1	1	Astrodata	27108
9109	8 input by 4 wide gating	2	1	Astrodata	27111
9110	18, 2-way nands	5	1	Astrodata	27112
9111	shift register	4	1	Astrodata	1717-2718100
9112	major time counter	1	1	Astrodata	1717-2718300
9113	time control and clock divider	1	1	Astrodata	1717-2718400

L.D.G.O. PART NUMBER	RECOMMENDED SPARE PARTS LIST AT EACH STATION DATA LOGGER #7104500100	QUANTITY PER STATION	SPARE QUANTITY PER STA.	MANUFACTURER	MANUFACTURER'S PART NUMBER
9114	Logger counter	1	1	Astrodata	1717-2718500
9115	band pass filter	3	1	Astrodata	1707-2800100
9116	low pass filter	3	1	Astrodata	1707-2800200
9117	muffin fan	7	1	Rotron	MK IV
9118	lampholder	41	4	08717	855-S1-9
9119	Receptacle -white	38	4	08717	855D-W
9120	Switch, toggle	17	2	Alcoswitch	MST205N
9121	Switch, pushbutton	19	2	Microswitch	1 PB 5
9122	Switch, thumbwheel	3	1	97525	1R177606G
9123	Switch, wafer	7	1	CTS	T 8
9124	Switch, pushbutton alt. action	2	1	Microswitch	2D26
9125	Switch, pushbutton momentary	3	1	Microswitch	2D100
9126	Switch, light unit	5	1	Microswitch	2C203
9127	Lamp	55	25	Chicago M.	327

L.D.G.O. PART NUMBER	RECOMMENDED SPARE PARTS LIST AT EACH STATION DATA LOGGER #7104500100	QUANTITY PER STATION	SPARE QUANTITY PER STA.	MANUFACTURER	MANUFACTURER'S PART NUMBER
9128	Wafer switch assembly	1	1	CTS	T207
9129	Register	3	1	Astrodata	17063
9130	Two-channel regulator	1	1	Astrodata	17080
9131	Register	1	1	Astrodata	17089
9132	Output buffer and decoder	1	1	Astrodata	17096
9133	D.A.C. L.S.D.	1	1	Astrodata	17101
9134	Pot. amp assembly	1	1	Astrodata	17103
9135	ADC control	1	1	Astrodata	17109
9136	D.A.C. M.S.D.	1	1	Astrodata	17124
9137	Low voltage regulator	1	1	Astrodata	17147
9138	Comparator	1	1	Astrodata	17193
9139	Output buffer and decoder	1	1	Astrodata	17324
9140	Oscillator 1.024 m Hz	1	1	Vectron	CO-211

95

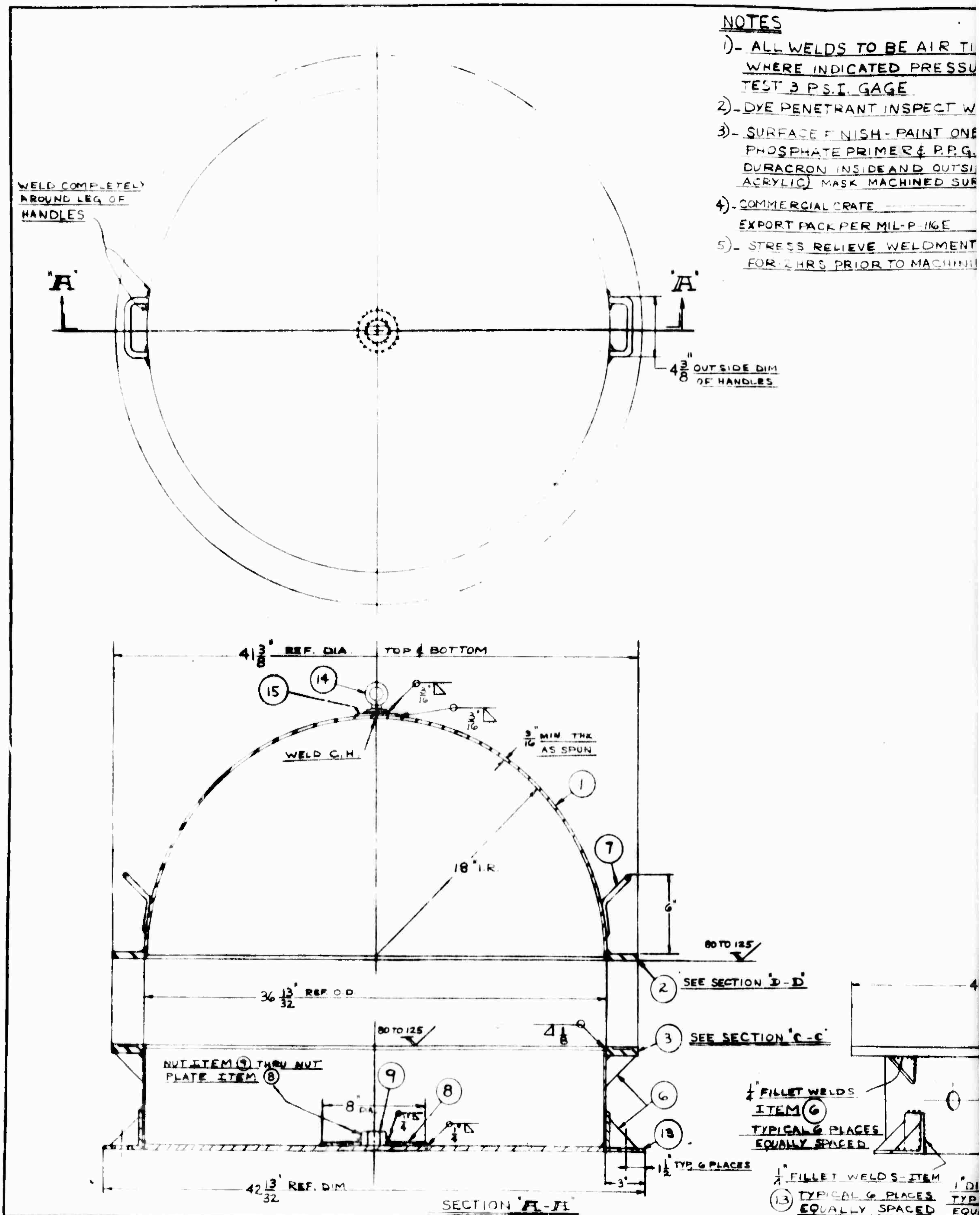
L.D.G.O. PART NUMBER	RECOMMENDED SPARE PARTS LIST AT EACH STATION DATA LOGGER #7104500100	QUANTITY PER STATION	SPARE QUANTITY PER STA.	MANUFACTURER	MANUFACTURER'S PART NUMBER
9141	Main board	1	1	Cipher	20060000
9142	Capstan drive card	1	1	Cipher	20061000
9143	Reel servo card	2	1	Cipher	1905400
9144	Relay	1	1	Clare	RP9895-63
9145	Relay	1	1	Sigma	KPP11D
9146	Capacitor 4000 UF 40 VDC	1	1	GE	1886944
9201 *	± 10V reference supply	1	2	06964	27019
9202 *	15 bit DAC	1	2	06964	27023
9203 *	Frequency selector (time tick filter)	1	2	06964	1717-2719700
9204 *	Power supply (5 volt)	1	2	ACDC	1C5N13.5-1
9205 *	Power supply (18 volt)	2	2	Sorenson	QSA18-1.1
9206 *	Power supply (24 volt)	1	2	Sorenson	QSA28-8.8
9207 *	Transformer	1	1	Cipher	1600063B
9208 *	Torque motor	2	1	Magnedine	204

* To be stocked at LDGO only

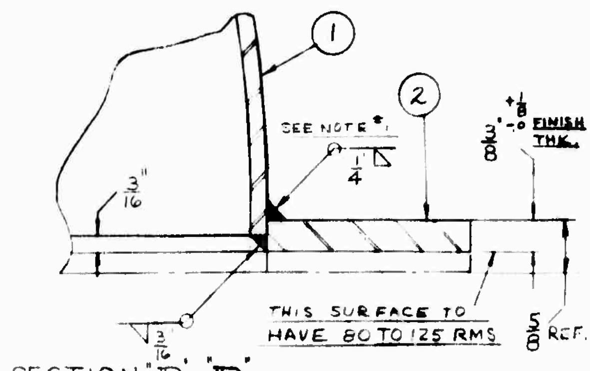
L.D.G.O. PART NUMBER	RECOMMENDED SPARE PARTS LIST AT EACH STATION DATA LOGGER #7104500100	QUANTITY PER STATION	SPARE QUANTITY PER STA.	MANUFACTURER	MANUFACTURER'S PART NUMBER
9209 *	Capstan motor	1	1	Cipher	69M31-577
9210 *	Power supply board	1	1	Cipher	1905201
9211	Muffin fan	1	1	Pamotor	4500
	* To be stocked at LDGO only				

DETAILED DRAWINGS AND MANUALS

APPENDIX II contains detailed drawings and most manuals. These are arranged in sequence of the four-part numbers as designated in APPENDIX I.

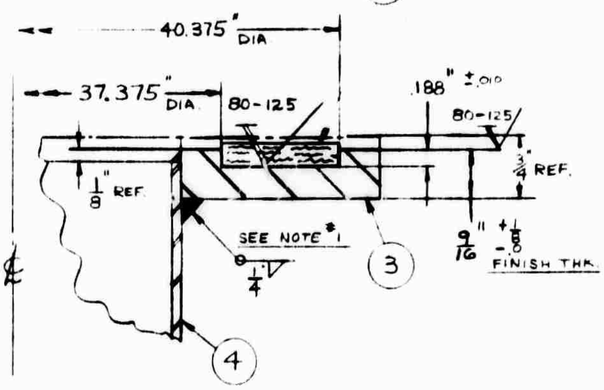

NOTES
1)- ALL WELDS TO BE AIR TI
WHERE INDICATED PRESSU
TEST 3 P.S.I. GAGE
2)- DYE PENETRANT INSPECT W
3)- SURFACE FINISH - PAINT ONE
PHOSPHATE PRIMER & P.P.G.
DURACRON INSIDE AND OUTSI
ACRYLIC) MASK MACHINED SUR
4)- COMMERCIAL CRATE
EXPORT PACK PER MIL-P-116E
5)- STRESS RELIEVE WELDMENT
FOR 2 HRS PRIOR TO MACHINI
WELD COMPLETELY AROUND LEG OF HANDLES
"A"
"A"
4 3/8" OUTSIDE DIM OF HANDLES
41 3/8" REF. DIA. TOP & BOTTOM
15
14
3/16
3/16
3/16" MIN THK AS SPUN
WELD C.H.
1
7
18" I.R.
6"
80 TO 125
2
SEE SECTION "D-D"
36 13/32" REF O.D.
80 TO 125
1/8
3
SEE SECTION "C-C"
NUT ITEM 9 THRU NUT PLATE ITEM 8
9
8
8" DIA
6
13
1 1/2" TYP 6 PLACES
3"
42 13/32" REF. DIM
SECTION "A-A"
1/4" FILLET WELDS ITEM 6 TYPICAL 6 PLACES EQUALLY SPACED
1/4" FILLET WELDS - ITEM 13 TYPICAL 6 PLACES EQUALLY SPACED

ELDS TO BE AIR TIGHT
INDICATED PRESSURE
P.S.I. GAGE
IETRANT INSPECT WELDS
E FINISH - PAINT ONE (1) COAT
ATE PRIMER & P.P.G. #600
ON INSIDE AND OUTSIDE (BAKED
MASK MACHINED SURFACES
IAL CRATE — 2 UNITS
ACK PER MIL-P-116E — 34 UNITS
RELIEVE WELDMENT AT 1000°F
RS PRIOR TO MACHINING FLANGES

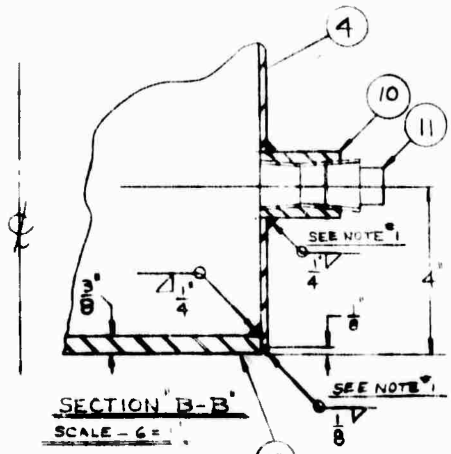


SECTION "D"-"D"

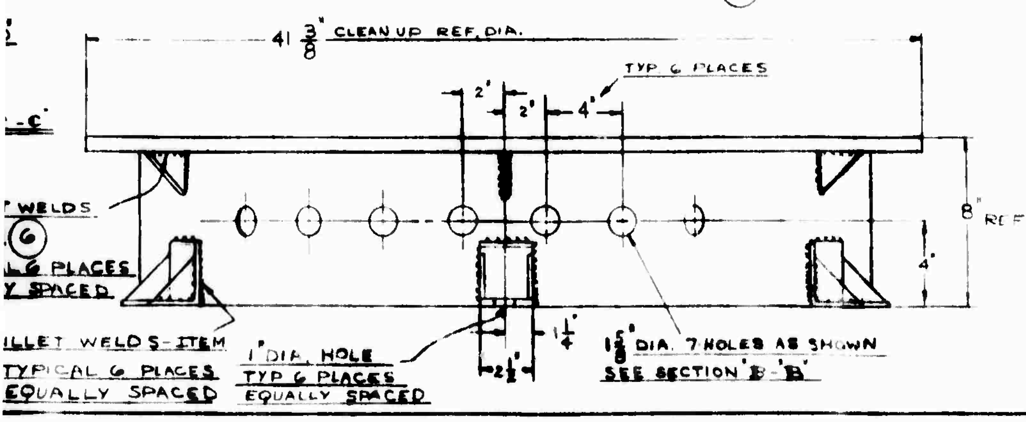
(12) GASKET



SECTION "C-C"
SCALE - 12" = 1'



SECTION "B-B"
SCALE - 6" = 1'



ITEM NO	BILL OF MATERIAL	NO REQD
15	EYE BOLT PAD - 3/4" THK. MILD STEEL x 3" DIA.	1
14	EYE BOLT - #4 PAD EYE CROSBY LAUGHLIN	1
13	HOLD DOWN ANGLES - 1/4" THK x 3 x 3" MILD STEEL x 2 1/2" LG.	6
12	GASKET - 1/4" THK. NEOPRENE DUROMETER - 40 - 40 5/16" O.D. x 37 7/16" I.D. (TOL. ±1/32 ON DIAMETERS)	1
11	PLUGS - 1" I.P.S. GALV. IRON	7
10	COUPLINGS - 1" I.P.S. BLACK IRON	7
9	NUT - STD. 1"-8 N.C. HEX. STEEL	1
8	NUT PLATE - 1/4" THK. MILD STEEL PLATE x 8" DIA.	1
7	HANDLE - 1/2" DIA ROD x 3 5/8" WIDTH MILD STEEL - PURCH FROM RES MFG.	2
6	GUSSETS - 1/4" THK x 2 1/4" x 2 1/4" MILD STEEL	18
5	BOTTOM - 3/8" THK. MILD STEEL x 36 7/32" DIA. +0 -1/8	1
4	CYLINDER - #11 GA (.1196") x 7 3/4" WIDE x 113 31/32" EXACT MILD STEEL	1
3	RING FOR CYL - 41 3/8" O.D. +1/8 -0 x 36 5/8" I.D. +1/8 x 3/4" THK. MILD STEEL	1
2	RING FOR HEMISPHERE - 41 3/8" O.D. +1/8 -0 x 36 3/8" I.D. +1/8 x 5/8" THK. MILD STEEL	1
1	SPUN HEMISPHERE - 1/4" THK x 48" O.D. MILD STEEL PLATE	1

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE AS FOLLOWS
DECIMAL ±.015"
FRACTIONAL ±1/32
ANGLE ±0°-30'
FINISH SEE W.O. AS SHOWN

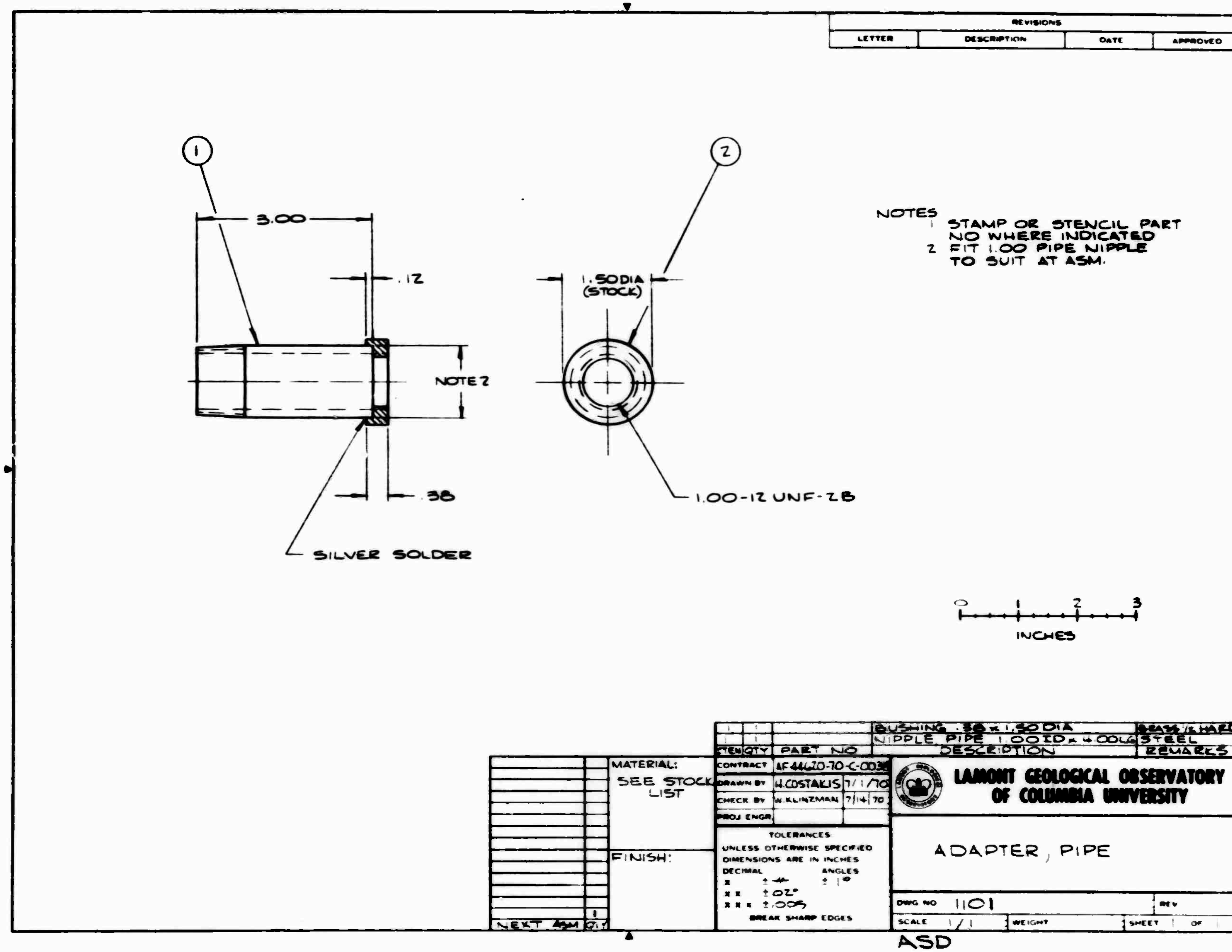
PHOENIX PRODUCTS CO.
MILWAUKEE WISCONSIN

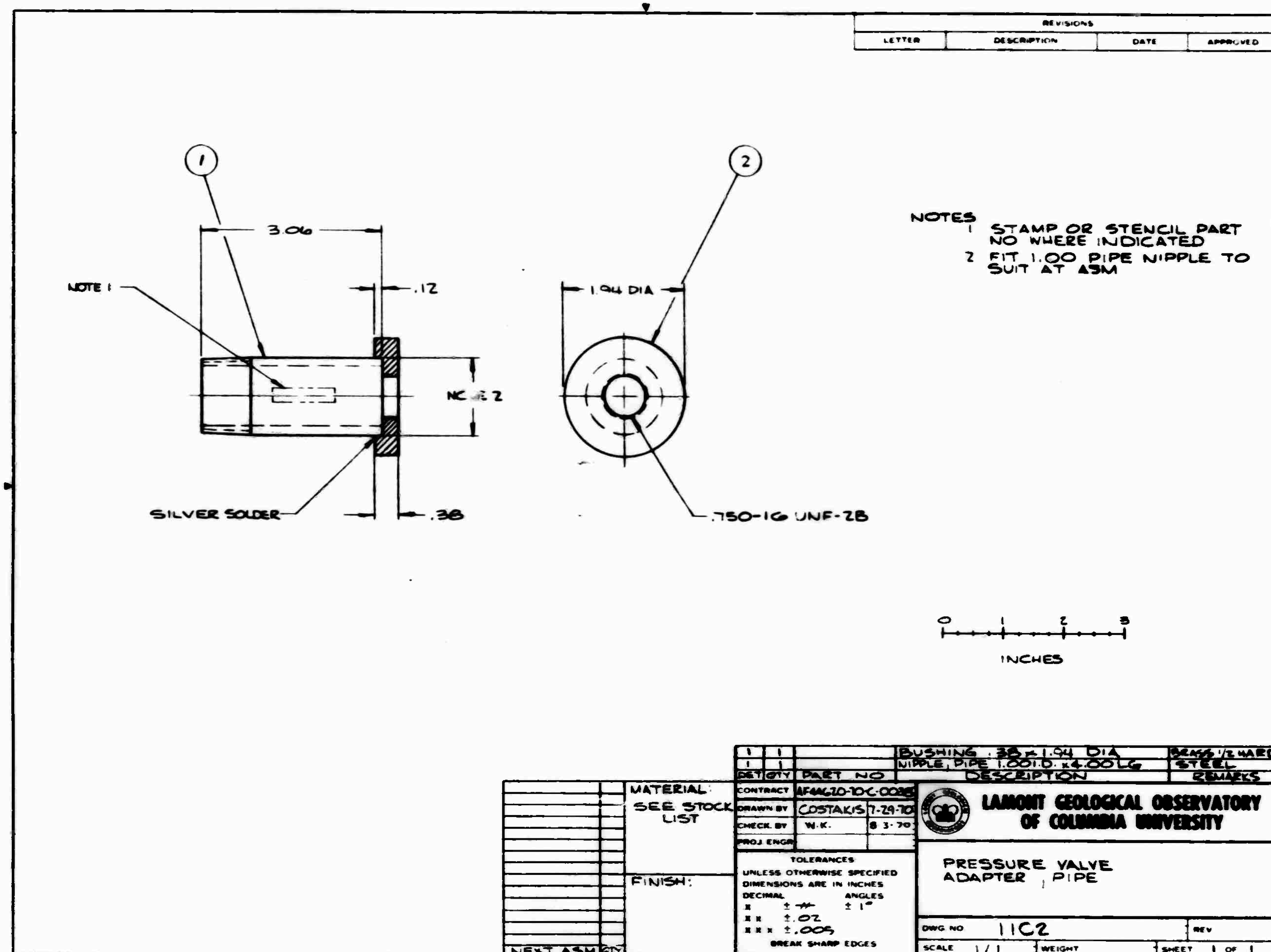
SEISMOMETER ENCLOSURE
1100

3/24/70
1006-D-5396

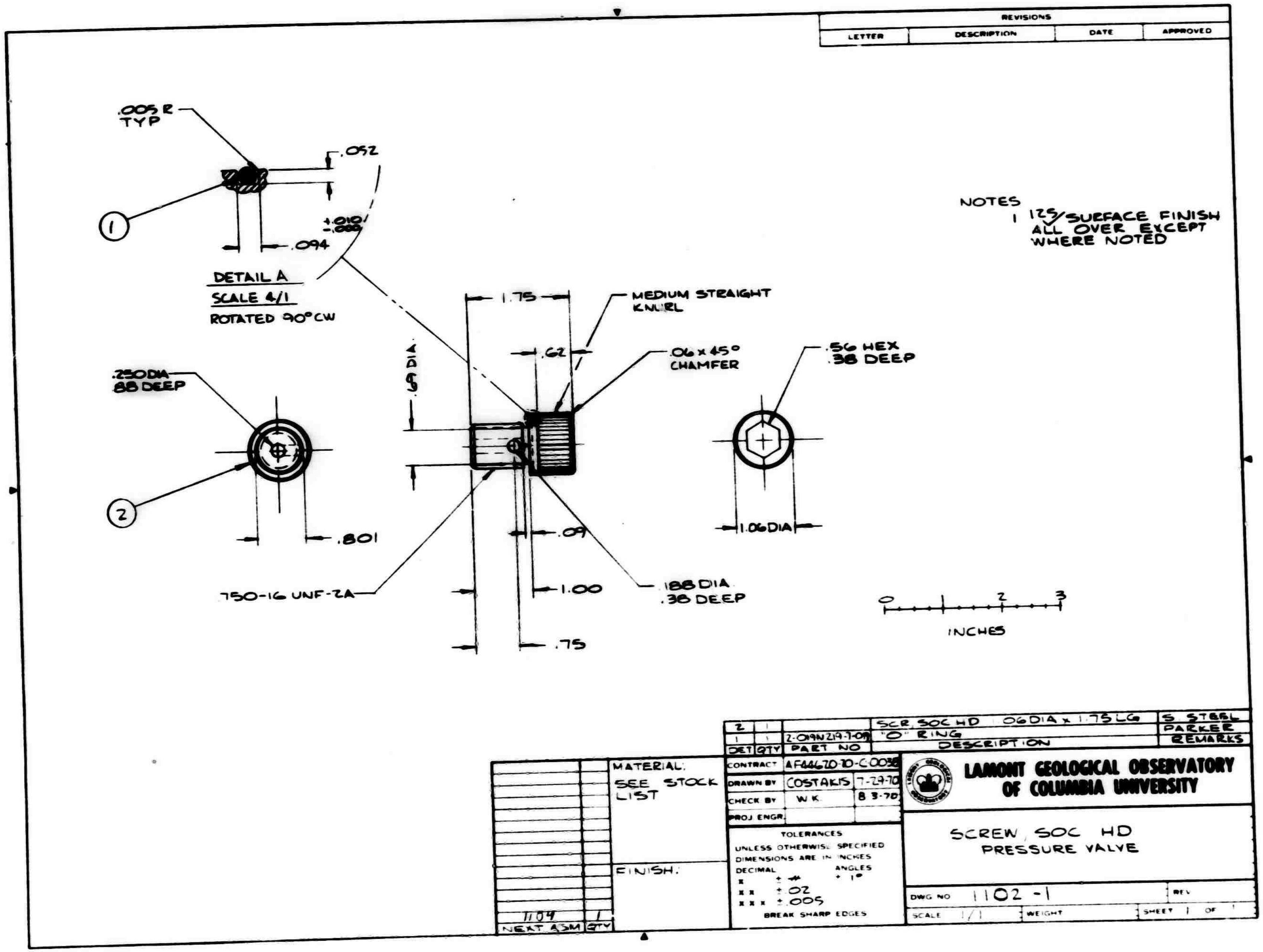
W.O. NO A-537

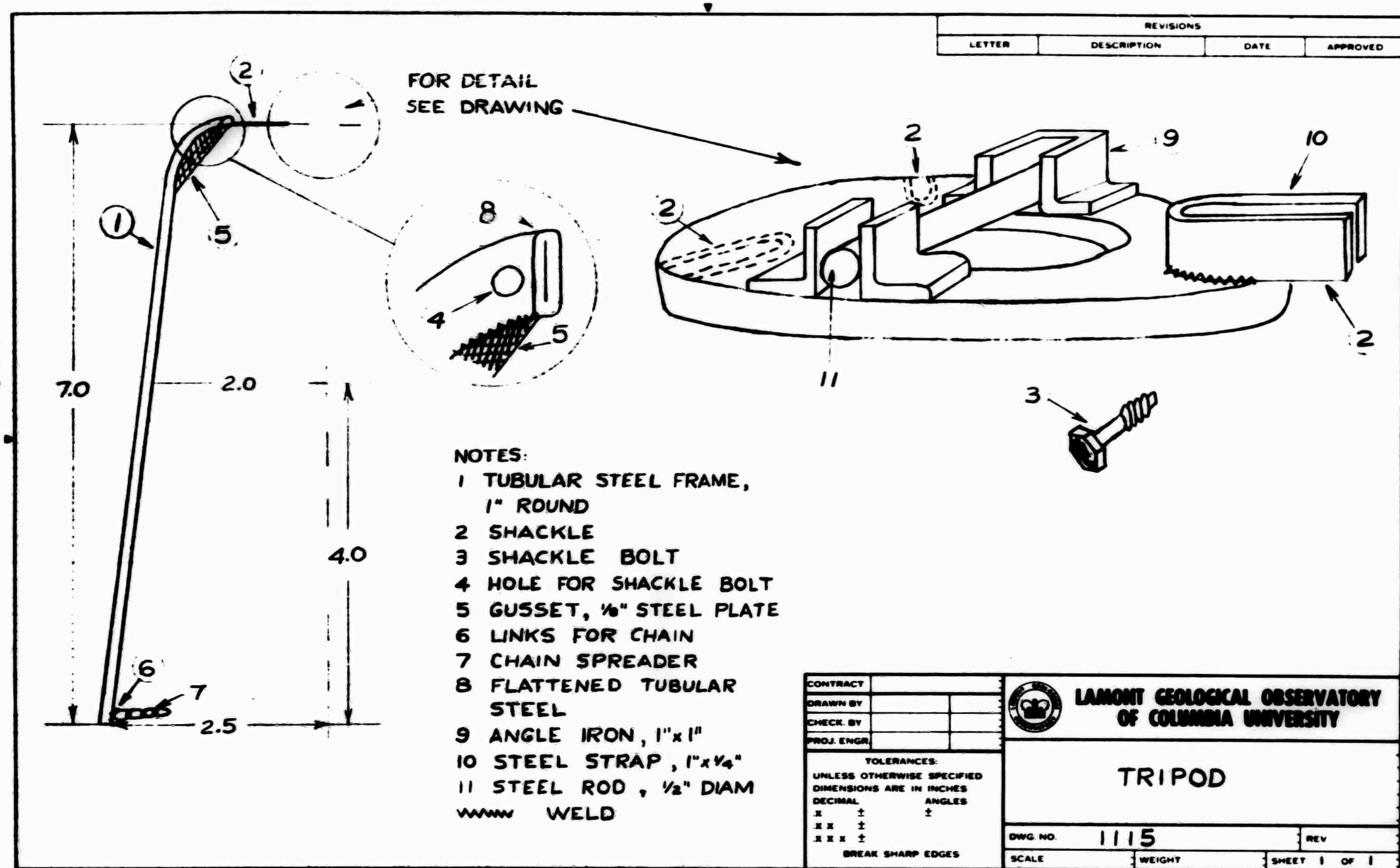
BLANK PAGE


REVISIONS
LETTER
DESCRIPTION
DATE
APPROVED
1
2
3.00
.12
NOTE 2
.38
SILVER SOLDER
1.50 DIA (STOCK)
1.00-12 UNF-2B
NOTES
1 STAMP OR STENCIL PART NO WHERE INDICATED
2 FIT 1.00 PIPE NIPPLE TO SUIT AT ASM.
0
1
2
3
INCHES
BUSHING .38 x 1.50 DIA
BRASS 1/2 HARD
NIPPLE PIPE 1.00 ID x 4.00 LG
STEEL
ITEM
QTY
PART NO
DESCRIPTION
REMARKS
MATERIAL:
SEE STOCK LIST
FINISH:
NEXT ASM
QTY
CONTRACT
AF 44620-70-C-0038
DRAWN BY
H. COSTAKIS
7/1/70
CHECK BY
W. KLINZMAN
7/14/70
PROJ ENGR
TOLERANCES
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
DECIMAL
ANGLES
±1°
.XX ±.02
.XXX ±.005
BREAK SHARP EDGES
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
ADAPTER, PIPE
DWG NO
1101
REV
SCALE
1/1
WEIGHT
SHEET
OF
ASD



REVISIONS
LETTER
DESCRIPTION
DATE
APPROVED
NOTE 1
3.06
.12
NC #2
SILVER SOLDER
.38
1.94 DIA
.750-16 UNF-2B
NOTES
1 STAMP OR STENCIL PART NO WHERE INDICATED
2 FIT 1.00 PIPE NIPPLE TO SUIT AT ASM
0 1 2 3
INCHES
BUSHING .38 x 1.94 DIA
NIPPLE, PIPE 1.00 I.D. x 4.00 LG
BRASS 1/2 HARD
STEEL
DET
QTY
PART NO
DESCRIPTION
REMARKS
MATERIAL: SEE STOCK LIST
FINISH:
NEXT ASM
QTY
CONTRACT
DRAWN BY COSTAKIS 7-29-70
CHECK BY W.K. 8-3-70
PROJ ENGR
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
TOLERANCES
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DECIMAL
ANGLES ± 1°
± .02
± .005
BREAK SHARP EDGES
PRESSURE VALVE ADAPTER, PIPE
DWG NO 11C2
REV
SCALE 1/1
WEIGHT
SHEET 1 OF 1


REVISIONS
LETTER
DESCRIPTION
DATE
APPROVED
.005 R TYP
.052
+.010 -.000
.094
DETAIL A
SCALE 4/1
ROTATED 90°CW
.250 DIA .88 DEEP
.801
750-16 UNF-2A
1.75
.62
.69 DIA
MEDIUM STRAIGHT KNURL
.06 x 45° CHAMFER
.09
1.00
.75
.188 DIA .38 DEEP
.56 HEX .38 DEEP
1.06 DIA
NOTES
1 125/SURFACE FINISH ALL OVER EXCEPT WHERE NOTED
0 1 2 3
INCHES
2 1 SCR, SOC HD .06 DIA x 1.75 LG S STEEL
1 1 2-019N219-7-09 "O" RING PARKER
DET QTY PART NO DESCRIPTION REMARKS
CONTRACT AF44620-70-C-0038
DRAWN BY COSTAKIS 7-29-70
CHECK BY W.K. 8-3-70
PROJ ENGR
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
MATERIAL: SEE STOCK LIST
FINISH:
TOLERANCES
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DECIMAL ANGLES
X ± .4 ± 1°
X X ± .02
X X X ± .005
BREAK SHARP EDGES
SCREW, SOC HD PRESSURE VALVE
DWG NO 1102-1
REV
SCALE 1/1
WEIGHT
SHEET 1 OF 1
1104 1
NEXT ASM QTY


REVISIONS
LETTER
DESCRIPTION
DATE
APPROVED
FOR DETAIL SEE DRAWING
7.0
2.0
4.0
2.5
NOTES:
1 TUBULAR STEEL FRAME, 1" ROUND
2 SHACKLE
3 SHACKLE BOLT
4 HOLE FOR SHACKLE BOLT
5 GUSSET, 1/8" STEEL PLATE
6 LINKS FOR CHAIN
7 CHAIN SPREADER
8 FLATTENED TUBULAR STEEL
9 ANGLE IRON, 1"x1"
10 STEEL STRAP, 1"x1/4"
11 STEEL ROD, 1/2" DIAM
WWW WELD
CONTRACT
DRAWN BY
CHECK. BY
PROJ. ENGR.
TOLERANCES:
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
DECIMAL
ANGLES
.x ±
.xx ±
.xxx ±
±
BREAK SHARP EDGES
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
TRIPOD
DWG. NO. 1115
REV
SCALE
WEIGHT
SHEET 1 OF 1

1200-1

M2-7505A

OPERATION AND MAINTENANCE MANUAL

LONG-PERIOD VERTICAL SEISMOMETER, MODEL 7505A

GEOTECH
A TELEDYNE COMPANY
3401 Shiloh Road
Garland, Texas

104

10 July 1968

BLANK PAGE

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF ILLUSTRATIONS

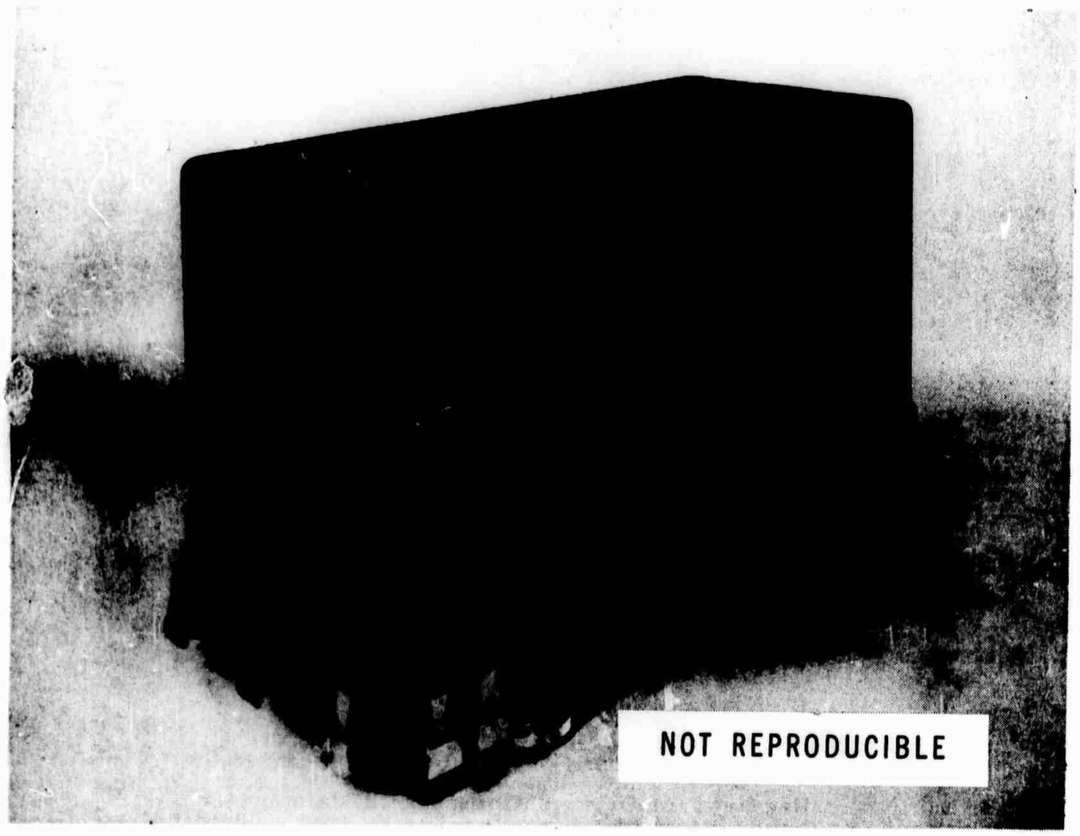
LIST OF ILLUSTRATIONS (Cont'd)

LIST OF TABLES

INTRODUCTION

This publication contains technical instructions for Long Period Vertical Seismometer, Model 7505A, a highly sensitive electromechanical device which converts vertical motion into electrical signals. The publication consists of seven chapters bound in one volume. Chapter 1 contains general information and leading particulars; the installation phase is covered in Chapter 2; Chapter 3 (operating instructions) is not applicable, principles of operation are described in Chapter 4; Chapter 5 provides instructions for maintenance and overhaul; Chapter 6 is the illustrated parts breakdown· Chapter 7 contains complete circuit diagrams for the unit. The following publications govern t e u e of abbreviations, symbols, and reference designations in this publication:

Abbreviations for Use on Drawings and in Technical-Type Publications
Electrical and Electronic Symbols
Electrical and Electronic Reference Designations



108

Figure 1-1. Long Period Vertical Seismometer, Model 7505A

CHAPTER I
GENERAL INFORMATION

1-1. DESCRIPTION AND PURPOSE.

1-2. Long-Period Vertical Seismometer, Model 7505A, is a highly sensitive electromechanical device, using two moving coils and two magnets to convert vertical motion into electric signals. The Seismometer has an adjustable natural period (10-30 seconds); its outputs are normally proportional to velocity of the vertical motion. When the cover is properly secured, the Seismometer is sealed against water and barometric pressure changes. This pressure-seal plus the internal heater assembly permit operation under adverse environmental conditions. The Seismometer is shown in figure 1-1.

1-3. INFORMATION AND REFERENCE TABLES.

1-4. Tables 1-1 through 1-4 contain information which will be helpful in the operation and maintenance of the Seismometer.

Table 1-1. Leading Particulars

A-c power	4.0 v, 150 ma, 60 cps (for Mass Position Monitor)
	115 v, 350 ma, 60 cps (for Remote Centering Unit)
D-c power	22.5 v, 1.5 ma (for Mass Position Monitor)
	24 v, 115 ma (for Seismometer Heater)
	24 v, 1.5 amps maximum (for Thermal Jacket Heater)
Weight	160 pounds
Dimensions	15.5 x 12 x 24 inches

Table 1-2. Capabilities and Limitations

Natural period	10 to 30 seconds, adjustable
Weight of inertial mass	10 kg ±1%
Transducer:	
Type	Moving coil
Damping	Electromagnetic
Effective generator constant	105 v/meter/sec (each coil)
Maximum flux density in air gap	1950 ±100 gauss

Table 1-2. Capabilities and Limitations (Cont'd)

Data coil:	
Number of coils	Two
Terminal resistance	565 ±10 ohms (each coil) at 77° F (25°C)
Turns	3260
Wire size	No. 36
Length of wire	1324 feet
Inductance	Negligible
Calibration coil:	
Number	One per data coil
Resistance	0.2 ± 0.05 ohms at 77°F (25°C)
Turns	1
Wire size	No. 36
Effective motor constant	0.032 newtons/amp ±0.002 newtons/amp
Critical damping resistance	80 times natural period, in ohms ±10%
Spring rate	10.3 lbs per inch ±3%
Thermal Jacket (accessory which houses Seismometer)	
Inputs	5 (to Seismometer) 1 (to Thermal Jacket heater)
Heater power required	24 vdc, 1.5 amp (maximum)
Air leak rate	8 hr time constant from 1-1/2 psig differential
Dimensions	36 inches (height) x 43 inches (diameter)
Pressure	Insensitive to normal atmospheric variations
Humidity	0 to 95%
Mass Position Monitor (accessory mounted on Seismometer)	
Output	Zero to ±1.5 vdc (maximum)
Power required	1.5 ma at 22.5 vdc 150 ma at 4 vac, 60 cps
Dimensions	1-1/4 x 3-1/4 x 1-3/4 inches
Weight	0.25 pounds
Remote Centering Motor (accessory mounted on Seismometer)	
Type	Synchronous, single phase, bidirectional

Table 1-2. Capabilities and Limitations (Cont'd)

Number of poles	6
Speed	1200 rpm reduced to 25.8 rpm by gear box
Power required	[illegible]0 ma. at 115 vac, 60 cps

Table 1-3. Equipment Supplied

NAME	QUANTITY	DESCRIPTION AND PURPOSE
Long-Period Vertical Transducer, Model 7505A	1	Moving-coil Transducer to convert vertical motion into electrical [illegible]
Connector, P101	1	MS3106A-20-4P
Connector, P102	1	MS3106A-20-11S
Connector, P104	1	MS3106A-10SL-4S
Cable clamp	2	MS3057-12
Cable clamp	1	MS3057-4
Calibration kit: (1 weight, 200 mg, and 1 spool of silk thread)	1	Used to deflect the mass when testing Transducer
Expanded polystyrene insulating cover, Part No. 16375	1	Used as insulation to minimize the effects of temperature [illegible]
Glass Insulator Assemblies, Part Nos. 16954-1, 16954-2, and 16954-3 (1 each)	3	Used to support, level, [illegible] Transducer
Wrench, Part No. 1118-2	2	Used to adjust and lock leveling screws when installing the Transducer
Plug, Pipe, 1/4 in. NPTF	1	Used to seal Transducer case
Shipping Crate	1	Special container used during [illegible]
Adjustor Assembly, Part No. 10220 (Supplied when Remote Centering Accessory No. 10075 is not installed at factory)	1	Use to manually adjust the mass position mechanism
Thermal Jacket, Model 14414*	1	Houses and isolates the Transducer from pressure and temperature changes
Mass Position Monitor, Model 10073*	1	Used to generate mass position signal for external indicator (Monitor mounted on Transducer)
Remote Centering Accessory, Model 10075*	1	Used to center boom travel when [illegible] ducer is at rest (mounted [illegible]

*Not furnished. Available as optional accessory.

Table 1-4. Equipment Required but not Supplied

QUANTITY	EQUIPMENT	MODEL OR DESCRIPTION
1	Vacuum Tube Voltmeter (VTVM)	Hewlett-Packard, Model 410B, or equivalent
1	Microvoltmeter	Hewlett-Packard, Model 425A, or equivalent
1	Wheatstone Bridge	Leeds and Northrup, Model 5300, Type S, or equivalent
2	Power Supply	Hewlett-Packard, Model 721A (or equivalent)
1	Helicorder Amplifier	Geotech, Model 4983, or equivalent
1	Volt-Ohm Milliammeter	Triplett, Model 630, or equivalent
1	Helicorder	Geotech, Model 2484-1, or equivalent
1	Electric Timer	Standard, Model S-1
1	Potentiometer (500 ohms, 2 watts)	Any manufacture
1	Decade Resistor	General Radio, Model 1432-N, or equivalent
1	Decade Voltage Divider	General Radio, Model 1454-A, or equivalent
1	Battery	Burgess No. TW-2 or equivalent
1	Resistor, 100 ohms, 10 watts	Any manufacture
1	Stop Watch	Type A-8
2	Power Supply	Hewlett-Packard, Model 721A, or equivalent
1	Hand Pump	Any manufacture
1	Air Pressure Gauge	Fisher 0-20 oz/in^2 or equivalent
1	Aneroid Barometer	Any manufacture; 0.02 inches of mercury/division

112

Table 1-4 Equipment Required but not Supplied (Cont'd)

QUANTITY	EQUIPMENT	MODEL OR DESCRIPTION
1 tube	Sealant	Permatex No. 2 or equivalent
1	Pressure test adapter **	For performing pressure test of Seismometer
	1 valve cap	For tank valve
	1 tank valve	Schrader No. 645A6
	1 bushing	3/8 in. to 1/4 in., ID
	1 reducing tee	3/8 in. x 3/8 in. x 1/4 in.
	1 nipple	1/4 in. ID x 1-1/2 in. long
	1 bushing	1/4 in. ID to 1/4 in. dryseal
	1 nipple	3/8 in. ID x 2 in. long
	** Component parts	
1 pkg	Graph paper	10 x 10 divisions/inch (linear), any manufacture
1 pint	Cleaner, soldering	Kester Thinner, Formula 101, or equivalent
1 pint	Flux, soldering	Kester Formula 135 or equivalent (pure resin in alcohol)
1 spool	Solder, thermal free (2 ft.)	Leeds & Northrup 107-1-0-1 or equivalent
1	Phototube Amplifier	Geotech Model 4300 (with 3 cps galvanometer, no. 4100-213, and resistive filter)
1	Thermometer	Mercury, indoor, 2°/division, any manufacturer

113

BLANK PAGE

CHAPTER 2
INSTALLATION

2-1. INTRODUCTION. This chapter provides information necessary to install the Seismometer and to prepare it for operation.

2-2. LOGISTICS.

2-3. UNPACKING. The Seismometer and insulating cover are shipped in a specially designed plywood shipping crate. Connectors, insulators, the calibration kit, the Thermal Jacket, wrenches, etc., are shipped in separate cartons. To unpack the equipment, proceed as follows:

a. Check the packages against table 1-3. Report any missing or damaged items immediately.

b. Place the shipping crate containing the Seismometer near the location selected for installation.

c. Remove the cover of the crate after removing the ten bolts.

d. Remove the tape from the waterproof paper and fold the paper back to expose the expanded polystyrene insulation cover.

e. Carefully lift off the insulation cover.

f. Carefully lift the Seismometer off the expanded polystyrene base and out of the crate.

g. If the Seismometer appears damaged, determine the extent of damage and if necessary, send it to the depot for repairs and adjustment.

h. Remove the shipping covers from the polystyrene base in the bottom of the packing crate, and lift out the two masses and the trim weights. Do not remove the polystyrene base since this material is a part of the shipping crate.

NOTE

Retain the shipping crate and the associated packing material for use in installation or reshipment.

i. Unpack the other containers and examine their contents. Report any shortage or damage immediately.

WARNING

When removing polyutherane wrapping from Seismometer spring, do not rotate or turn spring out of adjustment.

Table 2-1. Estimated Packaged Weights and Dimensions

Case No. 1 (Seismometer)	
Dimensions	17-1/4 x 28-3/4 x 20 inches
Weight	210 pounds
Volume	5.94 cubic feet

Table 2-1. Estimated Packaged Weights and Dimensions (Cont'd)

Case No. 2 (Seismometer parts)	
Dimensions	2 x 8 x 8 inches
Weight	2 pounds
Volume	128 cubic inches
Case No. 3 (Thermal Jacket)	
Dimensions	52 x 52 x 45 inches
Weight	435 pounds
Volume	70 cubic feet
Case No. 4 (Jacket installation materials)	
Dimensions	30 x 30 x 32 inches
Weight	115 pounds
Volume	18.8 cubic feet
Case No. 5 (Jacket installation hardware)	
Dimensions	14 x 14 x 8 inches
Weight	22 pounds
Volume	0.9 cubic feet

2-4. MATERIAL HANDLING. The Seismometer can be transported in a light truck. Two men can handle the unit without special handling equipment. The mass sections (including trim weight) shall be removed from the boom assembly, and the boom assembly shall be locked against the bottom stop by the stop screw when the Seismometer is moved or shipped. A length of polyutherane sheet shall be wrapped and tied securely around the spring. The Seismometer shall be shipped in a specially designed shipping crate. No other special handling precautions are necessary beyond ordinary care to avoid excessive shock, vibration, or temperature extremes.

2-5. INSTALLATION PROCEDURES.

2-6. To install the Seismometer at the selected site, proceed as follows:

a. Insure that Thermal Jacket, Model 14414, has been installed in accordance with TI 2W-1-1.

b. Set glass insulator assemblies on floor of Thermal Jacket, Model 14414, as shown in figure 2-1. Place the Seismometer leveling screw assemblies on these insulators with the rear leveling screw assembly (foot) on insulator A".

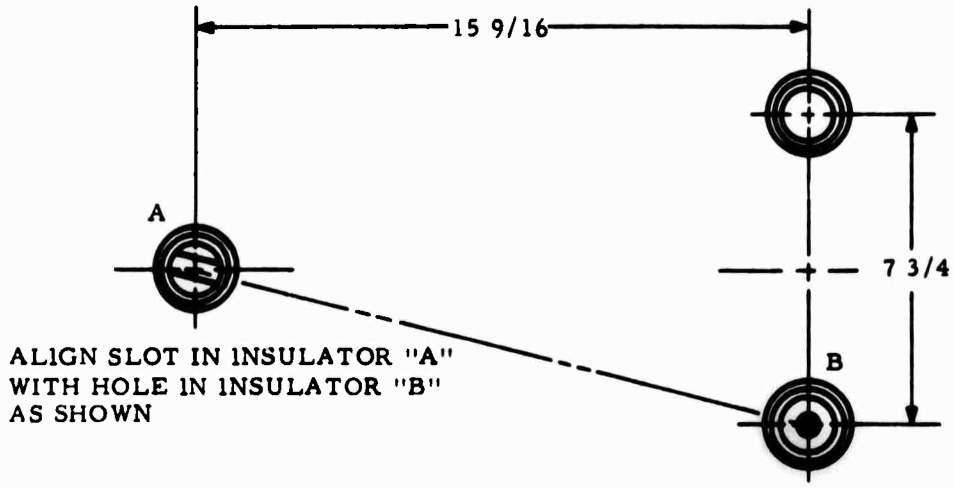


Figure 2-1. Installation of Glass Insulator Assemblies

CAUTION

Do not allow dirt, dust, or moisture to fall into the Seismometer when the cover is off. The presence of foreign material inside the case may affect operation of the Seismometer.

c. Brush all loose insulation, dust, and dirt off the cover. Open the twenty latches and remove the cover. Be careful not to strike the internal parts.

d. Level the Seismometer using the leveling screw assemblies and the level assembly mounted on the base of the instrument. When both bubbles are centered, lock the leveling screws with the two wrenches furnished.

e. Perform tests described in paragraphs 5-9 and 5-10.

f. Remove the polyutherane covering from the spring.

g. Remove the two inertial masses and trim weights (if supplied) from the Seismometer shipping crate. Install the masses and weights using the mounting bolts attached to the boom.

CAUTION

Care must be taken when loosening the stop screw to prevent the boom from swinging upward at a fast rate, thereby damaging the instrument.

h. Loosen the stop screw until the mass position pointer reaches the top of the scale when the boom assembly is lifted.

i. Check that the boom assembly swings freely from stop to stop without binding, sticking, or dragging.

j. If a coil sticks in a magnet assembly air gap, loosen slightly the two screws that hold the coil support to the boom assembly. Shift the coil support until the boom assembly swings freely from stop to stop without binding. Tighten both coil support screws securely. With the boom assembly at the center of its travel, the coils shall be centered in the air gaps of the magnet assemblies.

NOTE

When the coils are in the correct position and the boom assembly is at one of its stops, there is approximately 1/64-inch clearance between the coil and the magnet. The adjustment in step j must be made with care to insure that the coils will have sufficient clearance at both extremes of their travel.

k. Install connectors P101, P102, and P104. (P101 is not used in paralleled data coil hookups). P102 connects to the mass-position, remote-centering, and calibration circuits. P104 connects to the heater circuit.

l. Apply 115 volts a-c between pins M and N of connector P102. The Remote Centering Accessory shall raise the boom assembly. Apply 115 volts a-c between pins L and N of connector P102. The accessory shall lower the boom assembly. Again apply 115 volts a-c between pins M and N of connector P102 to bring the boom assembly to the center of its travel.

m. Replace the Seismometer cover and secure the twenty latches.

n. Replace the plastic shipping plug with the steel pipe plug, with threads coated with Permatex No. 2 or equivalent sealant.

o. Perform the tests and adjustments described in paragraph 5-13.

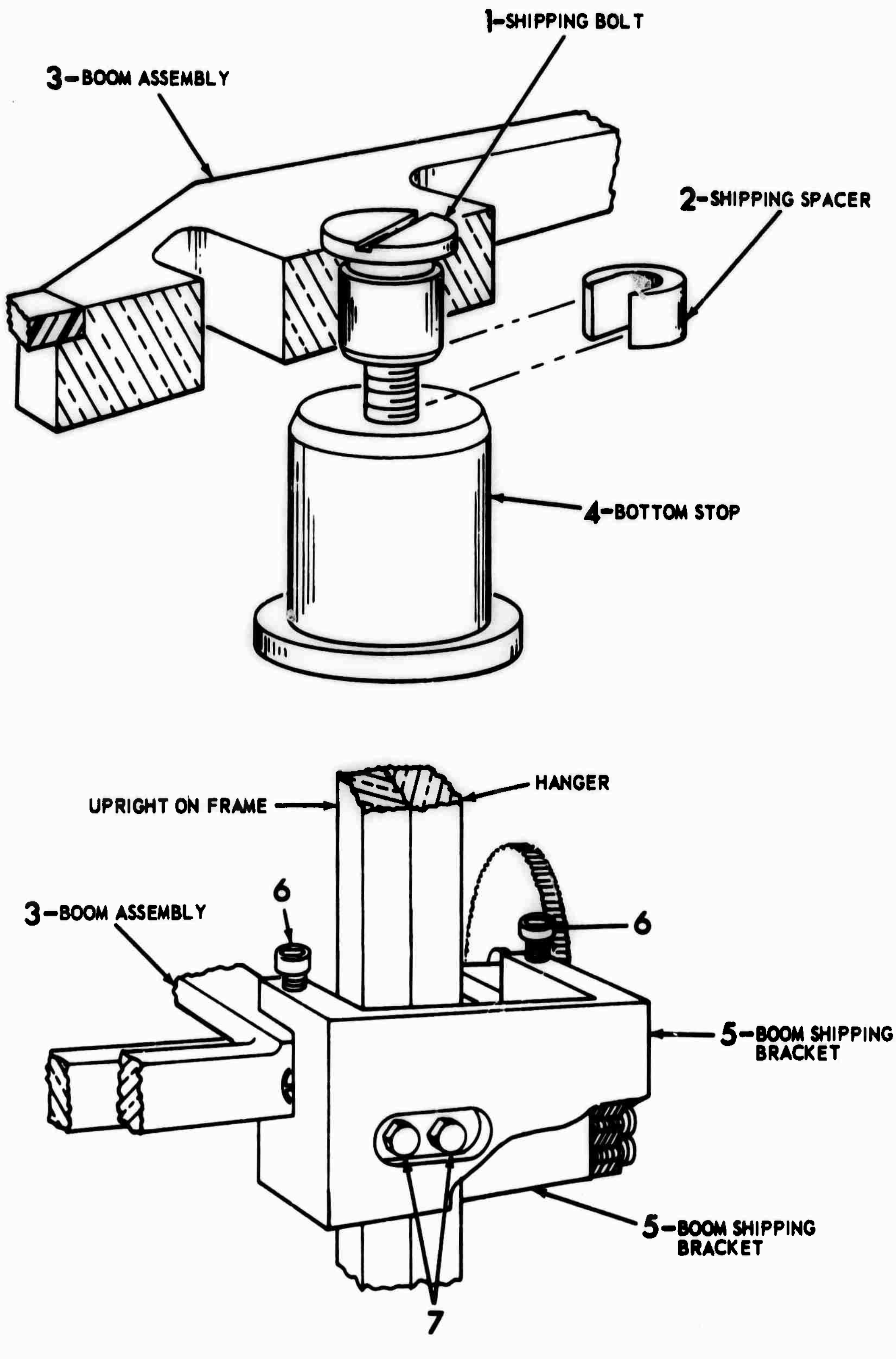


Figure 2-2. Shipping Bolt and Spacer, and Shipping Bracket Installation

G 1655

NOTE

When the coils are in the correct position and the boom assembly is at one of its stops, there is approximately 1/64-inch clearance between the coil and the magnet. The adjustment in step j must be made with care to insure that the coils will have sufficient clearance at both extremes of their travel.

m. Install connectors P101, P102, and P104. (P101 is not used in paralleled data coil hookups). P102 connects to the mass-position, remote-centering, and calibration circuits. P104 connects to the heater circuit.

n. Apply 115 volts a-c between pins M and N of connector P102. The Remote Centering Accessory shall raise the boom assembly. Apply 115 volts a-c between pins L and N of connector P102. The accessory shall lower the boom assembly. Again apply 115 volts a-c between pins M and N of connector P102 to bring the boom assembly to the center of its travel.

o. Replace the Seismometer cover and secure the 20 latches.

p. Replace the plastic shipping plug with the steel pipe plug, with threads coated with Permatex No. 2 or equivalent sealant.

q. Perform the tests and adjustments described in paragraph 5-13.

r. Install and tighten down Thermal Jacket lid until metal to metal contact is made between the retaining ring and the side of the tank.

2-7. PREPARATION FOR RESHIPMENT.

2-8. DISCONNECTING AND LOCKING. If it is necessary to reship the Seismometer, proceed as follows before repacking:

a. Remove Thermal Jacket lid and plastic insulation bags. Remove the Seismometer from the Thermal Jacket. Remove the insulation covering from the Seismometer.

b. Remove connectors P101 from receptacle J101 and P102 from receptacle J102. Remove leads from binding posts E101 and E102. Remove connector P104 from receptacle J104 in cover.

c. Remove pipe plug from Seismometer cover and replace with special vented plug. Use of the special shipping plug is important to prevent excessive internal pressures during high-altitude air shipment.

CAUTION

Do not allow dirt, dust, or moisture to fall into the Seismometer when the cover is off. The presence of foreign material inside the case may affect operation of the Seismometer.

d. Brush all loose insulation, dust, and dirt off the cover. Open the 20 latches and remove the cover. Be careful that the cover does not strike any internal parts.

NOTE

Item numbers in parentheses in steps e through i refer to index numbers appearing in figure 2-2.

e. Place the shipping spacer (4) between the boom (3) and the bottom stop (4).

f. Tighten the stop screw finger-tight against the boom (3).

g. Attach and secure the shipping brackets (5).

h. Remove the stop screw and secure it to the frame with tape.

i. Install the shipping bolt (1).

j. Wrap and tie the spring with polyutherane or some damping material such as foam rubber.

k. Replace the cover and secure the 20 latches. Screw in the leveling screws.

2-9. REPACKING. To repack the Seismometer, proceed as follows:

a. Place the Seismometer in the shipping crate taking care to set leveling screws in the cutouts in the insulation.

b. Cover the Seismometer with the expanded polystyrene insulation and waterproof paper. Seal the waterproof paper with waterproof, pressure-sensitive tape.

c. Replace the cover of the shipping crate and secure it with the 14 bolts.

d. Pack the connectors, glass insulator assemblies, calibration kit, adjustor, insulation cover, and wrenches in a cardboard carton.

CHAPTER 3
OPERATION

NOT APPLICABLE

is called the External Critical Damping Resistance (CDRX) at that frequency. Critical damping is defined as the amount of damping that will return the boom assembly (after a deflection) to the center of its travel in the shortest time without overshoot and without appreciable reduction of deflection. CDRX varies inversely with the natural frequency and must be redetermined whenever the natural frequency of the Seismometer is changed.

4-8. REMOTE CALIBRATION.

4-9. A calibration coil is wound on the same form as each main coil and is located within the field of the same magnet. A current pulse applied to either calibration coil will deflect the boom assembly. The amount and rate of deflection is determined by the current, the characteristics of the deflection system (wiring configuration, resistance, voltage, etc.), the amount of damping in each main coil, and the known motor constant of each calibration coil. The output of the main coils is determined by their generator constants and how they are wired to the output circuit (independently or in parallel). If the input current to the calibration coils is known, the output of the main coils may be used for remote calibration of the Seismometer. Since the characteristics of the Seismometer change when the natural frequency is changed, the Seismometer must be recalibrated for each new natural frequency. The motor constants of the calibration coils do not vary with natural frequency; this allows remote calibration without knowledge of the natural frequency.

4-10. REMOTE CENTERING.

4-11. Best results are obtained if the inertial mass rests at the center of its travel when it is not deflected by motion. Under these conditions the characteristics of the suspension system and the portions of the magnetic fields traversed by the signal coils are symmetrical. Large temperature changes, especially during the first few weeks after installation, will cause the Seismometer inertial mass to rest off center. The inertial mass can be centered by changing the static balance of the boom assembly by moving the mass position trim weight. This can be accomplished manually with an adjustment plate or with the Remote Centering Accessory Motor.

4-12. MASS POSITION MONITOR.

4-13. The Mass Position Monitor Accessory produces a mass position signal at any time desired. The accessory consists of a lamp, an aperture, and a Wheatstone bridge consisting of two photoresistors and two fixed resistors. The aperture is mounted on the boom assembly in the light path between the lamp and the photoresistors. When the inertial mass is in the center of its travel, the aperture allows an equal amount of light to fall on each of the photoresistors. In this condition, the bridge is balanced. When the inertial mass is off center, the aperture premits more light to fall on one photoresistor than to the other, unbalancing the bridge. The amount and direction of unbalance is determined by the amount and direction that the inertial mass is off center. The unbalance of the bridge can be sensed by connecting a zero-center microammeter across the output terminals of the bridge.

4-14. HEATER.

4-15. The Seismometer Heater (see figure 7-1) consists of three power resistors mounted under the top of the Seismometer cover inside the instrument. This heater assembly is operated from a unit which supplies a 0-24 volt d-c input. The heater serves to stratify the air in the instrument case, thus, minimizing noise produced by air flow caused by temperature inversion.

4-16. THERMAL JACKET.

4-17. The Thermal Jacket is a special tank used to house the Seismometer. This tank is designed to isolate the Seismometer from barometric and temperature changes by: (1.) air stratification within the tank by heating the top of the tank with an internal heater, and by (2.) being nearly air-tight (the leak-rate time constant is 8 hours).

CHAPTER 5

MAINTENANCE

5.1 INTRODUCTION. This chapter contains information necessary to maintain the Seismometer. Section I covers organizational and field maintenance; Section II covers special maintenance.

SECTION I

ORGANIZATIONAL/FIELD MAINTENANCE

5-2. GENERAL. Test equipment required for organizational/field maintenance is listed in table 5-1. Performance tests and standards are listed in Section II. Those tests not specifically noted as depot or special tests may be performed in the field.

NOTE

Equipment characteristics shown in table 5-1 are the characteristics required to test the Seismometer and do not necessarily reflect the full capabilities of the equipment.

Table 5-1. Test Equipment Required for Organizational/Field Maintenance

EQUIPMENT	MANUFACTURER AND MODEL NO.	REQUIRED CHARACTERISTICS
Vacuum Tube Voltmeter (VTVM)	Hewlett-Packard Model 410B (or equivalent	Ohmmeter range: Zero to 500K ohms
Battery	Burgess No TW-2 or equivalent	12 volts
Potentiometer	Any manufacturer	Zero to 500 ohms, 2 watts
Power Supply (2 each)	Hewlett-Packard Model 721A (or equivalent)	22.5 volts d-c, 1.5 ma 4 volts d-c, 150 ma

CHAPTER 4

PRINCIPLES OF OPERATION

4-1. INTRODUCTION. This chapter contains information that will help the experienced maintenance technician understand the operat'on of the Seismometer. Refer to Chapter 6 for parts identification. A schematic diagram is shown in Chapter 7.

4-2. OPERATION OF TRANSDUCER.

4-3. The transducer converts vertical motion into electrical signals. Vertical motion is transmitted through the frame to two magnet assemblies. This causes a relative motion between the magnets and the main coils, located within tne fields of the magnets. The coils are mounted at the end of the boom assembly with the 10 kg inertial mass. The boom assembly is mounted on flexure pivots and tends to remain stationary. Relative motion between the magnets and the coils generates voltages in the coils proportional to either the velocity, acceleration, or displacement of the relative motion, depending on the natural frequency of the Seismometer. Two coils and two magnets are used to minimize "piston effect" and to improve linearity of the instrument.

4-4. SUSPENSION SYSTEM. The suspension system for the inertial mass assembly and the main coils consists of the two-section boom assembly, which is mounted on the frame by two flexure pivot assemblies; and a spring which is mounted by flexure pivot assemblies between the boom assembly and the frame. The flexure pivot assemblies permit relative motion between the Seismometer frame and the boom assembly in a vertical direction, but prevent such motion in the horizontal direction. Flexure pivot assemblies operate by bending flexure ribbons of spring brass rather han by the movement of bearing surfaces. Since there is no contact between moving parts of the suspension system, friction is eliminated and mechanical losses are reduced to the relatively small losses of the flexure ribbons.

4-5. The restoring force of the suspension system is provided by gravity and the spring. The geometry of the suspension system causes the spring to act as if it had zero length. Since movement of the boom assembly does not change the characteristics of the spring, linearity of period is maintained even though the relative mass position changes. Adjustments of mass position and period are made by adjustments on the boom assembly rather than by changing the length of the spring. The characteristics of the suspension system is not affected by these adjustments. The flexure pivot assemblies provide a small additional restoring force, bringing the period into the correct range.

4-6. NATURAL FREQUENCY. The natural or resonant frequency is the frequency at which the boom assembly would oscillate if it were undamped and set in motion. The natural frequency is determined by the spring specifications and mounting geometry, the weight of the inertial mass, and the setting of the period adjustment. Gravity and the spring assembly provide the major restoring forces. Changing the position of the period adjustment provides a natural frequency of any value between 0.033 and 0.1 cps. Stated another way; the natural period the reciprocal of the natural frequency, can be adjusted to any value between 10 and 30 seconds per cycle.

4-7. DAMPING. The voltage induced in the main coils causes a current to flow through them and the external load. As this current flows through the main coils, it creates forces which tend to oppose or damp the motion. Thus, electromagnetic damping is provided in the transducer by the action of induced current in the main coil assemblies. The amount of damping is determined by the total resistance in the main coil circuits and may be controlled by adjusting the external load. The amount of external load required for critical damping of each transducer at a given natural frequency

CHAPTER 5
MAINTENANCE

5.1 INTRODUCTION. This chapter contains information necessary to maintain the Seismometer. Section I covers organizational and field maintenance; Section II covers special maintenance.

SECTION I
ORGANIZATIONAL/FIELD MAINTENANCE

5-2. GENERAL. Test equipment required for organizational/field maintenance is listed in table 5-1. Performance tests and standards are listed in Section II. Those tests not specifically noted as depot or special tests may be performed in the field.

NOTE

Equipment characteristics shown in table 5-1 are the characteristics required to test the Seismometer and do not necessarily reflect the full capabilities of the equipment.

Table 5-1. Test Equipment Required for Organizational/Field Maintenance

EQUIPMENT	MANUFACTURER AND MODEL NO.	REQUIRED CHARACTERISTICS
Vacuum Tube Voltmeter (VTVM)	Hewlett-Packard Model 410B (or equivalent	Ohmmeter range: Zero to 500K ohms
Battery	Burgess No. TW-2 or equivalent	12 volts
Potentiometer	Any manufacturer	Zero to 500 ohms, 2 watts
Power Supply (2 each)	Hewlett-Packard Model 721A (or equivalent)	22.5 volts d-c, 1.5 ma 4 volts d-c, 150 ma

5-3. VOLTAGE REQUIREMENTS AND SOURCES. Table 5-2 lists the voltage requirements, their purposes, and suggested test sources.

Table 5-2. Voltage Requirements and Sources

REQUIREMENT	PURPOSE	SUGGESTED TEST SOURCE
4 volts a-c or d-c 150 milliamperes	Excite mass position monitor lamp	Power Supply - Hewlett-Packard, Model 721A (or equivalent)
115 volts a-c, 60 cps	Operate remote centering motor	Commercial or standard 115 volt a-c power source
22.5 volts d-c	Excite mass pos tion monitor photoresistor	Power Supply, Hewlett-Packard, Model 721A (or equivalent)

5-4. THERMAL FREE SOLDERING PROCEDURE. A special solder is used in the transducer coil assembly connections to reduce the generation of thermal voltages. When necessary to resolder a thermal free connection (usually painted bright green), use the following procedure:

a. Use a new soldering tip tinned with thermal free solder. Do not use this tip for any purpose other than soldering with thermal free solder.

b. Use any standard soldering iron from 30 watts to 200 watts, depending on the size of conductors to be soldered.

c. Use a clean and uncontaminated flux and apply with a non-metallic applicator. The flux must be pure resin in alcohol. (see table 1-4)

d. Clean all conductors to be soldered (with thinner). Tin the conductors using flux (pure resin in alcohol). Place the conductors as close together as possible to reduce the amount of solder necessary to make the joint.

e. Solder the connection. The joint will not have a bright smooth appearance, but may look like a cold joint. These joints, if properly made, are electrically and mechanically sound.

f. Paint the joint bright green to identify it as a thermal free connection during future repairs or wiring changes.

g. Do not allow soldering tip to overheat or become badly oxidized. Re-tin as necessary with thermal free solder.

SECTION II

SPECIAL MAINTENANCE

5-5. SPECIAL TOOLS AND TEST EQUIPMENT.

5-6. No special tools or special test equipment is required.

5-7. BENCH TEST.

5-8. Refer to table 1-4 for test equipment required to test the Seismometer.

NOTE

Use of test procedures described in this section may be performed at field level as prescribed by current operating instructions.

5-9 COIL RESISTANCE. This test may be performed in the field as well as the depot with limitations so noted herein. When the test is performed in the field, steps 1 through 4, table 5-3, are applicable. In the depot, steps 1A through 4A, table 5-3, are applicable. Prior to performing this test, lock the suspension system except as noted. To remove the cover and lock the suspension system, proceed as follows:

NOTE

If the test is being performed as a preinstallation test, the suspension system is locked and steps a through d may be omitted.

a. Remove the Thermal Jacket cover. Remove insulation cover (and any other materials) from the Seismometer. Remove connecto s P102 and P104 from connectors J102 and J104, respectively.

b. Brush all loose insulation, dust, and dirt off the Seismometer cover.

CAUTION

Do not allow dirt, dust, or moisture to fall into the Seismometer case when the cover is off. The presence of foreign material inside the case may affect operation of the Seismometer.

c. Remove cover being careful not to strike the internal parts.

d. Tighten the stop screw to lock the boom assembly against the bottom stop.

CAUTION

Since it is desirable to test the coil windings in the field without removing the cover, extreme care must be used in checking continuity without locking the suspension system. Use a range on the ohmmeter that presents the lowest voltage to the coils being tested, to avoid a violent movement of the boom assembly.

e. Replace cover and pressure test in accordance with paragraph 5-49. Measure resistance as indicated in table 5-3.

NOTE

Measurements in table 5-3 are for data coils connected separately. For data coils in parallel use one-half the standard (or 290 ohms) in steps 2 and 2A; infinity (open-circuit) for steps 1 and 1A.

Table 5-3. Coil Resistance Measurement

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS	PERFORMANCE STANDARDS
For field use				
1	Use VTVM on RX100 range	Between pins C and B on J101	Not applicable	Resistance shall measure 580 ohms ±20 ohms
2	As in step 1	Between E101 and E102	Not applicable	Resistance shall measure 580 ohms ±20 ohms
3	Use VTVM on RX1 range	Between pins D and A on J101	Not applicable	Meter shall measure 0.8 ±0.16 ohm
4	As in step 3	Between pins J and H on J102	Not applicable	Meter shall measure 0.8 ±0.16 ohm
For depot use				
1A	Use Wheatstone bridge (refer to table 1-4) adjusted to 1000 ohm range	Between pins C and B on J101	Not applicable	Resistance shall measure 580 ohms ±20 ohms
2A	As in step 1A	Between E101 and E102	Not applicable	Resistance shall measure 580 ohms ±20 ohms
3A	Use Wheatstone bridge adjusted to lowest range	Between pins D and A on J101	Not applicable	Resistance shall measure 0.8 ±0.16 ohm
4A	As in step 3A	Between pins J and H on J102	Not applicable	Resistance shall measure 0.8 ±0.16 ohm

5-10. INSULATION RESISTANCE. This test may be performed in the field as well as the depot. Be sure the suspension system is locked as in paragraph 5-9. Measure resistance as in table 5-4.

Table 5-4. Insula ion Resistance

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS	PERFORMANCE STANDARDS
1	Use VTVM on RX1 megohm range	Between pin A on J101 and ground	Not applicable	Resistance shal' measure 1 megohm minimum
2	As in step 1	Between B on J10 and ground	Not applicable	Resistance shall measure 1 megohm minimum
3	As in step 1	Between E101 and ground	Not applicable	Resistance shall measure 1 megohm minimum
4	As in step 1	Between pin H on J102 and ground	Not applicable	Resistance shall measure 1 megohm minimum

5-11. MASS CENTERING, NATURAL PERIOD, AND DAMPING. This test may be performed in the field as well as the depot with limitations as noted herein. To center the mass, find and adjust the natural period, and check the damping, perform the following steps:

NOTE

During the performance of this test, the mass sections shall be assembled to the boom, and the suspension system shall not be locked in any way. For tests performed in the field, do not remove the cover unless such removal has been specifically authorized by current operating instructions.

a. Level the Seismometer by adjusting the leveling screws while observing the level vials on the instrument. In the field, if the instrument was leveled during installation, it may be assumed to be level.

b. Apply heater power (24 volts, d-c) to J104 for 30 minutes to temperature-stabilize the instrument. If the cover has been removed, allow the Seismometer to reach the temperature of its surroundings. This may require as long as 12 hours

c. Connect a temporary short circuit between the terminal posts E101 and E102 to damp the mass movement.

d. Adjust the large gear of the Remote Centering Accessory until the mass position pointer, visible through the window in the front of the cover, is in the center of its scale. This adjustment may be performed either by momentarily app ying power to the Remote Center ng Accessory motor or by turning the gear with the adjuster assembly furnished (see figure 5-1).

NOTE

When operating the Remote Centering Accessory electrically, apply 115 volts a-c between pins L and N of receptacle J102 to move the mass down. Apply 115 volts a-c between pins M and N to move the mass up.

e. Remove the temporary short circuit from terminal posts E101 and E102

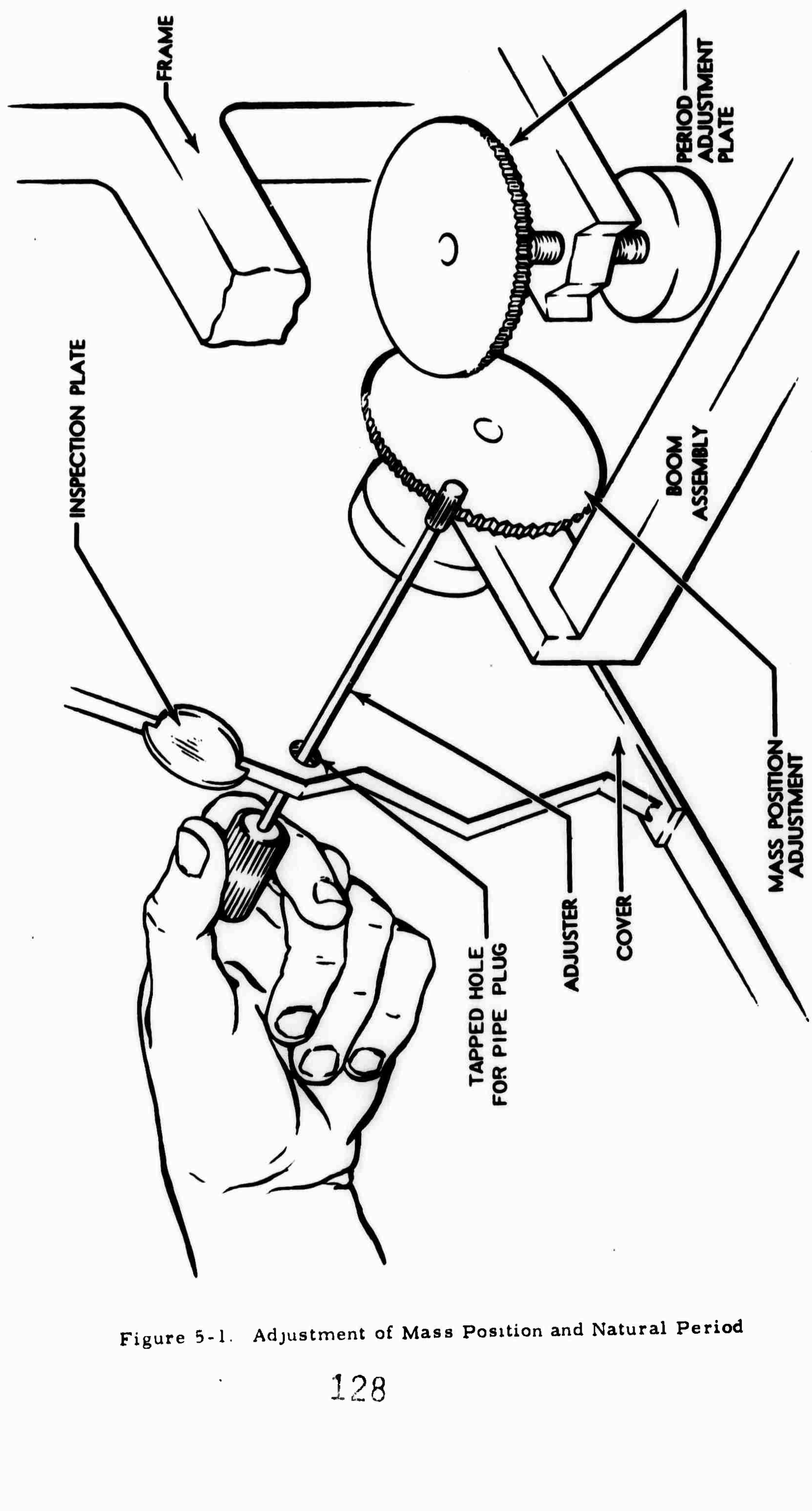


Figure 5-1. Adjustment of Mass Position and Natural Period

f. Connect the equipment as shown in figure 5-2 for the bottom coil. For field tests see figure 5-3. Adjust R1 for the lowest voltage that will give a usable deflection of the boom assembly when the switch is closed momentarily. Adjust R2 (figure 5-2) to approximately 10,000 ohms.

CAUTION

To avoid damage to the transducer, do not allow the current through the calibration coils to exceed 50 ma.

g. Set the boom assembly in motion by momentarily closing switch S1.

h. Using a stop watch, determine the time required for the pointer on the microvoltmeter to swing from zero to a maximum in one direction, back to zero, to a maximum in the other direction and back again to zero. The time required for this cycle is the natural period of the Seismometer. More accurate results are obtained if 3 to 5 initial cycles are timed and the results averaged.

NOTE

If this test is performed in the field and a stop watch is not available, use an ordinary watch having a sweep second hand.

i. If the test is being performed in the field, observe the mass position pointer through the window in the front of the Seismometer cover and time the cycle as in step h. Accuracy of the test is highest when performed with a recorder such as used in table 5-5.

j. If the natural period is not correct, adjust the large knurled adjustment plate as shown in figure 5-1. Turn the plate clockwise to increase the period; turn the plate counterclockwise to decrease the period.

k. After performing the adjustment described in step j, repeat steps g and h or i to determine the new period.

NOTE

The suspension system is subject to drift during the first few days following installation. It may be necessary to readjust the natural period every day during this initial period. Once this initial period is past, the Seismometer will continue to operate for a long time with only occasional slight readjustments.

l. Graph the output of the transducer or observe on a recorder. The output shall be a damped wave train reducing in amplitude over several cycles in the standard pattern for damped waves. Amplitude of the initial half cycle and the number of cycles in the wave train are dependent upon the magnitude of the electrical pulse to the calibration coil.

m. Check the electromagnetic damping by repeating step g and then shorting E101 and E102. The mass position pointer shall stop moving immediately, and the pointer of the microvoltmeter shall not move after the short is removed.

n. Disconnect the test equipment.

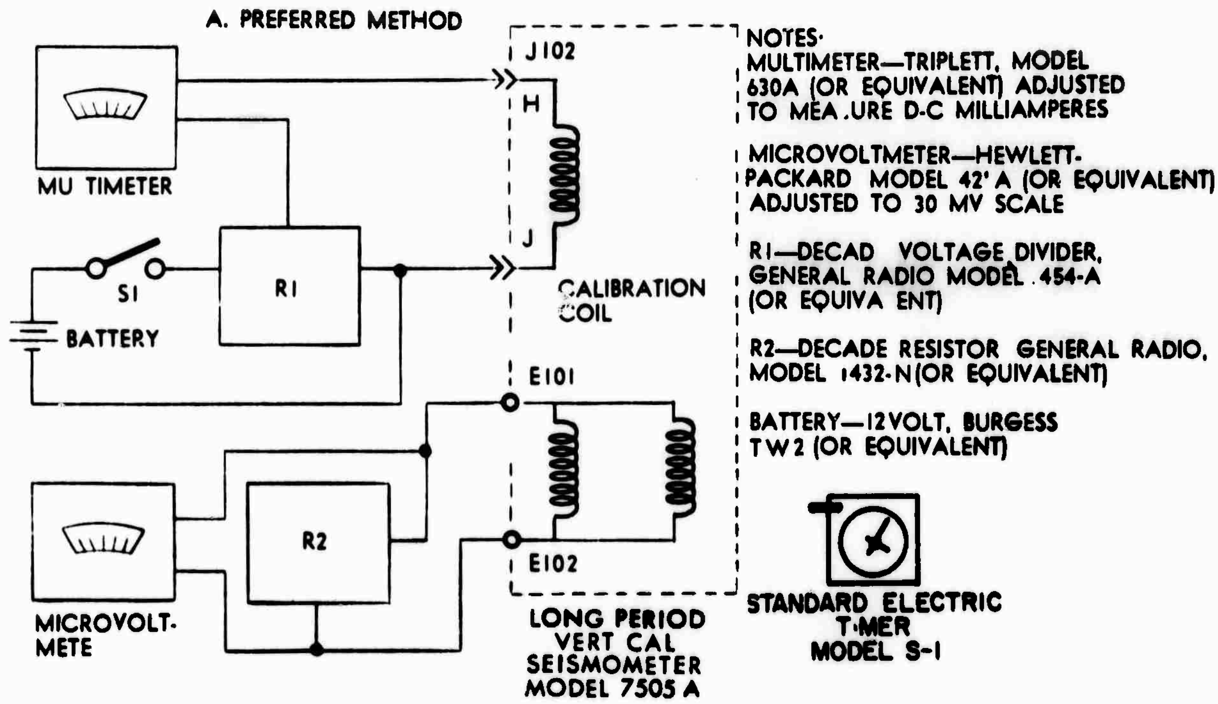


Figure 5-2 Tes Arrangement for Natural Period, and Damping (Depot Method)

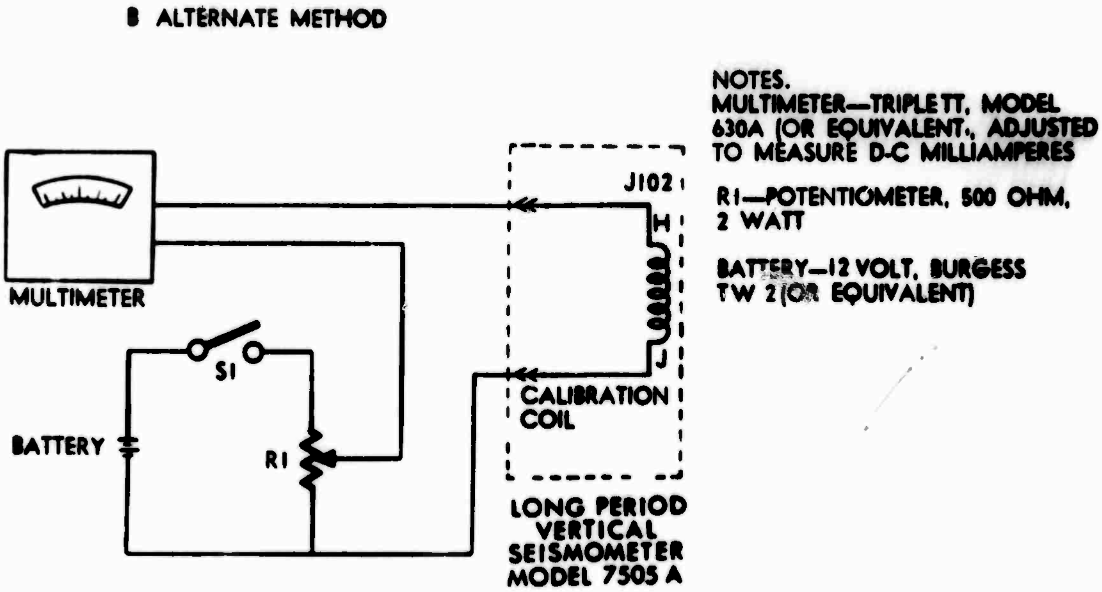


Figure 5-3 Test Arrangement for Natural Period, and Damping (Field Method)

5-12. PERFORMANCE TESTS.

5-13. WEIGHT LIFTS. When the instructions for a performance test state that weight lifts must be performed, proceed as follows: (These instructions assume that test equipment has been connected and weight lifts must be recorded.)

a. Level the Seismometer and adjust it for the correct period and mass position as described in paragraph -11.

b. Brush all loose in ulation, dust, and dirt from the top of the cover. Open the twenty latches and remove the cover from the Seismome er Be careful not to strike the internal parts with the cover.

CAUTION

Do not allow dirt dust, or moisture to fall into the Seismometer when the cover is off The presence of foreign material inside the case may affect operation of the Seismometer

c. Attach a short piece of thread to the 200 milligram test weight.

d. Place the test weight on the boom assembly at the indicated mark near the flexure pivots.

e. When the boom assembly has come to rest and when the test equipment is ready, li t the test weight sharply, holding it by the thread. The movement must be as nearly vertical as p ssible. Do not touch any part of the Seismometer; do not allow the test weight to touch any part of the Seismometer. Record and measure the deflection. The deflec ion may be either pos tive or negative depending on the polarity of the connect ons at E101 and E102. See the note at the bottom of page 5-11

f. When the required measurement is complete, replace the test weight on the boom as embly. Wait until t e boom assembly has come to rest, and then repeat step e Average the results of several weight lifts.

g. After replacing and latching the cover, replace the pipe plug in the cover (see figure 5-1).

Table 5-5. Performance Standards

Test No 1 Critical Damping Resistance (CDR)

PRELIMINARY INSTRUCTIONS: Determine both signal coi resistances as described in paragraph 5-9 to an accuracy of ±10 ohms Unlock suspension arm. Level the Seismometer and adjust for correct period and mass position. Determine the free period as described in paragraph 5-11. Connect test circuit as shown in figure 5-4.

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
1A		E101 and E 02	Perform weight lift as described in paragraph 5-13	

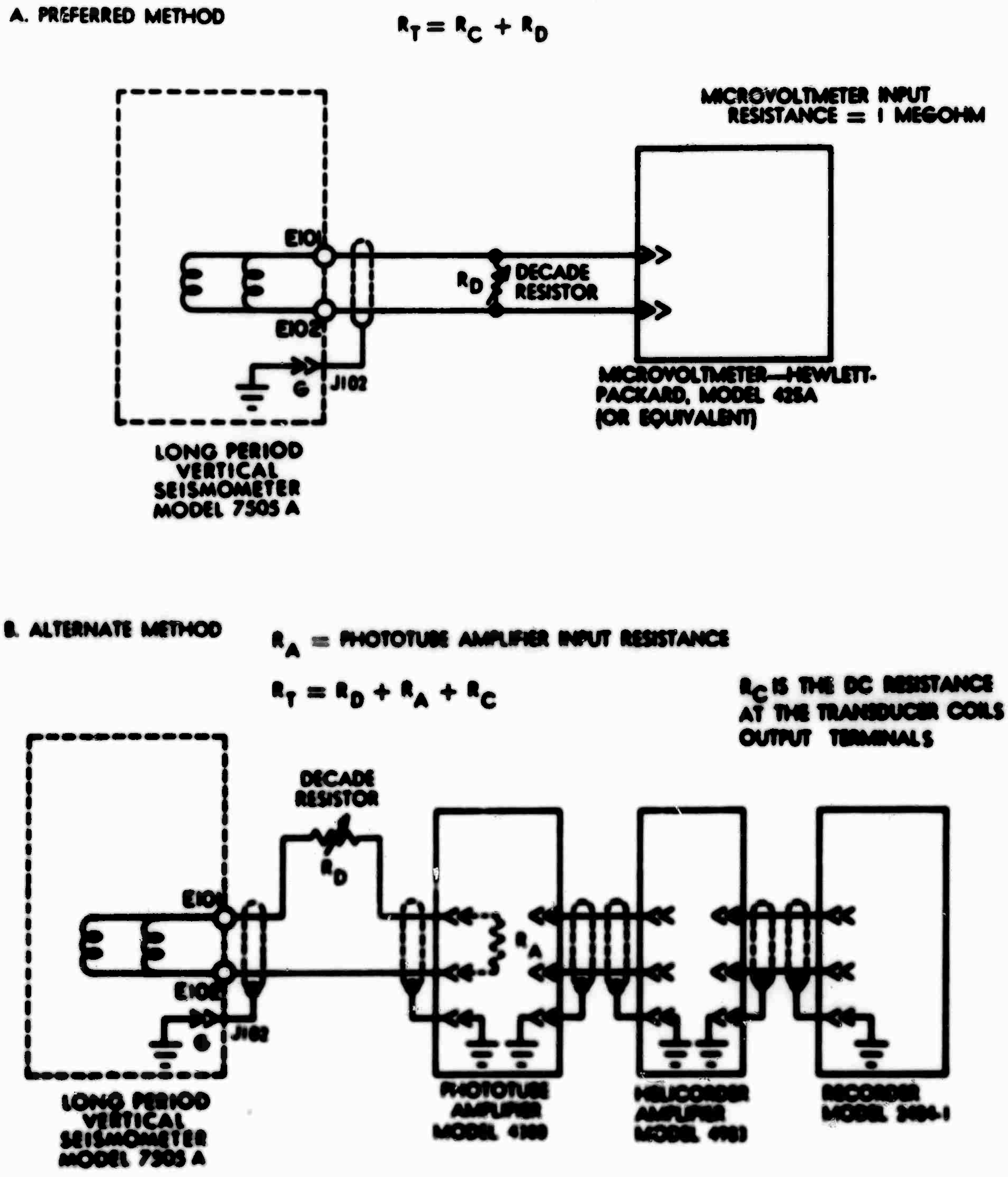
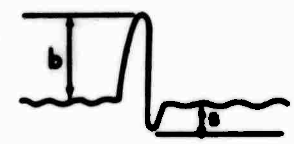


Figure 5-4. Test Setup for Critical Damping Resistance (CDR)

Table 5-5. Performance Standards (Cont'd)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
1B	Adjust decade resistor R_D until overshoot is between 20% and 25% (See note below)	E101 and E102	Repeat weight lifts as described in paragraph 5-13	a.  b. Percent overshoot = a/b x 100 c. Determine ratio of actual damping to critical damping (λ) from table 5-6
1C	Disconnect test equipment			a. Calculate the critical damping resistance (CDR) using the formula CDR = $R_T \times \lambda$* b. CDR = 80 x free period in ohms

Test No. 2 External Critical Damping Resistance (CDRX)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
2A				a. Calculate the external critical resistance (CDRX) using the formula CDRX = CDR-R_C* b. CDRX = 1600-290 ohms = 1310 ohms ±10% at t = 20 sec (coils connected in parallel)

NOTE

Polarity of transducer output should be positive when mass is moved down; negative when mass is moved up (or when weight is lifted).

* For preferred method $R_T = \frac{R_C}{2} + R_D$

For alternate method $R_T = \frac{R_C}{2} + R_D + R_A$

R_A = Input resistance of Phototube Amplifier

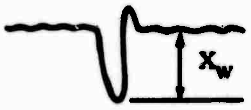
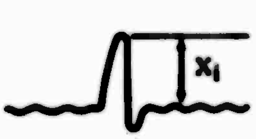
R_C = Resistance of data coil (d-c)

R_D = Resistance of decade resistor

Table 5-5. Performance Standards (Cont'd)

Test No. 3 Calibration Coil Motor Constant (G)

PRELIMINARY INSTRUCTIONS: Connect test circuit as shown in figure 5-5.

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
3A		E101 and E102	Perform weight lifts as described in paragraph 5-13, using 200 mg test weight Remove test weight before proceeding to next step.	a.  b Measure and record X_w in millimeters for each weight lift
3B	Complete circuit through top calibration coil as shown in figure 5-5. Close switch S1 and observe initial deflection. The deflection should be in the same direction as that of step 3A. If it is not, reverse battery connections. Leave S1 closed until the mass stops moving. Open S1 and record and measure the resulting deflection This deflection must be in the opposite direction to the deflection of step 3A.	E101 and E102	Not applicable **CAUTION** **Do not permit the current through the calibration coils to exceed 50 milliamperes at any time. To do so will damage the coils.**	
3C	Adjust variable resistor while opening and closing circuit through calibration coil, until X_i caused by opening circuit is within 10% of X_w	E101, E102		a. Measure and record X_i in millimeters  b. Record current (i) through calibration coil in amperes (zero-to-peak)

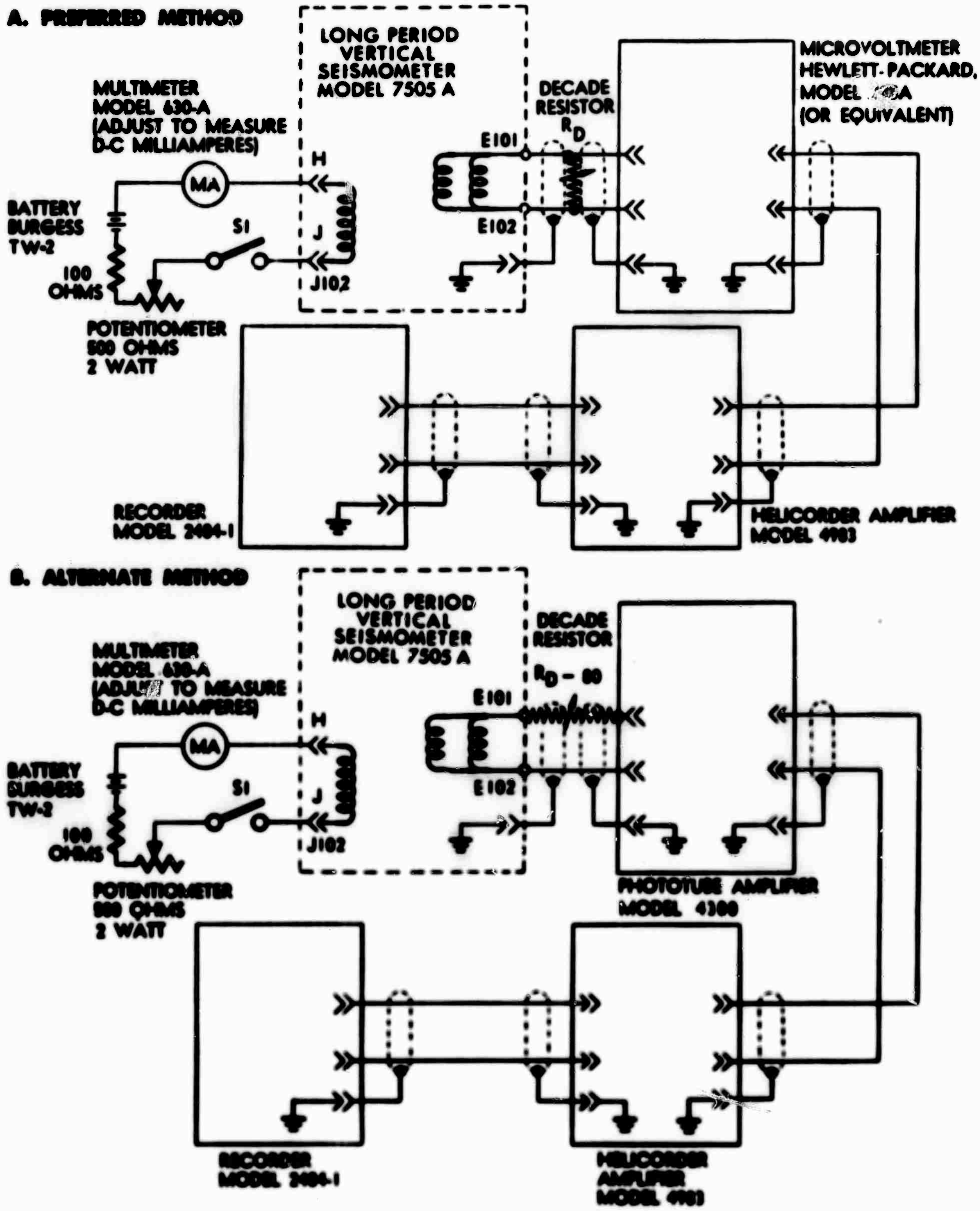


Figure 5-5. Test Setup for Calibration Coil Motor Constant (G)

Table 5-5. Performance Standards (Cont'd)

Test No. 3 Calibration Coil Motor Constant (G) (Cont'd)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
3D	Disconnect the test equipment			a. Calculate the motor constant of both calibration coils in newtons/ampere using the formula:* $G = \frac{980 \times 10^{-6} \times 0.04}{i} \left(\frac{X_i}{X_w}\right)$ b. G = .032 ±.002 newtons/ampere per coil

Test No. 4 Mass Position Monitor Alignment

PRELIMINARY INSTRUCTIONS: Remove the cover from the Seismometer (paragraph 5-17) and block the suspension arm with a small piece of wood. Be careful to block the arm with the mass position pointer centered on its scale. Check that the bar on the face of each photoresistor is vertical. Loosen the two screws holding the aperture to the boom assembly and adjust the aperture to be parallel to the face of the photoresistor housing and within 1/32 inch of the face. The aperture shall not touch the face of the photoresistor housing at any point in the travel of the suspension arm. Tighten the screw to secure the aperture clip to the arm.

Connect the test circuit as shown in figure 5-6.

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
4A	Set the power supplies for the voltages shown in the diagram. Set the microammeter to the 100 microamp scale	J102, pins A, B, C, D, E, and F		

* Top calibration coil is not used in parallel data coil configuration.

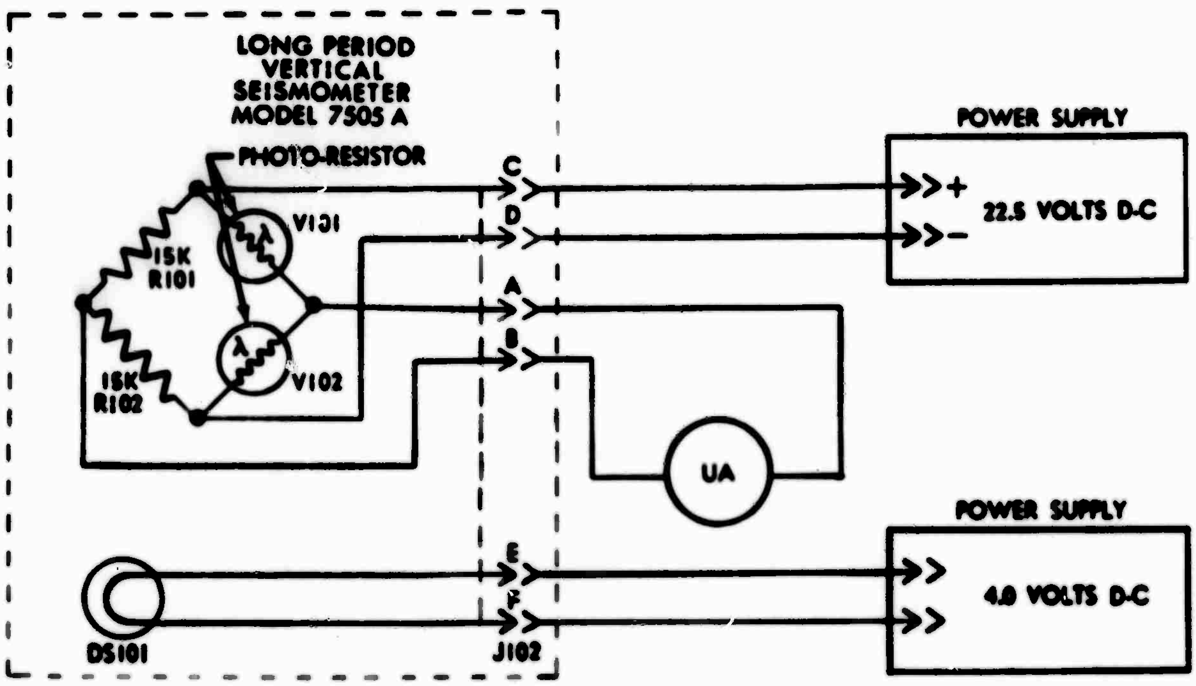


Figure 5-6. Test Setup for Mass Position Monitor Alignment

Table 5-5. Performance Standards (Cont'd)

Test No. 4 Mass Position Monitor Alignment (Cont'd)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
4B	Close the test circuits	J102 pins A and B	Loosen the two screws holding the aperture to the aperture clip on the suspension arm. Adjust the aperture until the microammeter reads zero. Tighten the screws, being careful not to disturb the adjustment.	Microammeter reads zero
4C		J102 pins A and B	Remove the block from the suspension arm. Carefully swing the arm from one stop to the other	The reading of the microammeter shall increase smoothly in one direction as the suspension arm swings toward a stop. The reading shall then decrease smoothly in the

Table 5-5. Performance Standards (Cont'd)

Test No. 4 Mass Position Monitor Alignment (Cont'd)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARDS
				other direction as the arm swings through center to the other stop.
4D	Disconnect test equipment			

Table 5-6. Ratio of Actual Damping to Critical Damping (λ)

PERCENT OVERSHOOT	λ
20.0	0.455
20.5	0.449
21.0	0.444
21.5	0.439
22.0	0.434
22.5	0.429
23.0	0.424
24.0	0.414
25.0	0.404

5-14. MASS POSITION VS. PERIOD TEST. The purpose of this test is to determine if the spring-mass adjustment, normally made at the factory, is within specified tolerances. After replacement of the spring or of any critical part of the indicator or the suspension system or if any of these parts are loosened or damaged in shipment, it will be necessary to perform this test. To perform this test, proceed as follows:

a. Prepare a graph similar to the one shown in figure 5-7.

b. Remove the cover and level the instrument in accordance with paragraph 5-11.

c. Determine the natural period of the Seismometer with the mass position adjustment at approximately mid-range and the natural period adjustment at its lowest (bottom) position.

d. Make adjustments with the rear leveling screw and the period adjustment so that the natural period is between 15 and 20 seconds. Keep the pointer centered with the mass position adjustment.

e. Plot 10 points on the graph by determining the period at mass positions from -10 to +10 on the pointer scale. Use only the mass position adjustment to change the mass position. Do not disturb the leveling screw adjustment or the period adjustment.

f. If the curve is symmetrical as shown by curve A in figure 5-7, the spring mass adjustment is within tolerance and the instrument is properly balanced.

g. If the curve is not symmetrical and appears as either curve B or curve C, adjustment of the spring is necessary as indicated (see figure 5-7).

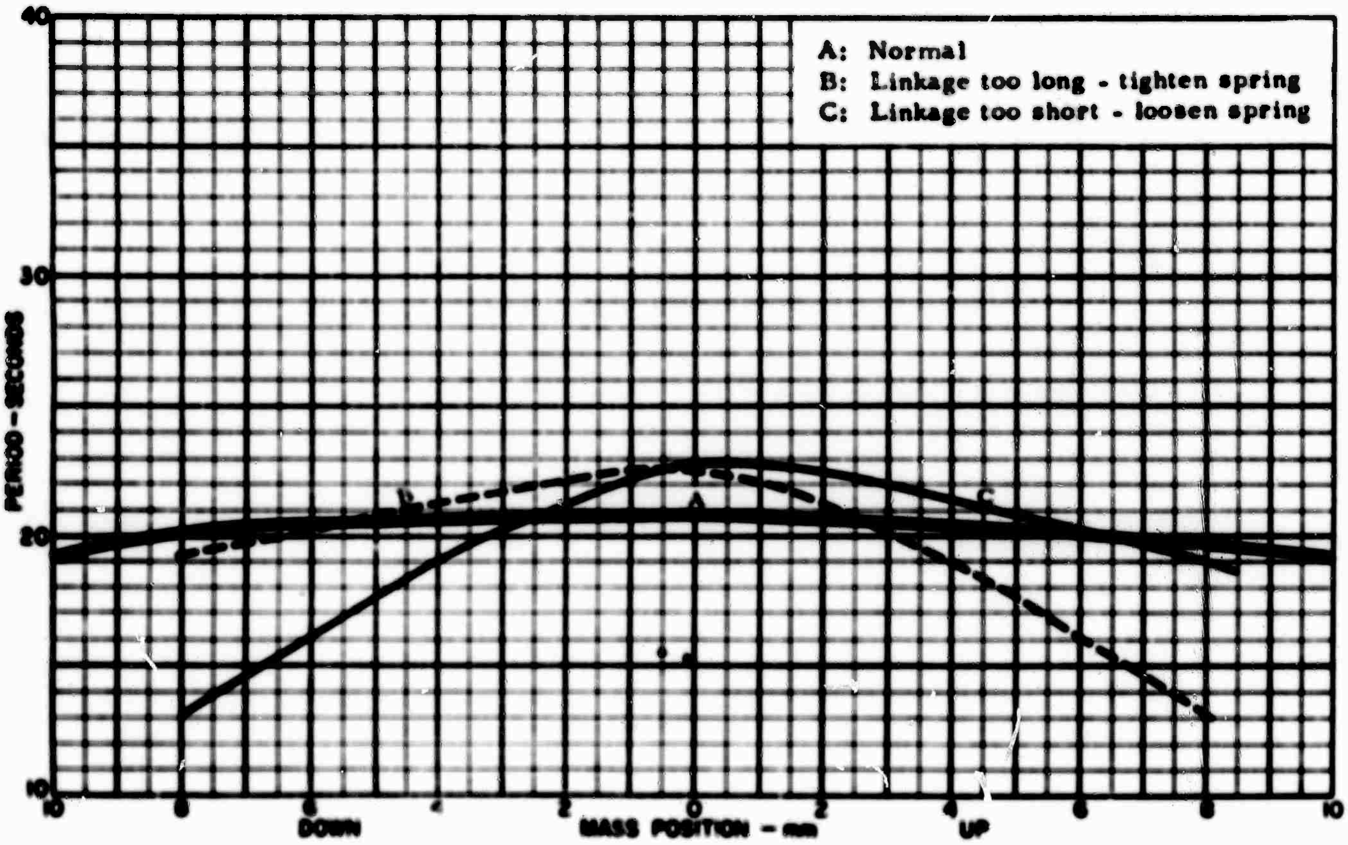


Figure 5-7. Mass Position Vs. Period Graph

NOTE

This adjustment is extremely critical near the point of proper spring tension. Do not turn the spring adjustment screws over 1/8 turn without plotting a new curve to determine if further adjustment is necessary.

h. Repeat steps e and g until a curve is obtained similar to curve A.

i. Level the instrument and adjust the natural period with the period adjustment to the desired frequency in accordance with paragraph 5-11.

j. Replace cover.

5-15. DISASSEMBLY.

5-16. Disassembly is described in the following paragraphs to the extent necessary for replacement and cleaning of critical parts. Further disassembly will rarely be necessary and requires no special instructions. Refer to Chapter 6 for identification and location of parts. The procedures must be performed in the order given; however, do not proceed further than necessary to remove the parts that require cleaning or replacement.

5-17. REMOVAL OF COVER.

5-18. To remove the cover, proceed as follows:

a. Brush all loose insulation, dust, and dirt off the cover. Wipe off any moisture.

CAUTION

Be careful that no dust, dirt, or moisture falls on the Seismometer while the cover is off.

b. Open the twenty latches.

c. Lift the cover straight up. Be careful that the cover doesn't strike any internal parts of the Seismometer.

5-19. REMOVAL OF COIL ASSEMBLIES.

5-20. To remove the coil assemblies, proceed as follows:

a. Remove four socket-head capscrews holding the top magnet assembly to the spacer and remove the magnet assembly.

CAUTION

Cover the magnet gaps with paper or tape to protect gaps from contamination with foreign matter. Be careful to keep magnetic materials away from the magnet.

b. Pull the pointer out of the end of the coil support.

c. Remove the two binder-head screws and the clamping block that hold the coil support and coil assemblies to the boom assembly.

d. Remove the coil support with the coil assemblies. Avoid unnecessary strain on the leads attached to the coils.

e. Separate the coil assemblies, the spacers, and the coil support after removing the screws that hold these parts together.

f. Disconnect the leads from the eight terminal posts of the coil assemblies. Be careful to avoid excessive heat; the plastic coil form melts readily.

NOTE

Use soldering iron tinned with thermal free solder to avoid contamination of leads and terminals.

5-21. REMOVAL OF SPRING AND FLEXURE ASSEMBLIES.

5-22. To remove the spring and the flexure assemblies that support it, proceed as follows:

a. Lock the boom assembly against the bottom stop by tightening the stop screw.

b. Remove the inertial masses from the boom assembly after removing the bolt that holds each mass in place.

c. Release the spring tension by loosening the adjusting nut at each end of the spring.

d. When the spring is relaxed, support the spring with one hand and remove the adjusting nut from the top end of the spring.

e. Lift the upper flexure assembly out of the hanger.

f. Remove the spring with the lower flexure assembly.

g. Inspect the flexure ribbons of both flexure assemblies to be sure that each is free of nicks, bends, and creases. Remove any defective flexure ribbons after removing the capscrews and clamp blocks that hold them in place.

5-23. REMOVAL OF BOOM ASSEMBLY AND MAIN PIVOTS.

5-24. To remove the boom assembly and the main pivots, proceed as follows:

a. Disconnect the fine wires that connect the three terminal boards of the boom assembly to the three terminal boards on the frame.

b. Remove the aperture from the boom assembly after removing the two screws that hold it in place.

c. Remove the screw that secures each of the two flexure pivot blocks (located under the boom assembly) to the hanger.

d. Loosen the friction screws in the bottom stop until the stop screw can be turned freely. Carefully support the boom assembly with one hand and remove the stop screw.

CAUTION

Handle the boom assembly and pivots with extreme care to avoid bending the flexure ribbons.

e. Carefully work the two flexure pivot blocks off the dowel pins.

f. When the flexure pivot blocks are free, slide the boom assembly forward, and remove it from the Seismometer.

g. Remove the four capscrews that secure the period support assembly.

h. Remove the capscrew that secures each of the two flexure pivot blocks to the boom assembly. Lift each of these two blocks off the dowel pins. Remove both sets of flexure pivots from the boom assembly.

i. Inspect the flexure ribbons to be sure that each is free of nicks, bends, and creases. Remove any defective flexure ribbons after removing the capscrews and clamp blocks that hold them in place.

5-25. CLEANING.

5-26. GENERAL. Cleaning disassembled parts includes refinishing or recoating the parts as necessary. The cleaning methods used must be adequate for the conditions without being harsh or injurious. Painting or coating with corrosion resistant compounds shall be limited to the exterior of the Seismometer.

5-27. The Seismometer operates as a sealed unit and should not require extensive cleaning unless a failure in the seal has allowed the entrance of dust, dirt, or moisture. Normally, wiping the parts carefully with a clean dry cloth, or brushing out any dust with a soft-bristled brush will be sufficient. If a solvent is necessary, use trichloroethylene sparingly and wipe clean of any deposited film. Do not use trichloroethylene or any other solvent on the plastic parts of the Seismometer.

WARNING

Trichloroethylene is extremely poisonous. Use only in a well-ventilated area.

5-28. CORRODED PARTS. If corrosion is present, it may be removed with very fine sandpaper or steel wool. Remove the magnet assemblies from the frame before reconditioning any part of the frame. Do not allow any steel particles to enter the air gaps in the magnet assemblies. The tolerances of the working parts of the Seismometer are very close; severely corroded parts shall be replaced. Do not attempt to sand or otherwise recondition the flexure plates, the coil assemblies, or the magnets. Brush or wipe off all foreign particles and apply a thin coat of grease (Fiske Bros. Refining Co., Lubriplate 630AA, or equivalent) or rust preventative (Humble Oil and Refining, Rust-Ban 392, or equivalent) after removing corrosion. Do not allow any grease or rust preventative to enter the magnet air gaps. When reassembling the Seismometer, perform the adjustments described in paragraph 5-31. After the Seismometer has been reassembled, perform the tests and adjustments described in paragraph 5-12.

5-29. CLEANING THE AIR GAPS. Clean the air gaps in the magnet assemblies before installing the coil assemblies. Remove particles from the gaps using a nonmetallic rod tipped with masking tape, sticky side out. Be careful to avoid causing nicks or burrs in the gaps or at their edges. Keep magnetic materials away from the air gaps.

NOTE

Upper magnet assembly has shunts on the outside of the magnet case.

5-30. REASSEMBLY AND ADJUSTMENT.

5-31. The reassembly instructions in the following paragraphs begin where the disassembly procedures in paragraph 5-15 stopped. If the Seismometer was not disassembled to this extent, begin reassembly at the appropriate paragraph. The procedures must be performed in the order given. Refer to Chapter 6 for identification and location of parts. Be sure to perform all the tests and adjustments described in the reassembly procedures. After reassembly has been completed, perform the tests and adjustments described in paragraph 5-10.

5-32. INSTALLATION OF BOOM ASSEMBLY AND MAIN PIVOT FLEXURE RIBBONS.

5-33. To install the main pivot flexure ribbons and the boom assembly, proceed as follows:

CAUTION

Exercise extreme caution in handling and mounting to avoid bending or damaging the flexure ribbons.

a. Assemble the dowel pins and the flexure ribbons to the flexure pivot blocks, being careful not to bend the ribbons while placing them over the dowel pins. The two left-hand flexure pivot blocks form a pair; the two right-hand flexure pivot blocks form a second pair.

b. Install the clamp blocks in place to secure the flexure ribbons Be sure that there is not dirt, dust, or other foreign matter between the ribbons and the clamp blocks. Orient the clamp blocks so that the edge of the block is aligned with the edge of the flexure pivot block.

c. Install the two 4-40 x 3/8 capscrews that secure each clamp block. Tighten the capscrews until they are snug.

d Place the side of one flexure pivot block of one pair on a smooth flat surface such as a surface plate. Place a 9/32 inch toolmaker's flat under the other flexure pivot block of the pair (see figure 5-8). While holding one block against the surface plate and the other block firmly against the flat, tighten all eight capscrews securely.

e. Repeat step d for the other pair of flexure pivot blocks.

f. Install the two reassembled pairs of flexure pivot blocks on the boom assembly with the dowel pin and capscrew that secures each pair. Tighten the capscrews until they are snug.

g. Install the four capscrews that secure the period support assembly to the two flexure pivot blocks. Tighten the capscrews until they are snug.

h. Place the boom assembly in its position in the frame. Carefully work the two flexure pivot blocks (under the boom assembly) onto the dowel pins at the bottom of the hanger

i. Install the socket-head capscrew that secures each of these two flexure pivot blocks to the hanger. Tighten these screws until they are snug but not tight Align the boom until the side of the boom is parallel to the frame and the distance from boom to frame is the same on both sides. Tighten the screws securely.

j. Install the stop screw and tighten it sufficiently to hold the boom down while the spring is installed.

k. Install the aperture on the boom assembly.

l. Connect the fine wires (No. 40 AWG) between the three terminal boards of the boom assembly (TB101, TB102, and TB105) and the three terminal boards (TB103, TB104, and TB106) on the frame (see figure 7-1).

5-34. INSTALLATION OF SPRING AND FLEXURE ASSEMBLIES.

5-35. To install the spring and the flexure assemblies that support it, proceed as follows:

CAUTION

Exercise care in handling and mounting to avoid bending or otherwise damaging the flexure ribbons.

a. Assemble the upper and lower flexure assemblies with the dowel pins and the 4-40 x 7/16 inch capscrews. Be sure that there is no dirt, dust, or other foreign matter between the flexure ribbons and the clamp blocks. Orient the clamp blocks so that the edge of each block is aligned with the edge of the support, anchor, or yoke to which it is attached. Tighten the capscrews until they are snug but not tight

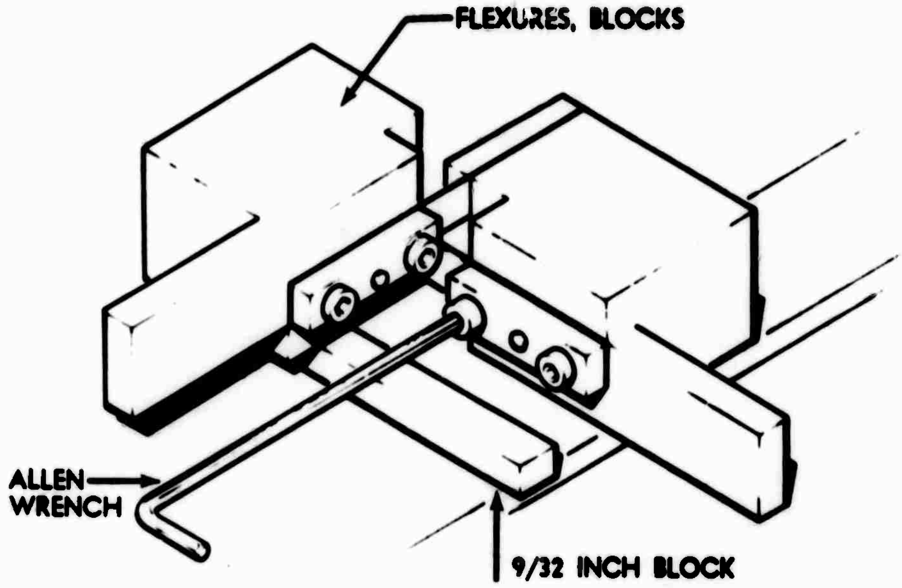


Figure 5-8. Flexure Pivot Reassembly

b. Hang the upper flexure assembly in its position near the top of the hanger.

c. Attach the tie rod at one end of the spring to the lower flexure assembly with one adjusting nut Do not tighten the nut beyond the f rst one or two threads.

d. Hook the lower flexure assembly in the recesses in the boom assembly. Attach the tie rod at the top of the spring to the upper flexure assembly with the adjusting nut.

e. Install both inertial mass sections on the boom assembly with the two large bolts The two dowel pins in the boom assembly prevent installing a mass section on the wrong side. Be sure to install the trim weights supplied with each mass section.

f. Install the coil assemblies as described in paragraph 5-36. Then adjust the flexur ribbons as described in paragraphs 5-38 and 5-40.

5-36. INSTALLATION OF COIL ASSEMBLIES.

5-37. To install the coil assemblies, proceed as follows·

a. Assemble the coil assemblies, the spacers, and the coil support. Install and tighten the screws that hold these parts together.

CAUTION

Be careful to keep magnetic materials away from the magnet

b. If the magnet assemblies were removed from the frame, reinstall the bottom magnet assembly before proceeding. Note that the bottom magnet case does not have magnet shunts.

c. Clean the air gap in the magnet assembly as described in paragraph 5-29.

NOTE

Use only the thermal free solder.

d. Solder the leads to the eight terminal posts of the coil assembly. Use the schematic diagram in Chapter 7 to determine the correct connections. Avoid excess heat; the plastic coil form melts readily.

e. Install the coil support with the coil assemblies on the boom assembly. Be careful that the bottom coil assembly does not touch any part of the magnet assembly. Secure the coil support in place with clamping block and screws.

f. Replace the magnet spacer.

g. Replace the pointer in the end of the coil support.

h. Replace the top magnet assembly. Top magnet case has two magnet shunts on the outside of the case.

5-38. ADJUSTMENT OF SPRING AND FLEXURE RIBBONS.

5-39. If the spring was removed or loosened during disassembly, readjust the spring tension and the flexure ribbons as described in the following steps. If the spring was not loosened or removed and the flexure ribbons were not removed, omit this adjustment and proceed with paragraph 5-41.

a. Tighten the adjusting nut at each end of the spring until about 1/4 inch of tie rod is exposed beyond each nut.

b. Loosen the stop screw until the mass position pointer reaches the top of its scale when the boom assembly is lifted.

c. Check that the boom assembly swings freely from bottom stop to stop screw without binding, sticking, or friction.

d. If the coil sticks in the magnet assembly, loosen the two screws that clamp the coil support to the boom assembly. Shift the coil support until the coils are centered in both magnet assemblies air gaps when the boom assembly is in the center of its travel, and the boom assembly can swing from stop to stop without binding. Tighten both screws securely.

NOTE

When the coil assemblies are in the correct position and the boom assembly is at one of its stops, a clearance of approximately 1/64 inch exists between each coil and the magnet assembly. Therefore, the adjustment of each coil position described in step d must be made with care so that each coil will have sufficient clearance at both ends of its travel.

e. Tighten the adjusting nut at each end of the spring until the boom assembly floats near the center of its travel. This adjustment must be made carefully, since there is only one spring tension at which the Seismometer will operate properly.

f. Check that the tie rod at each end of the spring is centered between the collars.

g. Check that the four capscrews securing the period support assembly are slightly loose. Check that the capscrews securing the flexure pivot blocks to the boom assembly and to the hanger are slightly loose. Check that the capscrews securing each flexure ribbon, with the exception of those flexures of the boom support blocks, are slightly loose.

h. Tighten all the capscrews enumerated in step g until they are snug.

i. Tighten all the capscrews enumerated in step g until they are tight, working in a random pattern to avoid tightening any one flexure completely before tightening the others partially and to divide equally the load among the flexure ribbons.

j. Inspect the flexures to be sure that the flexure ribbons do not touch at the crossing point. Inspect each flexure ribbon to be sure that it is free of nicks, bends, and creases.

5-40. ADJUSTMENT AND TEST AFTER REASSEMBLY.

5-41. After reassembling the Seismometer or any other time after adjusting the spring or flexures, perform the adjustments and tests described in the following steps:

a. Loosen the stop screw until the mass position pointer reaches the top of its scale when the boom assembly is lifted.

b. Check that the boom assembly swings freely from bottom stop to stop screw without binding, sticking, or friction.

c. If the coil sticks in the magnet assembly, loosen the two screws that clamp the coil support to the boom assembly. Shift the coil support until the coil is centered in the magnet assembly air gap when the boom assembly is in the center of its travel, and the boom assembly can swing from stop to stop without binding. Tighten screws securely.

NOTE

> When the coil assembly is in the correct position and the boom assembly is at one of its stops, there is a clearance of approximately 1/64 inch between the coil and the magnet assembly. Therefore, the adjustment of the coil position described in step c must be made with care so that the coil will have sufficient clearance at both ends of its travel.

d. Check that the tie rod at each end of the spring is centered between the collars.

e. Inspect the flexures to be sure that the flexure ribbons do not touch at the crossing point. Inspect each flexure ribbon to be sure that it is free of nicks, bends, and creases.

f. Perform the tests and adjustments described in paragraph 5-7.

g. Adjust the setscrews in the bottom stop so that the stop screw can be adjusted against the drag and will stay wherever it is set.

h. When the Seismometer is in proper operating condition, prepare it for reshipment as described in paragraph 2-7.

CAUTION

To avoid damaging the flexures, never move the Seismometer without first locking the boom assembly.

5-42. REPAIR OF MASS POSITION MONITOR ACCESSORY.

5-43. REPLACEMENT OF LAMP.

5-44. To replace the lamp located in the mass position monitor accessory lamp housing, proceed as follows:

a. Remove the bayonet-base lamp from its socket by using a pair of tweezers and working through the aperture in the side of the lamp housing.

b. When the lamp is free, hold the open lamp end of the housing downward and allow the lamp to slide out.

c. If it is necessary to remove the lamp socket, use a pencil or similar object to push the socket and retaining ring out of the socket end of the housing. Otherwise, install a new lamp using the tweezers as in step a. Note that the lamp can only be installed in the socket when the socket is inside the housing.

5-45. REPLACEMENT OF PHOTORESISTORS.

5-46. If it becomes necessary to replace one photoresistor, both must be replaced with a matched pair. To replace the photoresistors, proceed as follows:

a. Remove the photoresistor bridge assembly from the base by lifting it out of the mounting clip. Be careful not to damage the leads.

b. Remove the cover surrounding the housing to gain access to the leads.

c. Disconnect the leads and remove both photoresistors from the housing.

d. Install two matched replacement photoresistors in the housing. The light-sensitive face of each photoresistor shall be flush with the front of the housing, and the bar on the face of each photoresistor shall line up with the bar on the other photoresistor. Do not connect the photoresistor leads.

e. Perform test No. 4 of table 5-5 to check that the photoresistors are correctly aligned.

f. Solder the leads to the terminals in the housing. Hold the lead with a pair of pliers while soldering, to conduct heat away from the photoresistor. See figure 7-1 for connections.

g. Slide the sleeve back into place surrounding the housing and covering the connections.

h. Install the photoresistor bridge assembly on the frame by snapping it into the mounting clip. The bar on the face of each photoresistor shall be vertical.

i. Perform test No. 4 of table 5-5 to check that the photoresistors are operating correctly and that the aperture is adjusted correctly.

5-47. MAINTENANCE OF REMOTE CENTERING ACCESSORY.

5-48. Disassembly and reassembly of the remote centering accessory requires no special instructions. Refer to Chapter 6 for identification and location of parts. The remote centering accessory shall not be lubricated.

5-49. PRESSURE TEST. Connect the Seismometer as shown in figure 5-9. Secure latches on Seismometer. Seal all threaded connections with Permatex No. 2 or an equivalent sealant. To test the pressure seal of the Seismometer, perform the following steps:

a. Pump gauge to 20 ounces per square inch and disconnect pump.

b. Wait 1 hour for the temperature to stabilize. If gauge drops below 14 ounces per square inch, add air to 20 ounces per square inch again; if gauge rises above 20 ounces per square inch, bleed off the excess.

c. Read and record gauge reading (G_1), barometer reading (B_1), and thermometer reading (T_1) at test location. Repeat in 4 hours to obtain G_2, B_2 and T_2.

NOTE

Always tap the pressure gauge and barometer before taking a reading.

d. Convert B_1 and B_2 from inches of mercury to ounces per square inch by multiplying by 7.86.

e. Convert T_1 and T_2 from degrees Fahrenheit to degrees Rankins (°R) by adding 460.

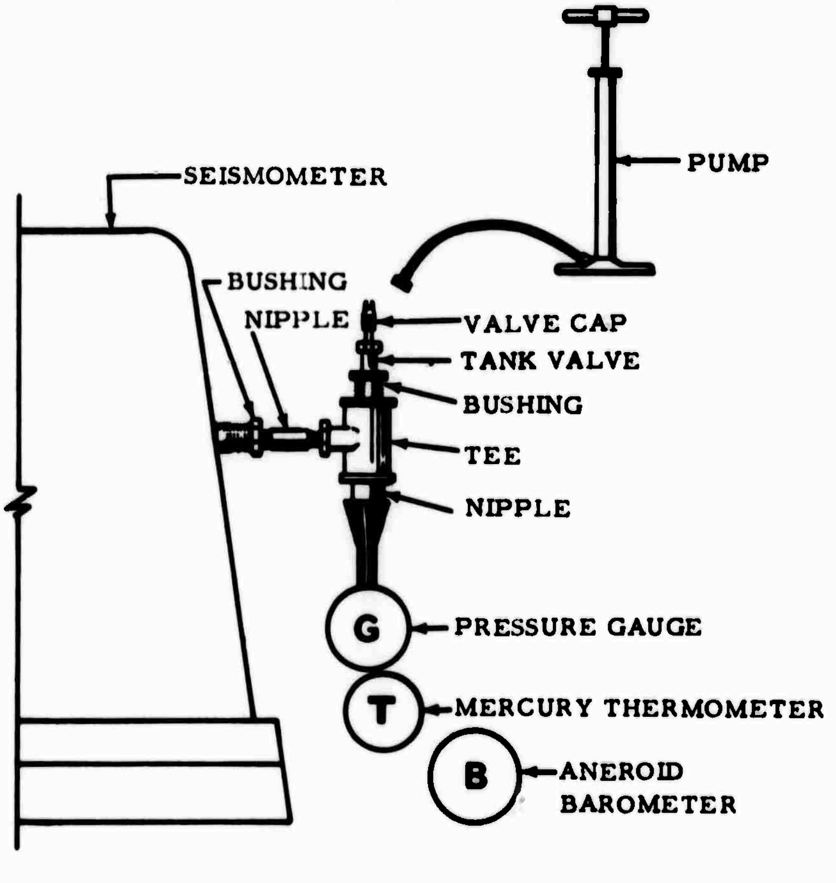


Figure 5-9. Pressure Test Setup

f. Calculate the correction for change in barometric pressure by subtracting B_1 from B_2:

$$B_2 - B_1 = \text{pressure correction (in ounces per square inch)}$$

g. Calculate the correction for change in temperature by the following formula:

$$P_1\left(1 - \frac{T2}{T_1}\right) = \text{temperature correction (in ounces per square inch)}$$

where $P_1 = B_1 + G_1$

NOTE

The temperature and pressure corrections may be negative numbers.

h. Calculate the corrected final gauge pressure (G_{2c}) by the following formula:

$$G_{2c} = G_2 + \text{(pressure correction)} + \text{(temperature correction)}$$

NOTE

If either correction is a negative number, it must be subtracted from G_2.

i. Compute the pressure drop ratio $\frac{G_1}{G_{2c}}$

j. Pressure drop ratio must not exceed 1.65.

k. If the pressure drop ratio is greater than 1.65, check the fittings on the test setup; the latches for metal-to-metal seal between the base and the cover; and the connectors and glass window seals.

BLANK PAGE

CHAPTER 6
ILLUSTRATED PARTS BREAKDOWN

SECTION I

INTRODUCTION TO ILLUSTRATED PARTS BREAKDOWN

6-1. GENERAL.

6-2. This illustrated parts breakdown lists and illustrates parts for the LONG PERIOD VERTICAL TRANSDUCER, Model 7505A. This breakdown will be used for requisitioning, stocking, issuing, identifying parts and for illustrating assembly and disassembly relationship.

6-3. Related publications: None.

6-4. MAJOR SECTIONS.

SECTION I	Introduction
SECTION II	Numerical Index
SECTION III	Reference Designation Index
SECTION IV	Group Assembly Parts list

6-5. NUMERICAL INDEX.

6-6. The numerical index contains all parts that appear in the Group Assembly Parts List, superseded parts, parts that are riveted or welded, altered vendors' parts and commercial hardware to which no part number has been assigned.

6-7. PART NUMBER SEQUENCE.

6-8. Part numbers are listed in alpha-numerical order. Commercial hardware parts are listed in sequence, considering the identifying noun as the part number.

6-9. STOCK NUMBERS.

6-10. Stock numbers are not included in this manual.

6-11. FIGURE AND INDEX NUMBER COLUMN.

6-12. Figure and index numbers in this column key part numbers to their location in the Group Assembly Parts List.

6-13. QUANTITY PER ARTICLE COLUMN.

6-14. The quantity shown in this column is the total quantity required per article.

6-15. REFERENCE DESIGNATION INDEX.

6-16. This section contains reference designations, indexed to the Group Assembly Parts List, figure and index numbers, stock numbers, when available, and the part numbers of the reference designated parts. All reference designations established for any electrical or electronic parts listed in the Group Assembly Parts List are included in this section.

6-17. GROUP ASSEMBLY PARTS LIST.

6-18 The Group Assembly Parts List prov des the parts identification drawing and parts l st.

6-19. PART NUMBERING SYSTEM.

6-20. The manufacturer's part number consists of a group of letters and digits assigned chronologically and has no particular significa ce.

6-21. ATACHING PARTS.

6-22. Attaching parts appear in the Group Assemb y Parts List following the item they attach. The symbol ****** indicates the end of attaching parts.

6-23. VENDORS' PARTS OR ASSEMBLIES.

6-24. Vendors' items are listed by the vendor part number. T e vendor's code is listed in the MFR CODE column. See Vendors' Code List at the end of S ction I to determine vendor's name and address.

6-25. UNITS PER ASSY.

6-26. The quantity listed in this column is the total quantity used at that location and is not necessarily the total quantity used in the equipment.

6-27. USABLE ON CODE.

6-28. The Usable On Code column does not apply for this equipmen

6-29. The symbol ** preceeding the Mfr Part Number designated reference to a footnote. The footnote will be located at the end of the figure.

6-30. HOW TO USE THIS ILLUSTRATED PARTS BREAKDOWN.

6-31. HOW TO FIND THE PART NUMBER.

a. Locate the part and its index number on the illustra ion.

b. Find the index number on the Group Assembly Parts List page to de ermine the part number or complete description.

6-32. HOW TO FIND THE ILLUSTRATION OF A PART IF THE PART NUMBER IS KNOWN.

a. Refer to the numerical index (Section II) and find the pa t number.

b. Turn to the Group Assembly Parts List (Sec ion IV) and ind the first figu e and index number indicated in the Numerical Index for that part. If his figure shows the part in a location other than the one desired, refer the other figure num ers lis ed in the Numerical Index.

c. On the face of the illustration, find the index n mber d termined in step b.

VENDORS' CODE LIST*

Code Number	Vendor's Name and Address	Code Numbe	Vendor s Name and Address
01351	Dynamic Gear Co , Inc Amityville, Ne v York	01528	Cal Ohm Laborator s, Inc. San iego, Californ

VENDORS' CODE LIST* (Cont'd)

Code Number	Vendor's Name and Address	Code Number	Vendor's Name and Address
03797	Eldema Corp. El Monte, California	72653	G. C. Electronics Mfg. Co. Rockford, Illinois
03911	Clairex Corp. New York, New York	73734	Federal Screw Products Co. Chicago, Illinois
06008	New Departure Division of General Motors Corp. Meriden, Connecticut	79566	Whitney Blake Co. New Haven, Connecticutt
11503	Keystone Mfg Co. Warren, Michigan	79963	Zierick Mfg. Corp. New Rochelle, New York
12139	Pic Design Corp. Van Nuys, California	81168	Linear, Inc. Philadelphia, Pennsylvania
24455	General Electric Co., Lamp Division of Consumer Products Group Nela Park (Cleveland), Ohio	85780	Moyer, W. A., and Sons Parkers Landing, Pennsylvania
25140	Globe Industries Inc. Dayton, Ohio	88245	U. S. Engineering Co. Glendale, California
70331	Alpha Wire Corp. New York, New York	89462	Waldes Kohinoor, Inc. Cambridge, Massachusetts
70903	Belden Mfg. Co. Chicago, Illinois	96188	Precision Rubber Products, Corp. Chicago, Illinois
71041	Boston Gear Works Division of Murray Co. of Texas Quincy, Massachusetts	97197	Edmund Scientific Corp. Barrington, New Jersey
71279	Cambridge Thermionic Corp. Cambridge, Massachusetts	98003	Nielson Hardware Corp. Hartford, Connecticut
		99515	Marshall Industries, Electron Products Division Pasadena, California

*Geotechnical Corp., Garland, Texas, as prime contractor is not listed

SECTION II

NUMERICAL INDEX

PART NO.	STOCK NO.	FIG. AND INDEX NO.	QTY PER ART.	S/C
A1-25		6-3-21	2	
		6-4-2		
B1-1		6-4-17	1	
C1.603		6-5-6	2	
CS-11		6-1-	2	
C53A117-1		6-4-16	1	
D3-750		6-1-	2	
D4-312		6-2-3	16	
		6-2-9		
D4-375		6-3-28	8	
D5-500		6-1-	6	
		6-3-31		
FB46-3		6-3-	2	
		6-4-22		
HS179286-2SS		6-1-6	20	
H310F		6-5-8	1	
LEVEL		6-1-	2	
MC250		6-1-9	3	
MS30 7-4		6-1-	1	
MS3057-12		6-1-	2	
MS3102C10SL4P		6-1-4	1	
MS3102C20-11P		6-1-42	1	
MS3102C20-4S		6-1-40	1	
MS3106A10SL4S		6-1-	1	
MS3106A20-11S		6-1-	1	
MS3106A20-4P		6-1-	1	
NUT		6-3-13	9	
		6-4-5		
PIN		6-1-45	4	
PLUG		6-1-7	1	
PVC105-5		6-5-2	AR	
PVC105-8		6-1-	AR	
		6-5-1	AR	
PVC 5-10		6-1-	AR	
RC0 F153J		6-5-4	2	
RS77R2		6-4-21	2	
		6-4-3		
SCREW		6-1-31	190	
		6-2-1		
		6-3-		
		6-4-		
SC-B83314-2		6-1-50	20	
SETSCREW		6-1-	12	
		6-4-1		
WASHER		6-3-	2	
WIRE		6-1-	AR	
		6-3-		
		6-5-		
W2-205		6-4-19	1	
1K5742		6-5-11	1	
10002		6-1-15	1	
10003		6-1-16	1	
10004		6-1-26	1	
10005		6-3-19	2	
		6-4-12		
10008		6-4-8	2	
10074		6-1-38	1	
10075		6-3-32	1	
10107		6-3-8	2	
10108		6-3-5	1	

PART NO.	STOCK NO.	FIG. AND INDEX NO.	QTY PER ART.	S/C
10121		6-3-18	1	
10132		6-3-6	1	
10133		6-3-2	1	
10134		6-3-3	1	
10155		6-1-17	1	
10159		6-1-18	1	
10166		6-1-28	1	
10170		6-1-14	2	
10171		6-1-13	1	
10172		6-1-	2	
10207		6-1-	3	
10216		6-1-33	1	
10220		6-1-48	1	
10283		6-1-37	2	
		6-3-		
10293		6-1-25	1	
10331		6-4-4	1	
10332		6-4-18	1	
10333		6-4-15	1	
10334		6-4-23	1	
10581		6-3-4	2	
10765		6-5-	1	
10766		6-5-	1	
10767		6-5-12	1	
10768		6-5-9	1	
10769		6-5-7	1	
10770		6-5-	1	
10771		6-5-15	1	
10772		6-5-14	1	
10775		6-5-3	1	
11-016		6-1-	1	
11-024		6-1-	2	
11013		6-3-	2	
11064		6-3-1	2	
1118-2		6-1-49	2	
116		6-3-	5	
12		6-5-10	1	
13296-1		6-3-30A	1	
13296-2		6-3-29A	1	
139		6-3-33	2	
1426		6-4-20	3	
15822		6-1-	3	
15823		6-1-	3	
15824		6-1-34	3	
15939-1		6-1-29	2	
15940		6-3-7	2	
15943-2		6-1-36	2	
		6-3-22	2	
16373		6-1-2	1	
16374		6-1-3	1	
16375		6-1-1	1	
16434		6-1-8	1	
16435		6-1-10	2	
16436		6-1-11	1	
16437		6-1-	1	
16438		6-1-	1	
16535		6-1-27	1	
16572-2		6-1-52	1	
16696		6-1-43	2	
16735		6-1-3A	1	

PART NO.	STOCK NO.	FIG. AND INDEX NO.	QTY PER ART.	S/C
16741		6-1-32	1	
16748		6-3-24	1	
16749		6-3-	1	
16792		6-3-10	5	
16937-1		6-3-9	1	
16892		6-1-2'	4	
16938		6-1-24	1	
16937-2		6-3-11	1	
16939		6-1-	1	
16950		6-1-39	1	
16951		6-1-41	1	
16954-1		6-1-35	1	
16954-2		6-1-	1	
16954-3		6-1-	1	
17041		6-1-	2	
17066-1		6-1-44	1	
17066-2		6-1-45	1	
17469		6-1-	1	
17800		6-1-30	1	
1853		6-1-	AR	
2041C		6-5-5	4	
2196		6-1-5	2	
251-186HS250		6-4-6	1	
33-110		6-1-	3	
		6-3-23		
389-7184		6-1-12	1	
4950		6-1-51	1	
5115-37C		6-1-	1	
7505A		6-1-	1	
3178		6-1-	1	

PART NO.	STOCK NO.	F G AND INDEX NO	QTY PER ART.	S/C
8728-3		6 1-47	1	
8730-3		6 3-41	1	
8731		6- -11	1	
8732		6- -12	1	
8733		6-2-6	1	
8734		6-2 5	1	
9085		6 4- 1	1	
9089		6-2-2	24	
		6-2-8		
		6-3-26		
		6-2-4	12	
9091-1		6-2-10		
		6-3-27		
		6-1-22	2	
9093		6-1-21	2	
9094		6-1-20	2	
9095		6-3-37	2	
9096		6-3-35	2	
9098		6-5-13	2	
91		6-3-40	1	
9101		6-1-19	1	
9103		6-3-38	1	
9108		6-3-39	1	
9109		6-3-17	2	
9113		6-4-10		
		6-3-30	1	
9143-1		6-3-29	1	
9143-2		6-4-13	1	
9990		6-3-15	1	
9994				

SECTION III

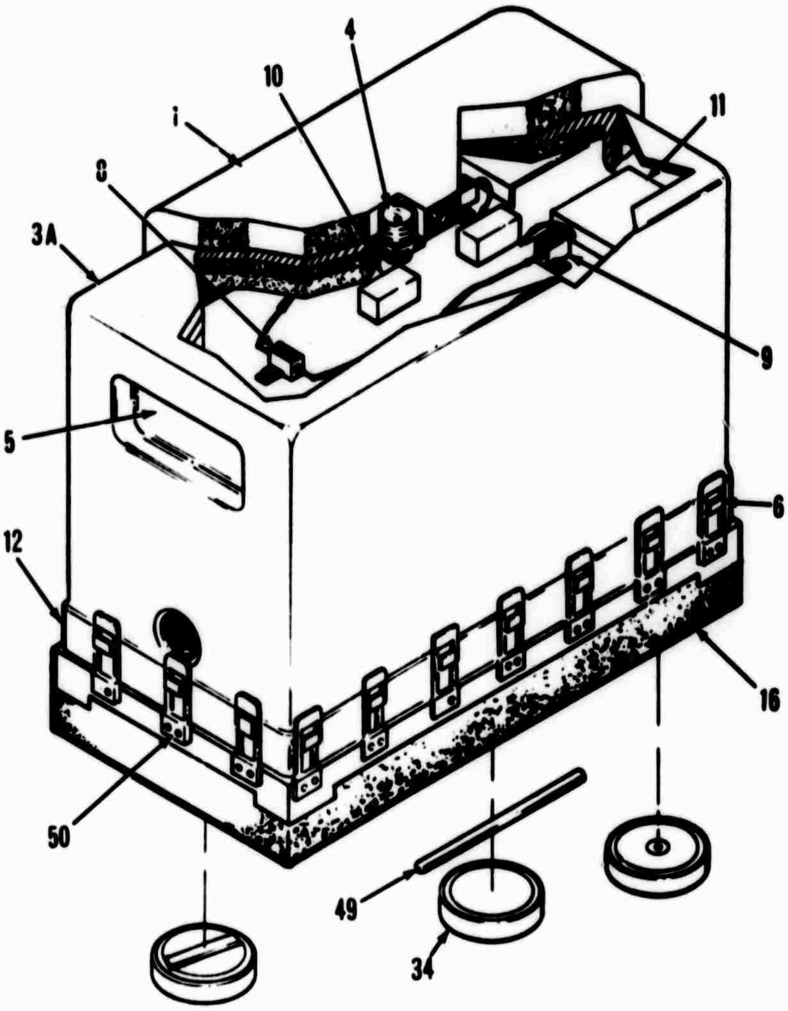
REFERENCE DESIGNATION INDEX

REF DESIG-NATION	FIG. AND INDEX NO.	STOCK NO.		PART NO.
B201	6-4-16			C53A117-1
C201	6-4-19			W2-205
DS101	6-5-10			12
E101	6-1-43			16696
E102	6-1-43			16696
J101	6-1-40			MS3102C20-4S
J102	6-1-42			MS3102C20-11P
J104	6-1-4			MS3102C10SL4P
L1	6-3-7			15940
L2	6-3-8			15940
P101	6-1-40			MS3106A20-4P
P102	6-1-42			MS3106A20-11S
P104	6-1-4			MS3106A10SL4S

REF DESIG-NATION	FIG. AND INDEX NO.	STOCK NO		PART NO.
R1	6-1-9			MC250
R101	6-5-4			RC70GF153J
R102	6-5-4			RC70GF153J
R2	6-1-9			MC250
R3	6-1-9			MC250
TB101	6-3-22			15943-2
TB102	6-3-22			15943-2
TB103	6-1-36			15943-2
TB104	6-1-36			15943-2
TB105	6-3-			10283
TB106	6-1-37			10283
V101	6-5-6			CL603
V102	6-5-6			CL603
XDS301	6-5-11			1K5742

SECTION IV

GROUP ASSEMBLY PARTS LIST



F gure 6-1. Long Peri d Vertical Se mometer (Sheet 1 of 2)

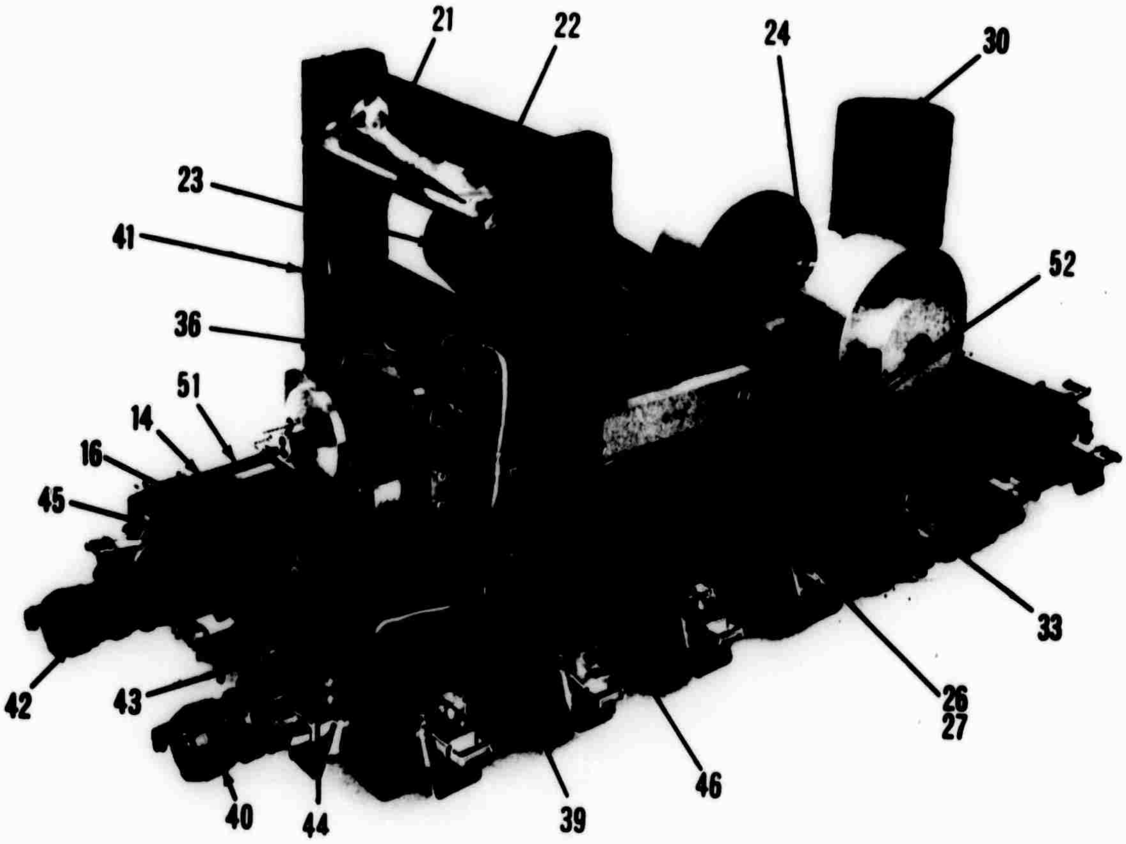
FIG. & INDEX NO.	PART NUMBER	DESC IPT ON 1 2 3 4 5 7	MFR. CODE	UN TS P R ASSY	USABL ON CODE
6-1-	505A	VERTICAL SEISMOMETER, Long Pe od		1	
-1	16375	. COVER ASS IN ULATION		1	
	17041	. . COVER, Round Plug		2	
-2	16373	. . COVER, Squ r Plug		1	
-3	16374	COVER INSULATION		1	
-3A	16735	. COVER AS Y		1	
-4	MS3102C10SL4P	. . CONNECTOR RECEPTACLE, ELECTRICAL		1	
		(ATTACHING PARTS)			
	COML	. . . SCREW MACHINE, Pan hd 4-40 thd size b 1/. ., sst		4	
	COML	. . . WASHER, L CK, Int tooth, no. 4, st		4	
	11-0 6	. . . SEAL, O-ring ******	8 168	1	
-5	2196	. WINDOW	97 97	2	

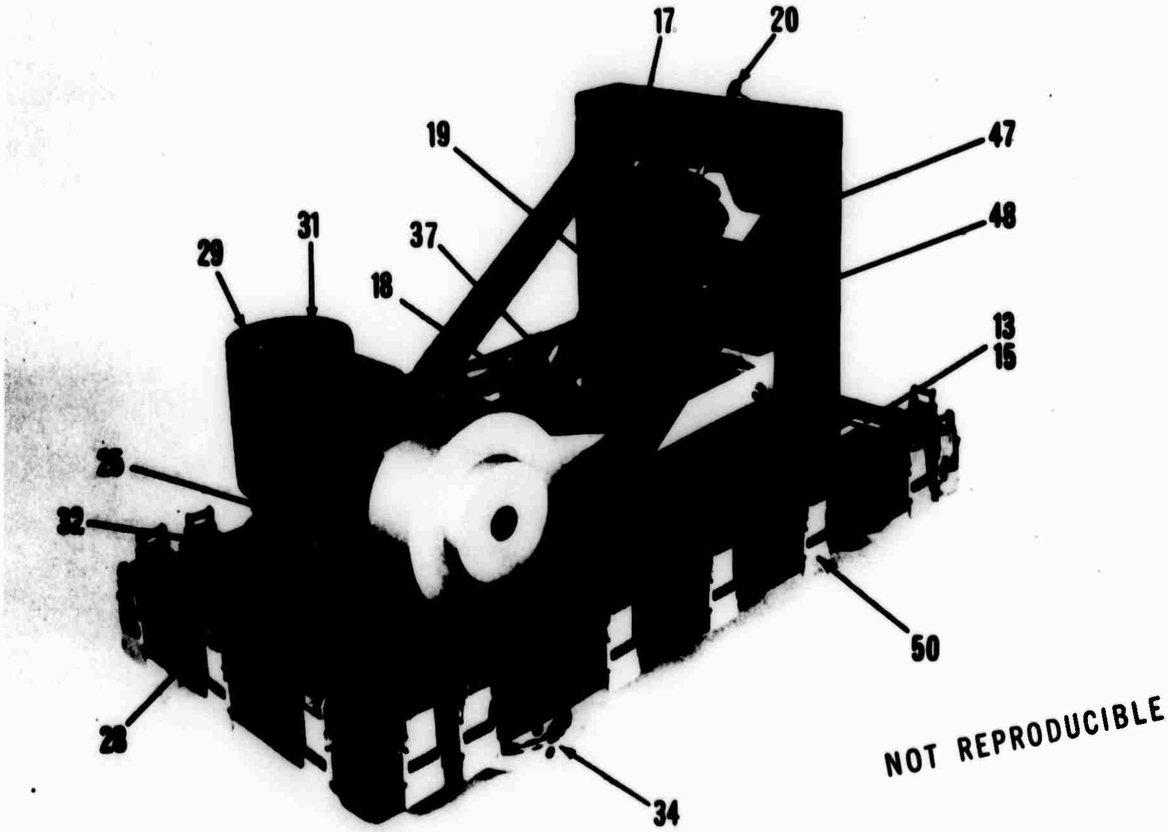
FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR CODE	UNITS PER ASSY	USABLE ON CODE
6-1-6	HS179286-2SS	. . STRIKE, Sst	98003	20	
		(ATTACHING PARTS)			
		. . SCREW, MACHINE Pan hd, 4-40 thd size by 1/4 in., sst		40	
		**** *			
-7	COML	. . PLUG Pipe 1/4 NPTF, Sst		1	
	16437	. INSULATOR, Lower heater		1	
	16 38	. . INSULATOR, Upper heater		1	
-8	16434	. . HEATER ASSY		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE Pan hd, 8-32 thd s ze by 7/16 'n , sst		2	
	COML	. . WASHER LOCK, In tooth, no 8 sst		2	
		******			
-9	MC250	. . . RESISTOR 70 ohm, 25W, ±.%	01528	3	
		(ATTACHING PARTS)			
	COML	. . . NUT, PLAIN, HEX, 4 40 thd size		6	
	COML	. . . WASHER, LOCK, Shakeproof, no. 4 ss		6	
	COML	. . SCREW, MACHINE, Pan hd, 4-40 thd size by 5/16 in., sst		6	
		******			
	1853	. . WIRE, ELECTRICAL	70331	AR	
-10	16435	. . . STANDOFF HEATER PLATE		2	
		(ATTACHING PARTS)			
	COML	. . . SCREW, MACHINE, Pan hd, 6-32 thd size by 5/ 6 in., sst		4	
	COML	. WASHER, LOCK Shakep oof, no 6 sst		4	
		******			
-11	6436	. . . PLATE HEATER		1	
-12	389-7184	. SEAL, O-Ring	96188	1	
-13	10171	. LEVEL ASS		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE Pan hd, 4-40 thd size by 5/16 in., sst		2	
		******			
	COML	. . NUT PLAIN HEX, 2-56 thd size, st		2	
	COML	. . SCREW, MACHINE Flat hd, 2-56 thd size by 5/8 in., ss		2	
	101 2	. SPRING, Compression		2	
	D3-750	. PIN DOWEL	121'9	2	
-14	10170	. . HOUSING ASSY		2	
	COML	. . . LEVEL 0.32 in d'a. 1 in lg, 2 PGMS gra 25-.5 sec (May be purchased from 85(80)		1	
-15	10002	. . . HOUSING		1	
-16	10003	. . BASE		1	
-17	10155	. FLEXURE ASSY, UPPER (See figure 6-2 for breakdown)		1	
-18	10159	. FLEXURE ASSY, LOWER (See figure 6-2 for breakdown)		1	
	9103	SPRING		1	
		(ATTACHING PARTS)			
-20	9095	. NUT, ADJUSTING		2	
-21	9094	. SPACER, ADJUSTING		2	
22	9093	. TIE ROD		2	
	COML	. SCREW, MACHINE, Socket hd, 4-40 thd size by 1/4 in., sst		10	
-23	16892	COLLAR, Spring tie rod		4	
		******			

156

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFT. CODE	UNITS PER ASSY	USABLE ON CODE
6-1-24	16938	. STOP ASSY		1	
	17469	. . COLLAR		1	
	16939	. . SCREW STOP		1	
	5115-37C	. . RING, External, circular self-locking	89462	1	
-25	10293	. SCALE		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Fill hd, 0-80 thd size by 1/8 in., brass		2	
		******			
-26	10004	. APERTURE		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Binder hd, 4-40 thd size by 1/2 in., sst		2	
		******			
-27	16535	. BOOM ASSY (See figure 6-3 for breakdown)		1	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, Socket hd, 6-32 thd size by 1/2 in., sst		4	
		******			
-28	10166	. SPACER		1	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, Socket hd, 4-40 thd size by 1/2 in., sst		8	
		******			
-29	15939-1	. MAGNET ASSY*		2	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, Socket hd, 6-32 thd size by 1/2 in., sst		4	
		******			
-30	17800	. . COVER, MAGNET		1	
		(ATTACHING PARTS)			
-31	COML	. . SCREW, MACHINE, Pan hd, 1/4-28 thd size by 1/2 in., sst		2	
		******			
-32	16741	. PLATE		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Flat hd, 1/4-28 thd size by 5/8 in., sst		2	
		******			
-33	10216	. STOP ASSY, Bottom		1	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, Socket hd, 1/4-28 thd size by 1/2 in., sst		3	
		******			
	CS-11	. . SETSCREW, No-mar, 8-32 thd size	12139	2	
-34	15824	. LEVELING SCREW ASSY		3	
	10207	. . SCREW, LEVELING		3	
	15822	. . PLATE, JAM		3	
	15823	. . PLATE, ADJUSTMENT		3	
-35	16954-1	. GLASS INSULATOR ASSY, Plane, right front leveling screw		1	
	16954-2	. GLASS INSULATOR ASSY, Hole left front leveling screw		1	
	16954-3	. GLASS INSULATOR ASSY, Slot, rear leveling screw		1	
-36	15943-2	. TERMINAL BOARD ASSY		2	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Flat hd, 2-56 thd size by 5/8 in., sst		4	
		******			

*Upper magnet assembly includes 2 shunts, magnet, part number, 13313-E





158

Figure 6-1. Long Period Vertical Transducer (Sheet 2 of 2)

FIG. & INDEX NO	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-1-37	10283	. TERMINAL BOARD		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Pan hd, 2-56 thd size by 5/16 in., sst		2	
	33-110	. WASHER, NONMETALLIC, Fiber	73734	1	
		******			
	COML	. PIN, DOWEL, 3/16 dia by 1-3/4 in.		2	
	D5-500	. PIN, DOWEL	12139	2	
-38	10074	. MASS POSITION MONITOR ACCESSORY		1	
		(See figure 6-5 for breakdown)		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Binder hd, 8-32 thd size by 3/8 in., sst		2	
		******			
39	16950	. CABLE ASSY, Frame		1	
	PVC-105-10	. . TUBING, PLASTIC	70331	AR	
	COML	. . CABLE, ELECTRICAL, 4-conductor, awg 20, strd 7/28, 0.010 in. chrome vinyl ins, 200 V (May be purchased from 70903, part no. 8484)		AR	
-40	MS3102C20-4S	. . CONNECTOR, RECEPTACLE, ELECTRICAL		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 4-40 thd size by 1/4 in., sst		4	
	11-024	. . SEAL, O-ring		1	
		******			
-41	16951	. CABLE ASSY, FRAME		1	
	PVC105-8	. . TUBING, PLASTIC	70331	AR	
	PVC105-10	. . TUBING, PLASTIC	70331	AR	
	COML	. . WIRE, ELECTRICAL, Tinned copper, awg 28, strnd 7/36, 0.010 in. polyvinylchloride ins, 600 V, temp rtng -55°C, +105°C		AR	
	COML	. . WIRE, ELECTRICAL, Tinned copper, awg 20, strnd 7/36, 0.010 in. polyvinylchloride ins, 600 V, temp rtng -55°C, +105°C		AR	
	8178	. . TERMINAL, ELECTRICAL, Lug	72653	1	
-42	MS3102C20-11P	. . CONNECTOR, RECEPTACLE, ELECTRICAL		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 4-40 thd size by 1/4 in., sst		4	
	11-024	. . SEAL, O-ring		1	
		******			
-43	6696	. BINDING POST ASSY		2	
-44	17066-1	. WIRE, Copper circuit		1	
-45	17066-2	. WIRE, Copper circuit		1	
	MS3106A20-4P	. CONNECTOR, PLUG, ELECTRICAL		1	
	MS3106A20-11S	. CONNECTOR, PLUG, ELECTRICAL		1	
	MS 3106A10SL4S	. CONNECTOR, PLUG, ELECTRICAL		1	
	MS3057-12	. CLAMP, CABLE		2	
	MS3057-4	. CLAMP, CABLE		1	
	COML	. PIN, DOWEL, 3/16 in., by 1-3/4 in.		2	
-46	D5-500	. PIN, DOWEL	12139	2	
	COML	. SCREW, CAP, Socket hd, 6-32 thd size by 5/8 in., sst		2	
-47	8728-3	. HANGER		1	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, Socket hd, 10-32 thd size by 1-1/2 in., sst		6	
		******			

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR CODE	UNITS PER ASSY	USABLE ON CODE
6-1-48	10220	. ADJUSTOR ASSY		1	
-49	1118-2	. WRENCH, Leveling screw		2	
-50	SC-B83314-2	. CATCH	98003	20	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Pan hd, 4-40 thd size by 3/8 in., sst		40	
		******			
-51	4950	. NAMEPLATE		1	
-5.	16572-2	. FRAME		1	
		**All coml wire may be purchased from 70331 or 70903. Specify color when ordering			
6-2-	10155	FLEXURE ASSY, UPPER (See figure 6-1 for next higher assembly)		Ref	
-1	COML	. SCREW, CAP, Socket hd, 4-40 thd size by 7/16 in., sst		16	
-2	9089	. CLAMP, Flexure plate		8	
-3	D4-312	. PIN, DOWEL	12139	8	
-4	9091-1	. RIBBON, Flexure		4	
-5	8734	. SUPPORT, Upper		1	
-6	8733	. YOKE, Upper		1	
	10159	FLEXURE ASSY, Lower		Ref	
-7	COML	. SCREW, CAP, Socket hd, 4-40 thd size by 7/16 in., sst		16	
-8	9089	. CLAMP, Flexure plate		8	
-9	D4-312	. PIN, DOWEL	12139	8	
-10	9091-1	. RIBBON, Flexure		4	
-11	8731	. ANCHOR, Lower		1	
-12	8732	. YOKE, Lower		1	

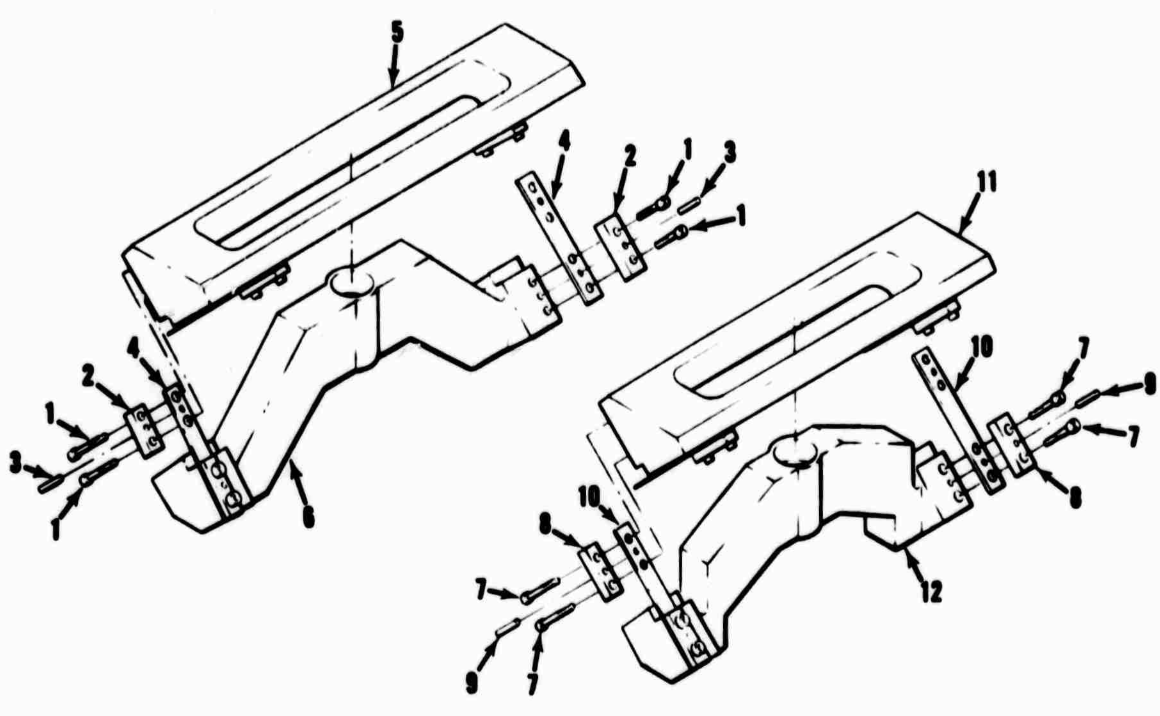


Figure 6-2. Flexure Assembly

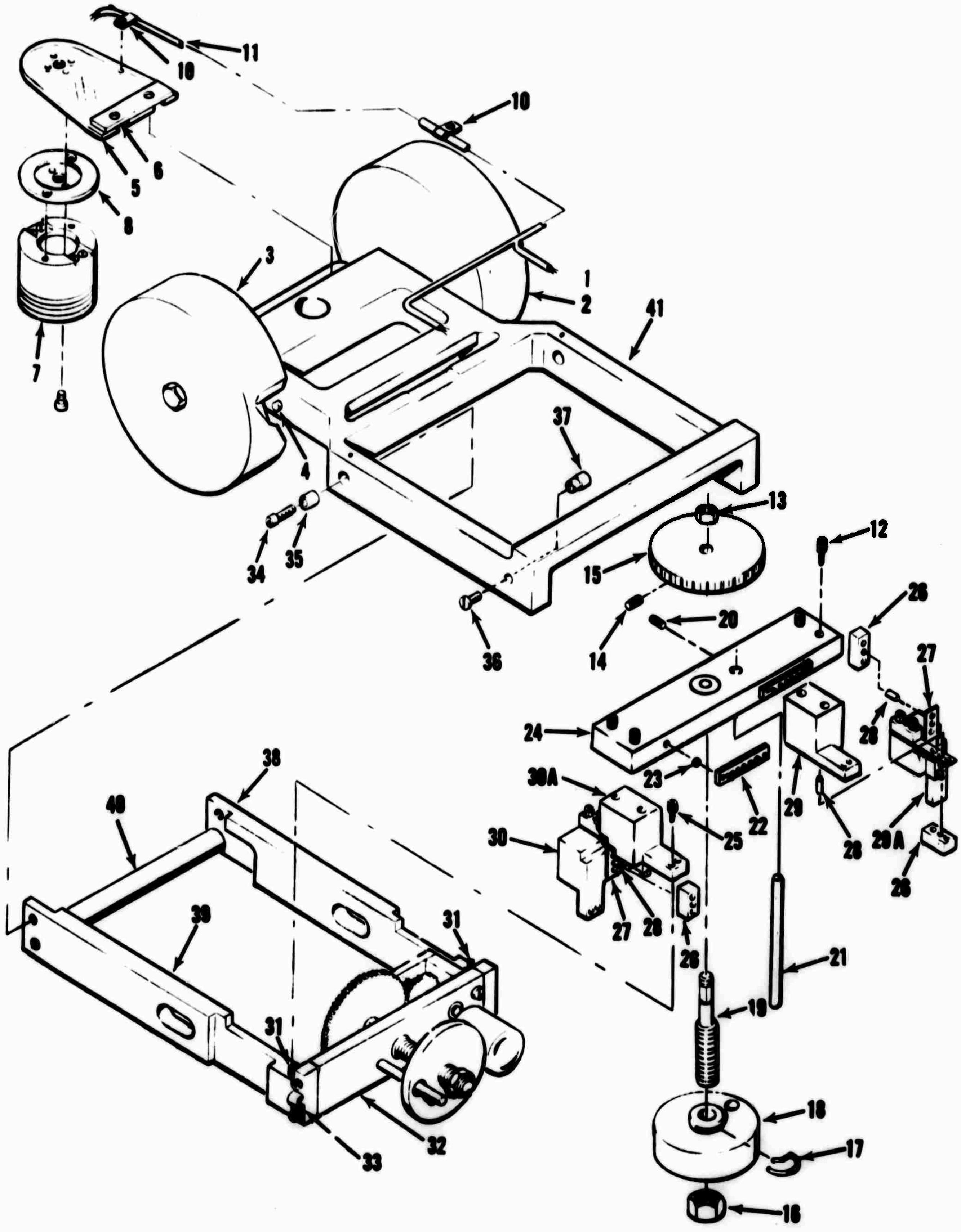


Figure 6-3. Boom Assembly

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-3-	16535	BOOM ASSY (See figure 6-1 for next higher assembly)		Ref	
-1	11064	. WEIGHT, TRIM		2	
-2	10133	. MASS, RH		1	
		(ATTACHING PARTS)			
	11013	. BOLT, BRASS		1	
		******			
-3	10134	. MASS, LH		1	
		******			
	11013	. BOLT, BRASS		1	
		******			
-4	10581	. PIN, DOWEL		2	
-5	10108	. SUPPORT, COIL		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Pan hd, 6-32 thd size by 1/2 in., brass		2	
	COML	. WASHER, LOCK, Int tooth, no. 6, sst		2	
-6	10132	. BLOCK, CLAMPING		1	
		******			
-7	15940	. COIL ASSY, Bottom		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Pan hd, 4-40 thd size by 5/16 in., brass		2	
	COML	. WASHER, LOCK, Int tooth, no. 4 sst		2	
	COML	. SCREW, MACHINE, Flat hd, 2-56 thd size by 3/8 in., brass		2	
-8	10107	. SPACER, Coil		1	
		******			
	15940	. COIL ASSY, Top		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Pan hd, 4-40 thd size by 5/16 in., brass		2	
	COML	. WASHER, LOCK, Int tooth, no. 4, sst		2	
	COML	. SCREW, MACHINE, Flat hd, 2-56 thd size by 3/8 in., brass		2	
	10107	. SPACER, Coil		1	
		******			
-9	16937-1	. CABLE ASSY, Boom (Made from 70903 part no. 8484 or 79566 part no. 161-1436)		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Pan hd, 2-56 thd size by 3/16 in., brass		7	
-10	16792	. CLAMP, CABLE		5	
	116	. CLAMP, CABLE,	79963	2	
		******			
-11	16937-2	. CABLE ASSY, Boom (Made from 70903 part no. 8484 or 79566 part no. 161-1436)		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Pan hd, 2-56 thd size by 3/16 in., brass		3	
	116	. CLAMP, CABLE	79963	3	
		******			
-12	COML	. SCREW, CAP, Socket hd, 6-32 thd size by 5/8 in., sst		4	
-13	COML	. NUT, PLAIN, HEX, 1/4-28 thd size, sst		1	
-14	COML	. SETSCREW, Socket hd, 4-40 thd size by 1/4 in., sst		2	
-15	9994	. PLATE, ADJUSTMENT		1	
	COML	. NUT, PLAIN, HEX, 3/8-24 thd size, 3/32 in. thick, sst		1	
-16	COML	. NUT, PLAIN, HEX, 3/8-24 thd size, sst		1	

1200-64

FIG & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-3-17	9113	. SPRING, Re ainer		1	
-18	10121	. WEIGHT		1	
-19	10005	. ROD		1	
-20	COML	. SETSCREW, Socket hd, 4-40 thd size .y 1/4 in., sst		1	
-21	A1-25	. SHAFT	12139	1	
-22	15943-2	. BOARD, TERMINAL		2	
		(ATTACHING PARTS)			
	COML	. SCREW MACHINE, Pan hd, 2-56 thd s ze by 5/8 in., sst		4	
		*:***			
-23	33-110	. WASHER, FIBER	73734	2	
	10283	. BOARD TERMINAL		1	
		ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Pan hd, 2-56 thd s ze by 3/8 in., sst		2	
		*****			
-24	16748	. SUPPORT, PERIOD ASSY		1	
	FB46-3	. . BEARING, FLANGED	71041	1	
	16749	. . SUPPORT, PERIOD		1	
-25	COML	. SCREW, CAP, Socket hd, 6-32 thd s ze by 1/2 in., sst		2	
-26	9089	. CLAMP FLEXURE PLATE		8	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, Socket hd, 4-40 thd siz by 3/8 in , sst		16	
		******			
-27	9091-1	. RIBBON, FLEXURE		4	
-28	D4-375	. PIN, DOWEL	12139	8	
-29	9143-2	. PIVOT BLOCK. Flexure,		1	
-29A	13296-2	. PIVOT BLOCK, Flexure,		1	
-30	9143-1	. PIVOT BLOCK, Flexure,		1	
-30A	13296-1	. PIVOT BLOCK, Flexure,		1	
-31	D5-500	. PIN, DOWEL	12139	2	
-32	10075	. REMO E CENTERING ACCESSORY (See figure 6-4 for breakdown)		1	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, Socket hd, 6-32 size by 5/8 in., sst		4	
		******			
-33	139	. CLAMP, CABLE	79963	2	
-34	COML	. SCREW, CAP, Socket hd, 10-32 thd size by 5/8 in., sst		2	
-35	9098	. PIVOT		2	
-36	COML	. SCREW, MACHINE, Pan hd, 10-32 thd size by 7/8 in. sst		2	
-37	9096	. STOP		2	
-38	9108	. HINGE, BOOM		1	
		(ATTACH NG PARTS)			
	COML	. SCREW, CAP, Socket hd, 4- 0 thd size by 3/8 in , ss		1	
		******			
-39	9109	. HINGE, BOOM		1	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, Sock t hd, 4-40 thd size by 3/8 in., s t		1	
		******			
-40	9101	. BRACE		1	
-41	8730-3	. BOOM		1	

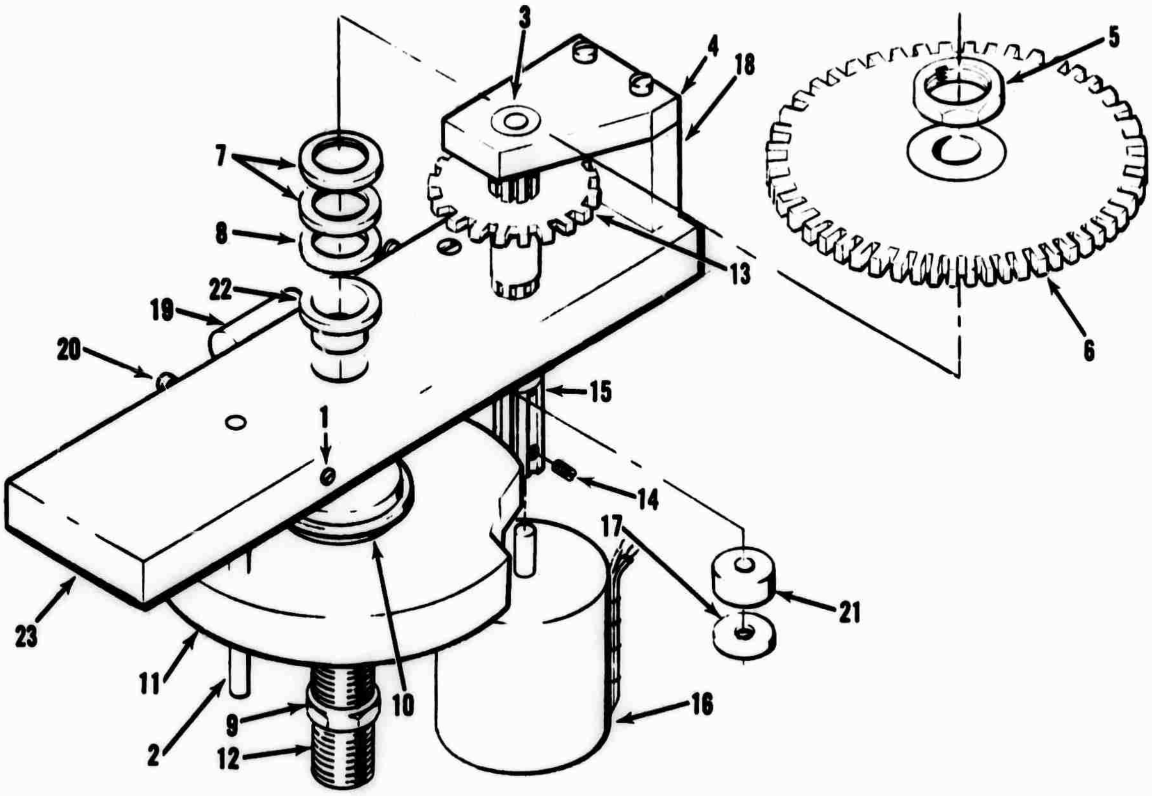


Figure 6-4. Remote Cen ering Accessory

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR CODE	UNIT PER ASSY	USABLE ON CODE
6-4-		REMOTE CENTER NG ACCESSORY (See figure 6- for next highe assy)		Ref	
-1	COML	. SETSCREW, Socket hd, 4 40 thd s ze by 1/8 in. sst		1	
-2	A1-25	. SHAFT	12139	1	
-3	RS77R2	BEARING, Ball	06008	1	
-4	10331	. PLATE, BEARING ATTACHING PARTS)		1	
	COML	. SC EW, MACHINE, Binder hd 4-40 hd size by 3/8 i , sst		2	
-5	COML	NUT PLAIN, HEX 1/4 28 thd size, sst		1	
-6	251-186HS250	GEAR	01351	1	
-7	COML	. WASHER 9/32 I D. x 1/2 O.D. x 1/16 n thk, b ass		2	
-8	10008	. WASH R, THRUST		2	
-9	COML	NUT, PLAIN, HEX, 3/8-24 thd size by 3 3 'n. thk. sst		2	
-10	9113	S RING RE AINER		1	
-11	9085	W IGHT		1	
-12	0005	. R D		1	
-13	9990	P ION AND SPUR GEAR ASSY		1	
-14	COML	S TS REW, Sock t hd, 2-56 thd s e y 8 in s.t		1	
-15	10333	PIN ON GEAR M tor		1	

164

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-4-16	C53A117-1	. MOTOR	25140	1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Binder hd, 4-40 thd size by 5/8 in., sst		2	
		******			
-17	B1-1	. SPACER	12139	1	
-18	10332	. SPACER		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE Flat hd, 4-40 thd size by 5/8 in., sst		2	
		******			
-19	TYPE W2-205	. CAPACITOR, 2.0 Mfd, 200V	99515	1	
-20	1426	. STANDOFF, Insulated	88245	3	
-21	RS77R2	. BEARING, Ball	06008	1	
-22	FB46-3	. BEARING, FLANGE	71041	1	
-23	10334	. BAR, MOTOR SUPPORT		1	
6-5-	10073	MASS POSITION MONITOR ACCESSORY (See figure 6-1 for next higher assembly)		Ref	
-1	PVC105-8	. TUBING, PLASTIC	70331	AR	
-2	PVC105-5	. TUBING, PLASTIC	70331	AR	
	10765	. BRIDGE ASSY, Photo resistor		1	
-3	10775	. . COVER		1	

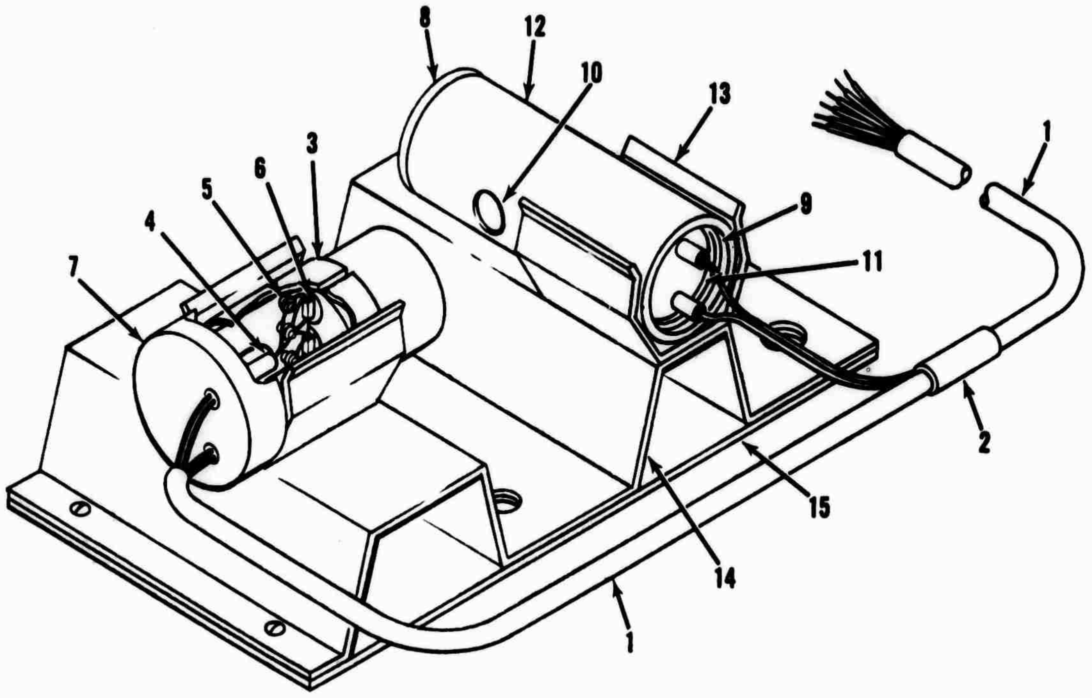


Figure 6-5. Mass Position Monitor

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-5-4	RC07GF153J	. . RESISTOR, FIXED, COMPOSITION, 15K, 1/4W, ±5%		2	
-5	2041C	. . TERMINAL	71279	4	
-6	CL603	. . PHOTO-RESISTOR	03911	2	
-7	10769	. . HOUSING		1	

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
	**COML	. . WIRE, ELECTRICAL, Tinned copper, awg 26, strd 7/34 0.010 polyvinylchloride ins, 600V, temp rtng -55°C, +105°C		AR	
	10766	. LAMP AND HOUSING ASSY		1	
-8	H310F	. . PLUG, Hole	72653	1	
-9	10768	. . RING		1	
-10	12	. . BULB	24455	1	
-11	1K5742	. . SOCKET	03797	1	
-12	10767	. . HOUSING		1	
	PVC105-8	. . TUBING	70331	AR	
	**COML	. . WIRE, ELECTRICAL, Tinned copper, awg 26, strd 7/34, 0.010 polyvinylchloride ins, 600V, temp rtng -55°C, +105°C		AR	
	10770	. BASE ASSY		1	
-13	91	. . CLIP	11503	2	
-14	10772	. . SUPPORT		1	
-15	10771	. . PLATE		1	

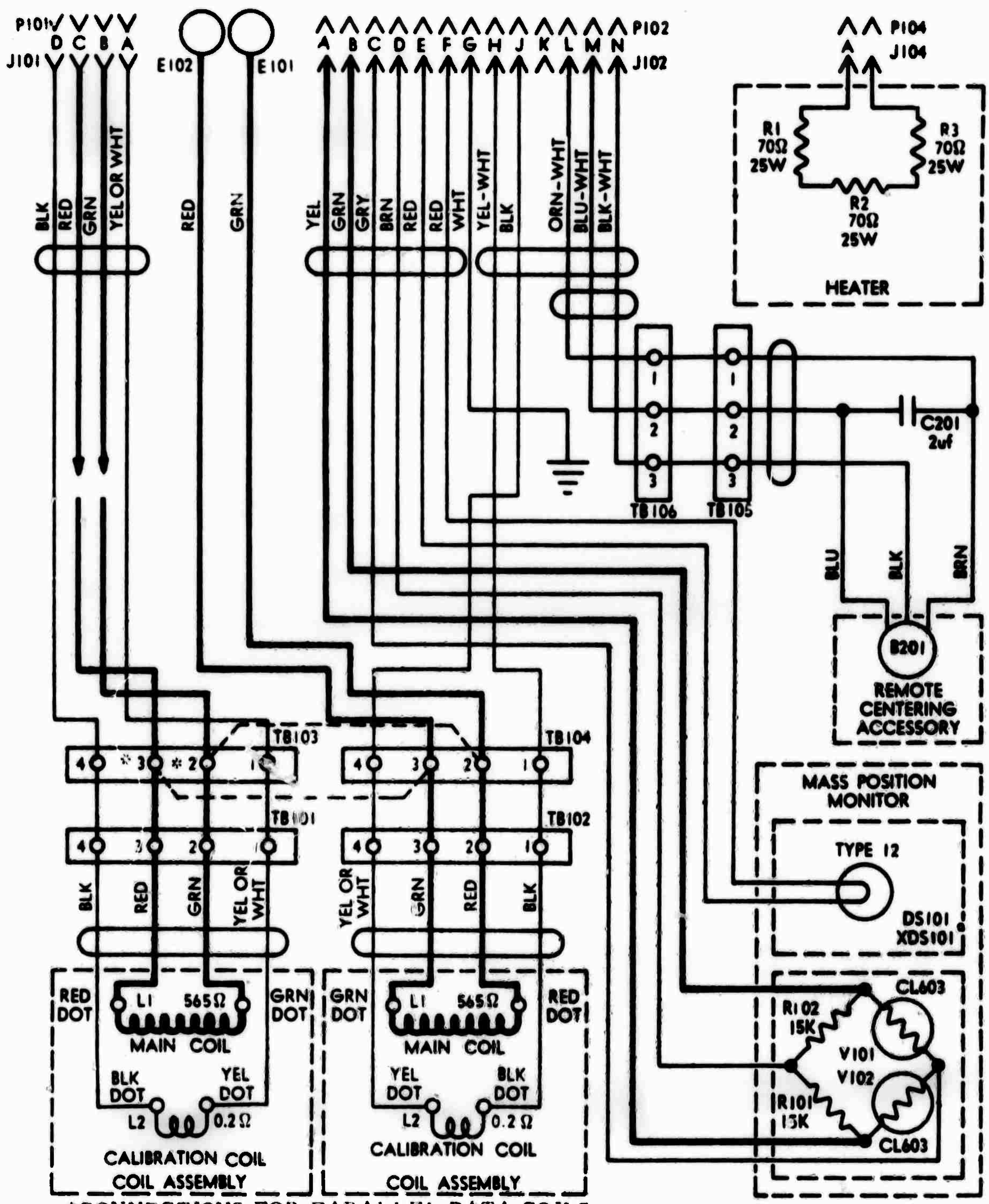
**All coml wire may be purchased from 70331 or 70903. Specify color when ordering.

BLANK PAGE

CHAPTER 7

CIRCUIT DIAGRAMS

7-1. INTRODUCTION. This chapter contains the schematic diagram of the Seismometer.



*CONNECTIONS FOR PARALLEL DATA COILS

168

Figure 7-1. Schematic Diagram

OPERATING INSTRUCTIONS

VARIABLE CAPACITANCE TRANSDUCER

MODEL VCT-201BA

I. General Description

The VCT-201BA Transducer is designed for use with a Long Period Seismometer when displacement meter operation is required.

a) The VCT-201 Transducer

The Sprengnether VCT-201 is a displacement sensing capacitance transducer where the capacitive element is incorporated into a variable discriminator circuit.

In FIG 3 two LC resonant circuits are formed between the detector plates and the shunt inductances L_1 and L_2.

The carrier voltage from the 1.5 mc crystal oscillator is loosely coupled to the detector circuit through the air transformer formed by the variable inductor pairs L_3 and L_1-L_2.

At equilibrium, the voltages generated in the circuits L_1C_1 and L_2C_2 are equal and the sum of the rectified output voltages developed across R_1R_2 and R_8R_9 is zero. Displacement of the center detector plate shifts the circuit resonant peaks with respect to the carrier frequency.

The voltages developed across the output resistors R_1R_2 R_8R_9 become unbalanced and their difference is observed as signal. Output stability of this circuit is dependent principally upon the oscillator frequency regulation. Consequently, system stabilities adequate for tidal observations are readily obtained.

b) VCT-201BA Transducer

The VCT-201 discriminator output requires a minimum load resistance of 10 megohms.

To make the transducer system compatible with standard recorder inputs, a buffer amplifier stage has been incorporated into the VCT-201BA system. Load resistance as low as 1000 ohms can be employed without signal distorti

c) Operation with a Vertical Seismometer:

Displacement Response
The VCT-201BA (LPV) combination functions as a displacement meter with stable output sensitivity of approximately 1.0 volt/mm of ground motion.

Gravity Response
The VCT-201BA (LPV) also functions as a gravity meter with a response proportional to the square of the seismometer period.

The Period-gravity response characteristic for gravity increments is given in FIG 5.

The observed gravity response for constant period is given in FIG 6 for periods of 10, 20, 30 and 50 seconds. The principal limitation on gravity meter operation is the barometric and temperature response of the LPV Seismometer.

To check gravity response load the boom at the center of mass using standard balance weights and observe deflection at scale. The sensitivity should be approximately 0.025 mm/mg for a seismometer period of 30 seconds.

To convert to equivalent gravity sensitivity, use the formula:

$$\Delta g = \frac{mg}{M} \text{ cm/sec}^2$$

Where

m = mass of added weight in grams
g = acceleration of gravity in cm/sec^2
M = seismic mass in grams

d) Operation with a Long Period Horizontal Seismometer.

The VCT-201BA Transducer is combined with the LPH Long Period Seismometer for displacement meter or tiltmeter operation.

VCT-201BA Displacement Meter Operation:
The VCT-201BA (LPH) combination functions as a displacement meter with a stable output sensitivity of about 1 volt/mm of boom motion.

LPH Tilt Meter Operation:
From the general theory of operation for the Long Period Horizontal Seismometer, the boom deflection resulting from a tilt (ψ) is given by:

$$\theta = \psi T^2 \left(\frac{g}{4\pi^2 L}\right)$$

where small deflections are assumed.

ϑ = deflection of boom
ψ = tilt of base in radians
i = angle of inclination of mast
g = acceleration of gravity
L = reduced pendulum length

II. Specifications:

a)	Detector Plate Gap	= ± 2 mm nominal
b)	Plate Area	= 25.8 cm^2
c)	Sensitivity Discriminator Output	= 0.5 v/mm plate displacement
		= 2.5 v/mm referred to scale for S-5100 V & H Seismometers
	Buffer Output	= 1 v/mm referred to scale for S-5100 V & H Seismometers
d)	Linear Range	= ± 2 mm plate displacement
		= ± 10 mm referred to scale for S-5100 V & H Seismometers
e)	Operating Temperature Range	= 0^oc to $+50^oc$ (-20^oc to $+50^oc$ with Special Amplifiers)
	Permissible Temperature Excursion about operating point	= ± 5^oc
f)	Power Comsumption	= ± 12 VDC, 0.5 watts, 20 ma quiescent
	Required Regulation	= 0.005% line and load
g)	VCT-201B Power Supply	= 110V, 60 Hz input ± 12 VDC, 60 ma output
	Regulation	= 0.005% line and load
h)	Mass of Center Plate Assembly	= 60 gm
i)	VCT-201BA Weight	= 2 lbs.

III. Installation

The seismometer and the discriminator/amplifier unit form a matched set.

The complete system has been assembled at the factory and tuned for optimum performance. If a proper field installation has been carried out, only minor adjustments will be required.

a) Connections:

The capacitance plates are shipped assembled on the seismometer.

The end plate assembly is mounted on the seismometer base. The center plate is an integral part of the boom and is connected electrically to the seismometer frame (ground).

Unpack the discriminator unit and set it on the pier adjacent to the seismometer.

Electrical connections are made through corresponding terminals on the boom and seismometer base. Coaxial leads connect to the discriminator unit. The seismometer base and the discriminator unit should be connected to a common ground located adjacent to the pier. Proper grounding insures negligible signal effects due to stray capacitance, displacement of leads, etc.

Connect power supply to discriminator unit terminal block OBSERVING CORRECT POLARITY (See FIG 1)

Power required is ± 12 volts DC, 30 ma; 0.005% line, load and temperature regulation.

Connect output to suitable recorder. Buffered output will accept loads down to 1000 ohms without appreciable distortion.

b) Preliminary Checkout

Activate the system and run a preliminary calibration by observing output voltage while moving the seismometer boom from stop-to-stop in one mm increments. The result should approximate Curve IV in FIG 4.

If the response is linear and the mechanical and electronic zero points coincide to a few tenths of a millimeter, the system is ready to operate. In this case, the complete tuning and adjustment procedure that follows can be omitted.

If the output voltage is low or fails to pass through zero as the boom is moved from stop-to-stop, the discriminator is detuned. Tuning procedures are given in Paragraph (d).

If output is obtained but fails to approximate the curves shown in FIG 3, one or more of four control adjustments will be required. Typical signal output diviations and the necessary corrective adjustments are outlined in FIG 9.

1. Failure to achieve linearity (FIG 9-A). Resonance peaks fall within the operating range. Paragraph (e) describes the adjustment for maximum linearity.

2. (FIG 9-B) Horizontal displacement of the electronic zero with respect to mechanical zero. The procedure for adjusting the discriminator zero point is given in Paragraph (g).

3. (FIG 9-C) Displacement of the output characteristic along the voltage axis. See Paragraph (h).

4. (FIG 9-D) Deviation of amplifier gain. See Paragraph (i).

If more than one of the output deviations described above occurs, apply the required adjustment procedures in the order given 1 through 4. This is necessary because operations 1 and 2 control the position of the dual discriminator characteristic with respect to true boom position, while 3 and 4 regulate the electronic voltage zero only. Adjustments 3 and 4 cannot be made until the detector response characteristic has been established.

c. Tuning the Discriminator Input

Equipment required: VTVM or equivalent high impedance voltage detector.

Loosen the 4 top panel screws on the electronic unit and lift the assembly from the box.

Identify the components according to FIG 2. The center inductor (L_3) is the primary of the air transformer. Connect the VTVM between either point A or point C (FIG 2) and the common output (use a miniture alligator clip to connect to the diode on the P.C. Board). Lock the seismometer boom at center zero. Adjust L_3 (center inductor) for maximum voltage.

d) Tuning the Discriminator

Unclamp the seismometer boom. Check position of detector plates for proper centering. They should not come into mutual contact at extreme boom positions.

If the plates are not properly centered, loosen clamp screws securing the outer plates (C_2 & C_3) to the seismometer frame. Insert a 0.020 inch (0.5 MM) spacer into the lower gap. (Right hand gap for LPH). Lock the boom at extreme lower (right) position and align lower plate (C_3) against spacer. Tighten clamp screws.

Clamp boom against upper stop and repeat operation for C_2. (Left hand stop for LPH).

Identify the three plate connectors with the associated inductor controls and connect as follows:

Left hand connector #1 to upper (left for LPH)
plate (C_2) and #1 inductor (L_1) (Point A).
Center connector (#2)to center plate (C),
Right hand connector (#3) to lower (right)
plate (C_3) and the L_2 inductor (Point C).

Connect the VTVM across A & B shown in FIG 1 with B positive. (i.e. between the ~~white~~ blk output lead and tuning Point "A" on the P.C. Board). Move the center plate towards C_3 by holding the boom against lower (right) stop. This will give a maximum gap in the circuit being monitored. Adjust L_1 for maximum positive voltage. Note that B is always positive with respect to A and C.

A value of 30-40 volts DC should be obtained.

Move center plate to a position adjacent to C_2 by holding boom against the upper (left) stop.

Transfer the negative VTVM probe from A to C and adjust L_2 for maximum voltage.

Check adjustment of L_3 for maximum voltage.

Repeat procedure with boom at upper (left) and lower (right) stops to obtain optimum tuning.

The discriminator circuit resonances will now be found at the extreme positions of the seismometer boom.

e) Adjustment for Maximum Linearity

Due to the angular deflection of the capacitance detector plates, the linear response range will be limited to about ± 4 mm boom displacement. To extend the range of linear response, it is necessary to increase the resonance peak separation. Turn the L_1 and L_2 controls clockwise (increasing inductance) by about 1/4 turn. Response should now be linear over the entire stop-to-stop range.

f) Calibration of discriminator output

Connect the VTVM between A & C (FIGS 1 & 2). Move the boom in one millimeter intervals, taking readings on the VTVM. The results should appear as in FIG 4, Curve III.

g) Zeroing the Discriminator Output

Occasionally the electronic and mechanical zero points do not coincide. (See FIG 9-B). To effect coincidence, translate the discriminator resonance along the frequency axis. To correct a negative zero voltage, move to the right by increasing L_1 and decreasing L_2 by equal amounts. To eliminate a positive zero voltage, reverse this procedure.

h) Output adjustment

Clamp the boom at center zero. Observe the signal output of the VCT-201BA on a recorder or the VTVM. If a zero shift is indicated (FIG 9-C), zero the output by adjusting the trim potentiometer (R_{15} FIG 2) mounted on the P.C. Board.

i) Gain

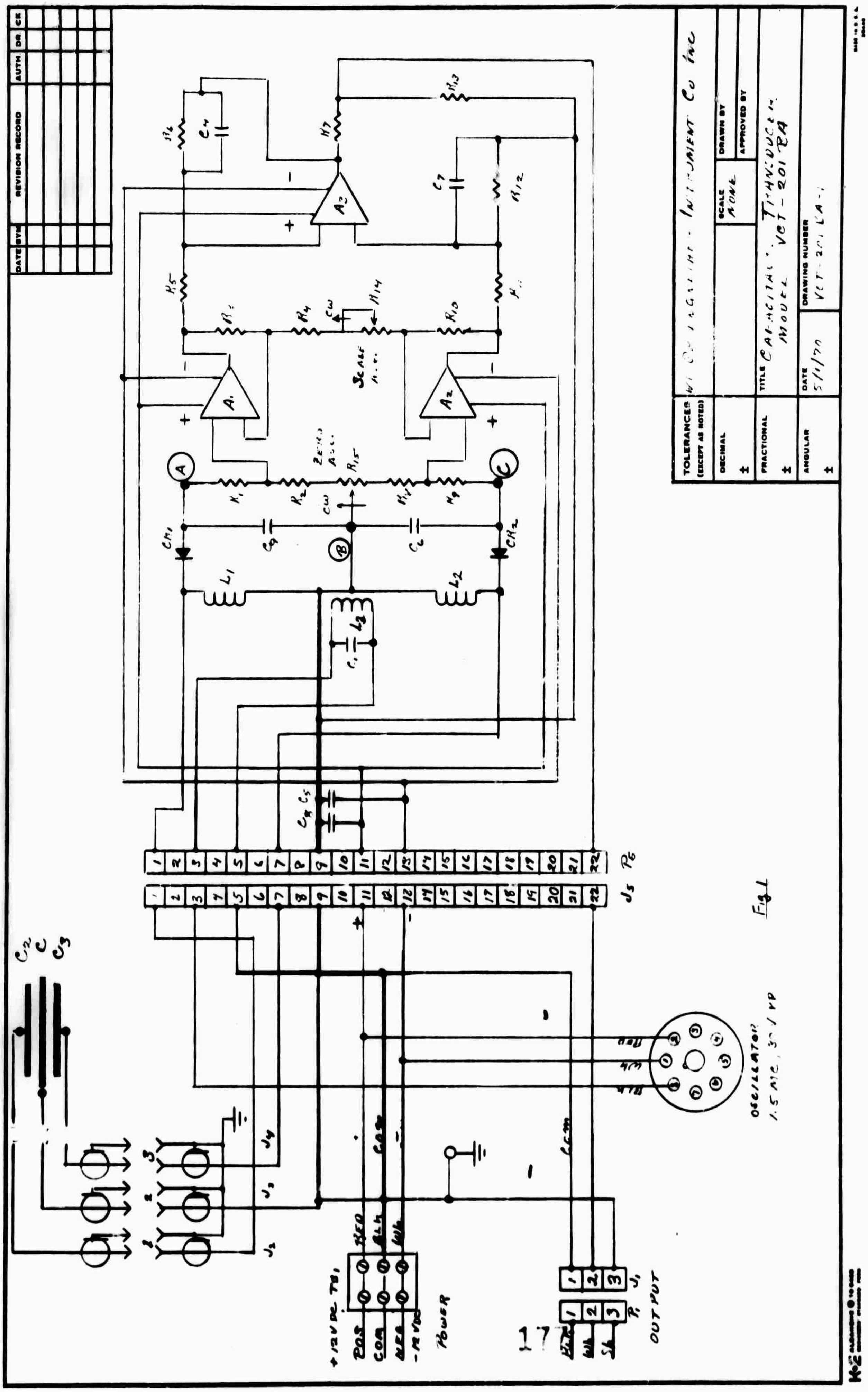
After zeroing, observe the maximum voltage output with the boom positioned at each extreme. The amplified voltage output is inverted. The output may be above or below the 1 V/mm specified for this equipment (FIG 9-D). To obtain the required ± voltage output, set the "Scale Adj." potentiometer (R_{14} FIG 2) until maxima of ± 10 volts are obtained.

Return unit to case and calibrate output at one millimeter intervals referred to scale.

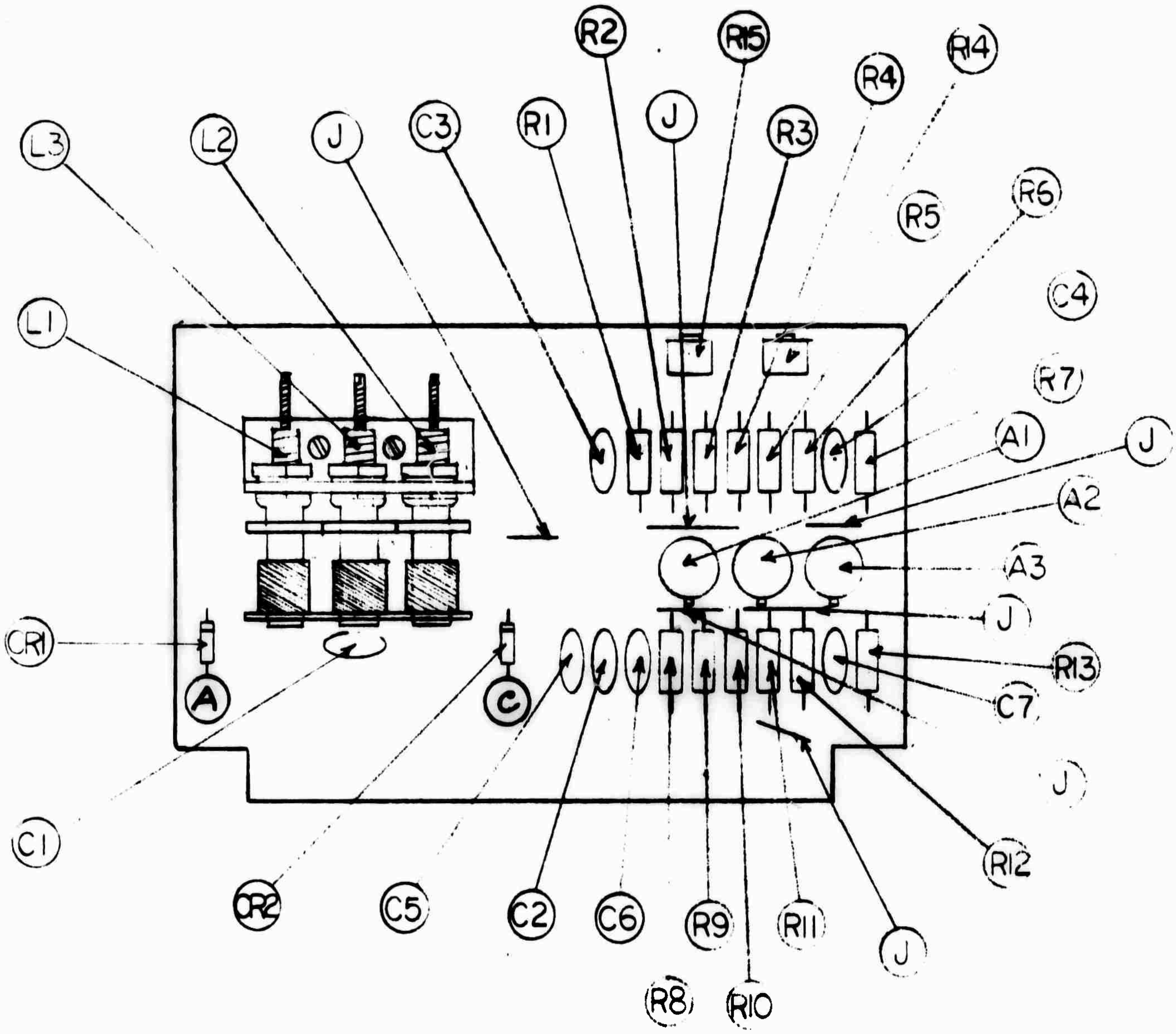
VCT-210
Addendum to Paragraph H

For Example:

With boom set to Left and Right maximum deflection, outputs of 8 and 9 volts respectively are observed. Adjust R_{15} with boom at Left until 8.5 volts is obtained. Move boom to Right. If setting is correct, an equal value of 8.5 volts will be observed.



REVISION RECORD
DATE
SYM
AUTH
DR
CK
TOLERANCES (EXCEPT AS NOTED)
DECIMAL
FRACTIONAL
ANGULAR
SCALE NONE
DRAWN BY
APPROVED BY
TITLE
DATE
DRAWING NUMBER
OSCILLATOR
POWER
OUTPUT
Fig 1



(J) INDICATES JUMPER

178

Fig 2

DATE	SYM	REVISION RECORD	AUTH.	DR.	CK.

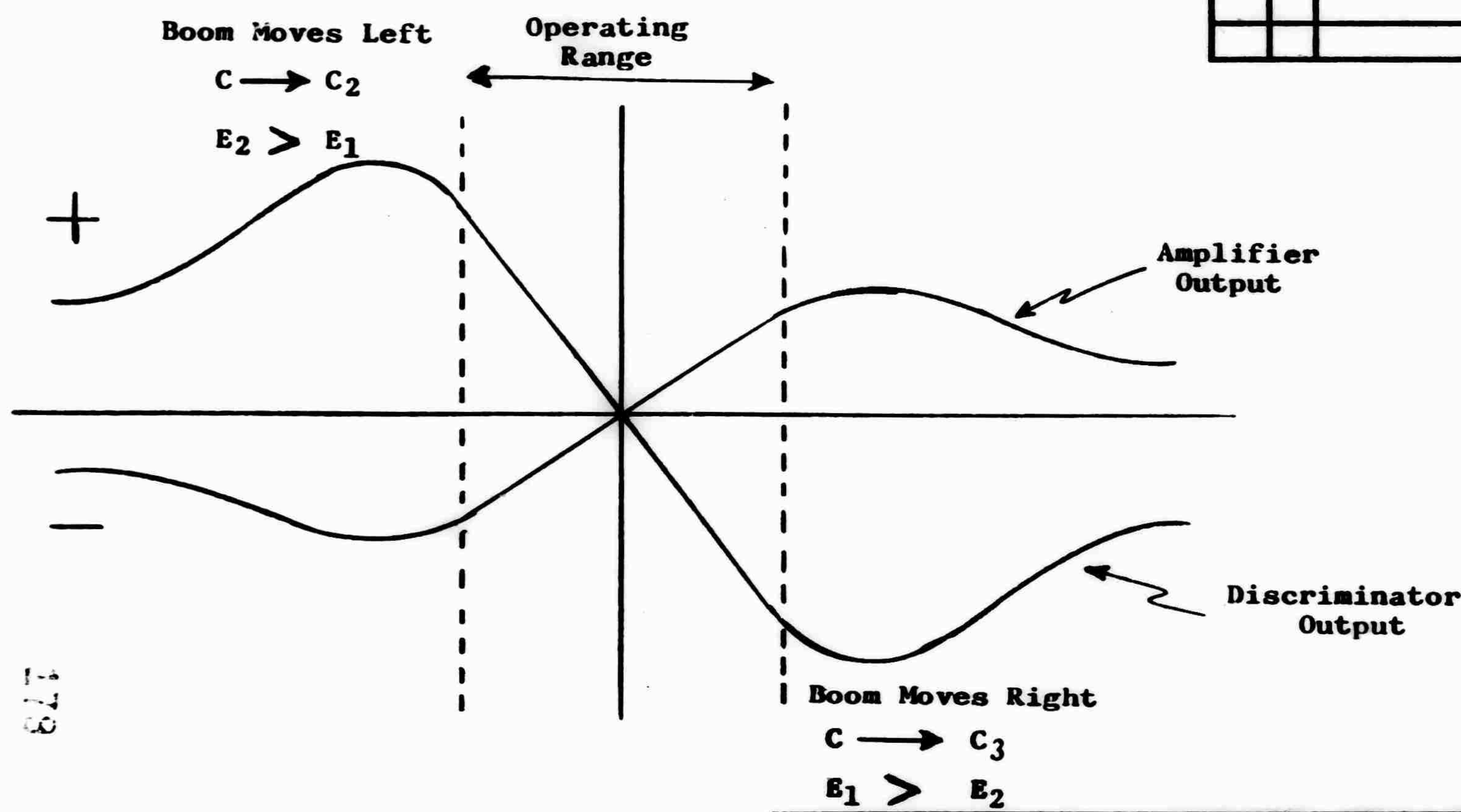


Fig 3.

TOLERANCES (EXCEPT AS NOTED)	W.F. SPRENGNETHER INSTRUMENT CO., INC.
DECIMAL ±	SCALE NONE / DRAWN BY / APPROVED BY
FRACTIONAL ±	TITLE CAPACITANCE TRANSDUCER MODEL VCT-201BA SIGNAL OUTPUT CHARACTERISTIC
ANGULAR ±	DATE 5/1/70 / DRAWING NUMBER VCT-201BA-2

K+E ALBANENE 10 5455

MADE IN U.S.A. 20757

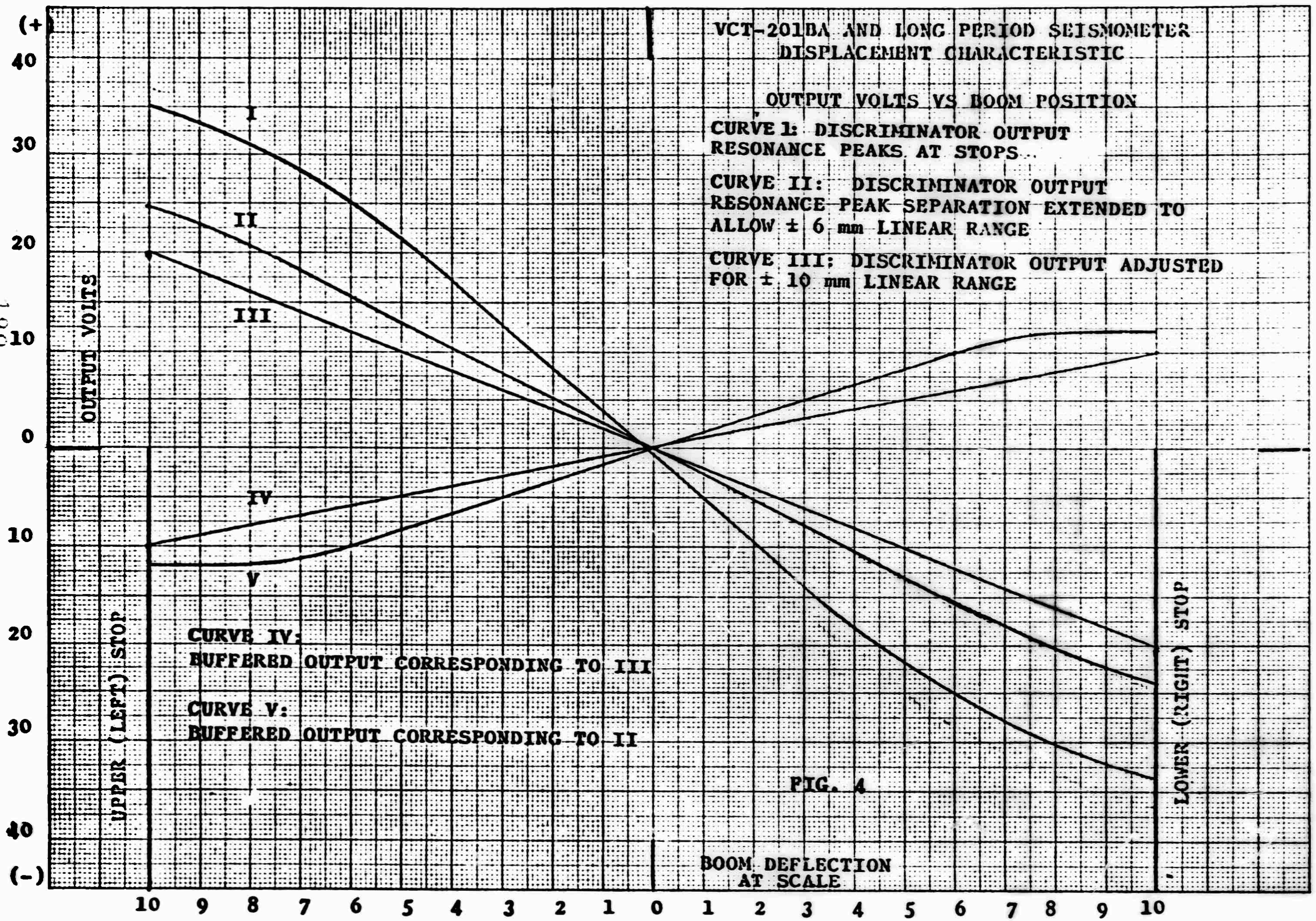

VCT-201BA AND LONG PERIOD SEISMOMETER
DISPLACEMENT CHARACTERISTIC
OUTPUT VOLTS VS BOOM POSITION
CURVE I: DISCRIMINATOR OUTPUT RESONANCE PEAKS AT STOPS
CURVE II: DISCRIMINATOR OUTPUT RESONANCE PEAK SEPARATION EXTENDED TO ALLOW ± 6 mm LINEAR RANGE
CURVE III: DISCRIMINATOR OUTPUT ADJUSTED FOR ± 10 mm LINEAR RANGE
CURVE IV: BUFFERED OUTPUT CORRESPONDING TO III
CURVE V: BUFFERED OUTPUT CORRESPONDING TO II
I
II
III
IV
V
OUTPUT VOLTS
(+)
40
30
20
10
0
10
20
30
40
(-)
UPPER (LEFT) STOP
LOWER (RIGHT) STOP
BOOM DEFLECTION AT SCALE
10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10

FIG. 4

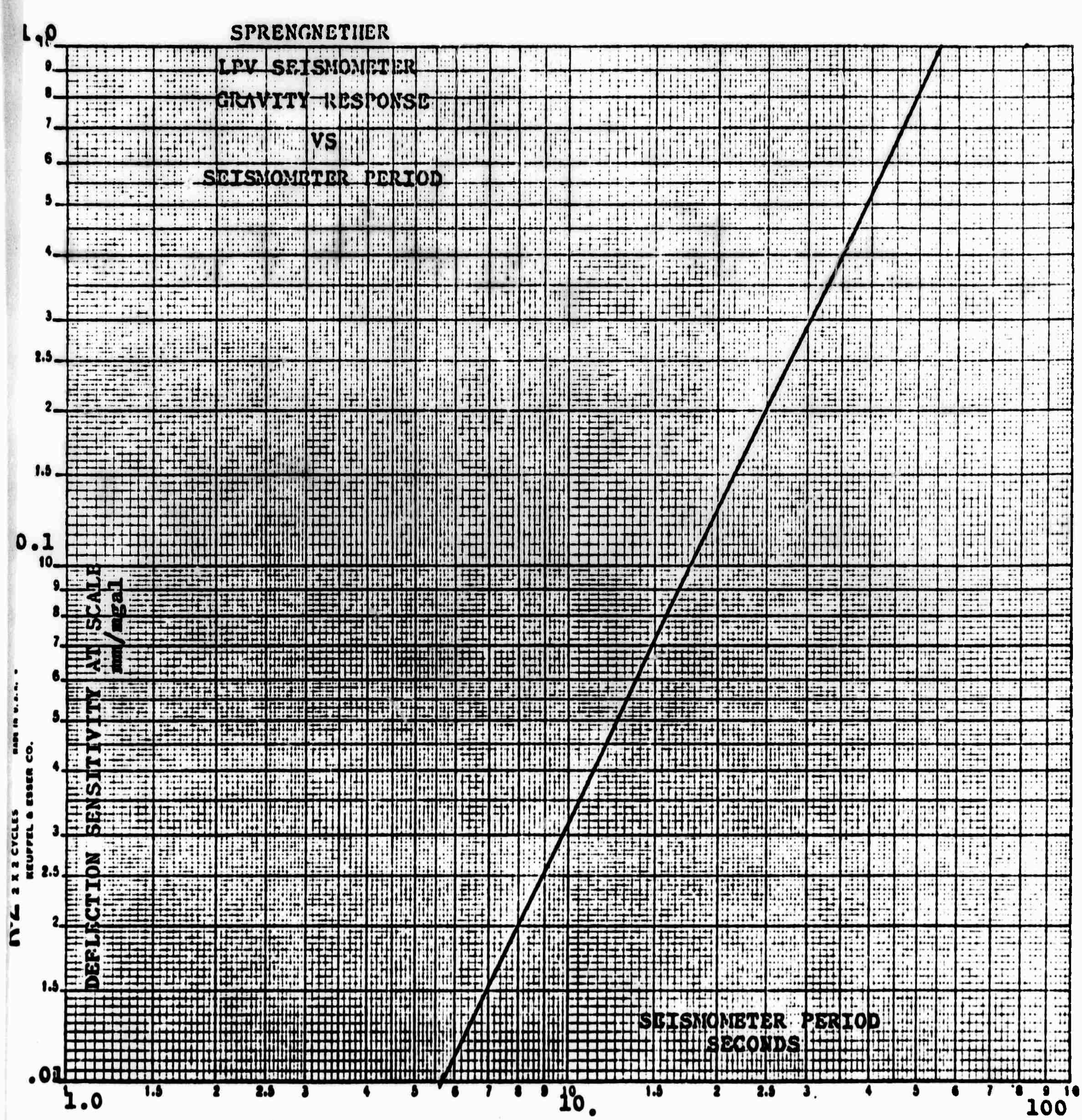
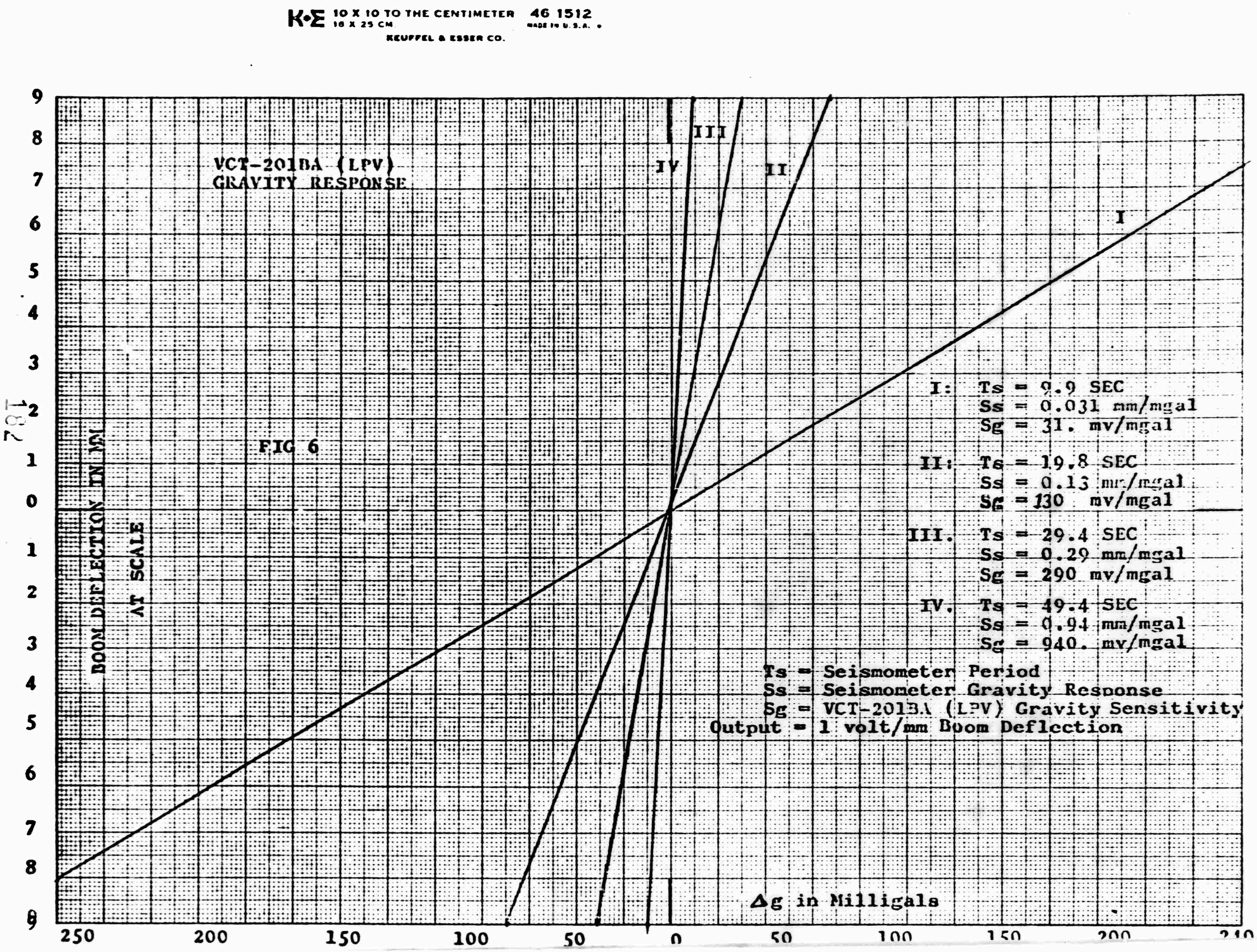
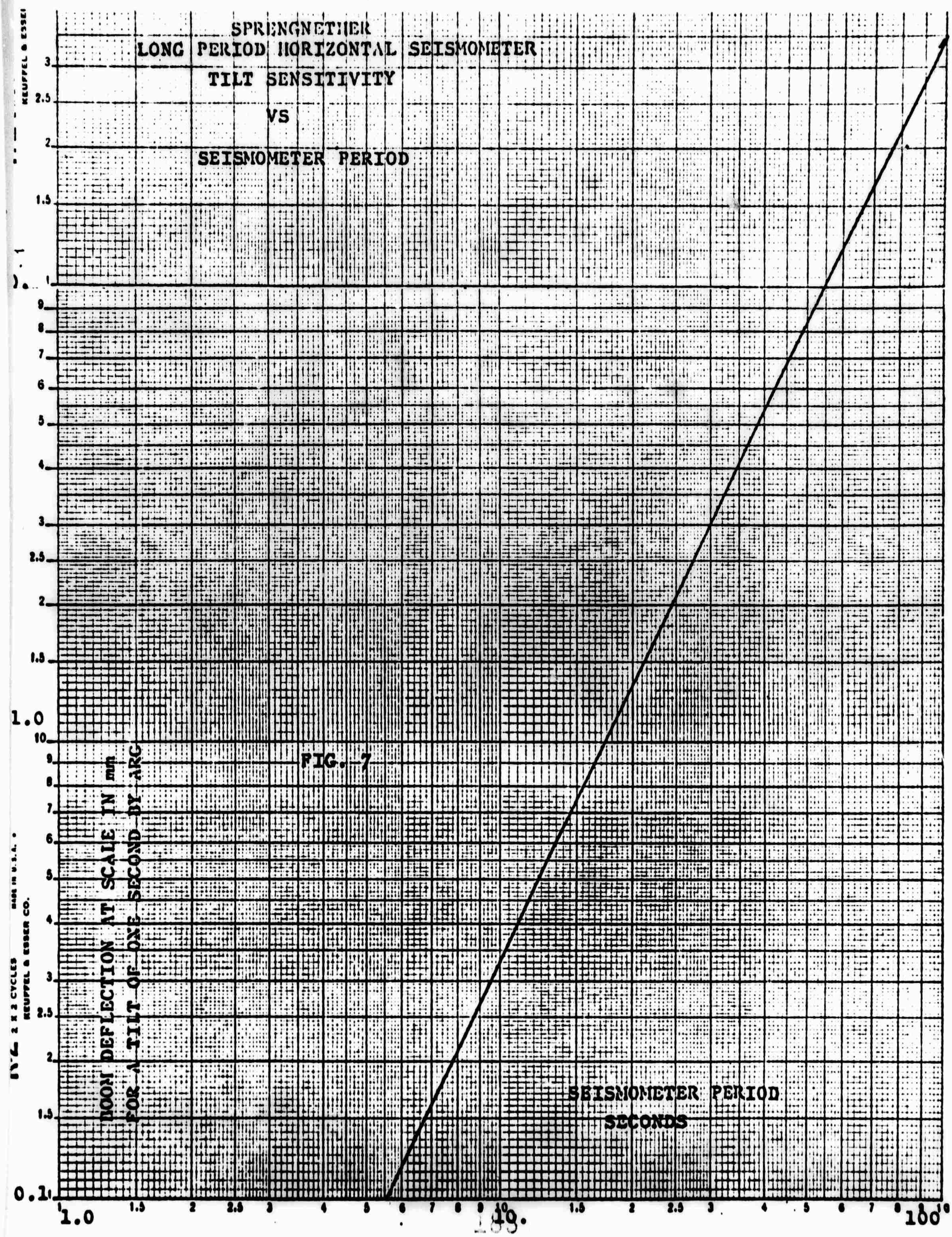
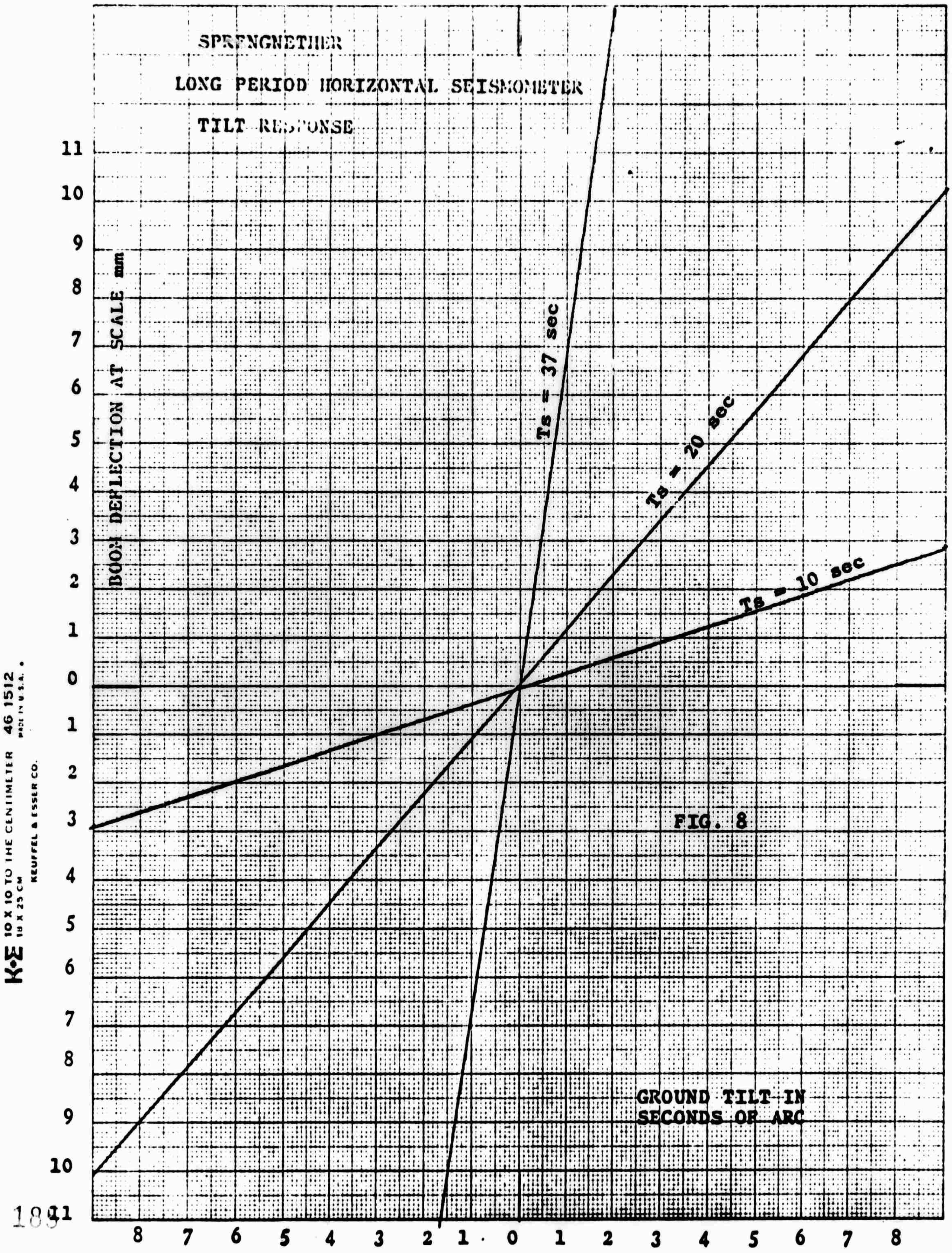

SPRENGNETHER
LPV SEISMOMETER
GRAVITY RESPONSE
VS
SEISMOMETER PERIOD
DEFLECTION SENSITIVITY AT SCALE
mm/mgal
SEISMOMETER PERIOD
SECONDS
1.0
0.1
.01
1.0
10.
100
KEUFFEL & ESSER CO.

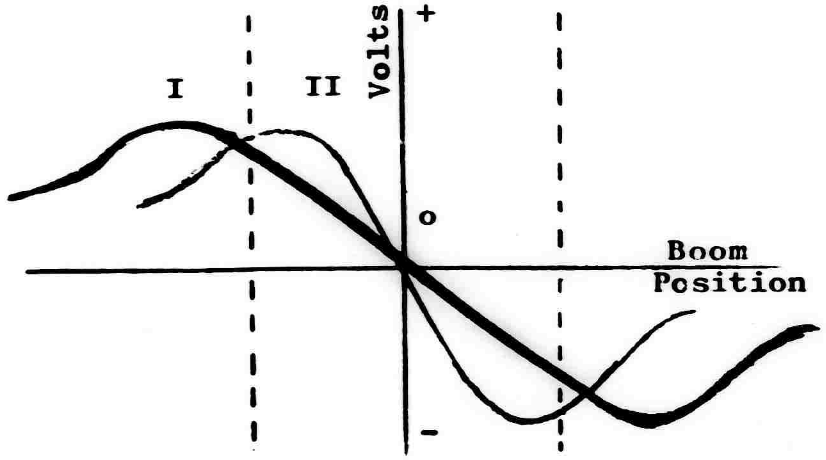
FIG. 5


K•E 10 X 10 TO THE CENTIMETER 46 1512
18 X 25 CM MADE IN U.S.A.
KEUFFEL & ESSER CO.
VCT-201BA (LPV)
GRAVITY RESPONSE
FIG 6
BOOM DEFLECTION IN MM
AT SCALE
I
II
III
IV
I: Ts = 9.9 SEC
Ss = 0.031 mm/mgal
Sg = 31. mv/mgal
II: Ts = 19.8 SEC
Ss = 0.13 mm/mgal
Sg = 130 mv/mgal
III. Ts = 29.4 SEC
Ss = 0.29 mm/mgal
Sg = 290 mv/mgal
IV. Ts = 49.4 SEC
Ss = 0.94 mm/mgal
Sg = 940. mv/mgal
Ts = Seismometer Period
Ss = Seismometer Gravity Response
Sg = VCT-201BA (LPV) Gravity Sensitivity
Output = 1 volt/mm Boom Deflection
Δg in Milligals
9
8
7
6
5
4
3
2
1
0
1
2
3
4
5
6
7
8
9
250
200
150
100
50
0
50
100
150
200


SPRENGNETHER
LONG PERIOD HORIZONTAL SEISMOMETER
TILT SENSITIVITY
VS
SEISMOMETER PERIOD
FIG. 7
BOOM DEFLECTION AT SCALE IN mm
FOR A TILT OF ONE SECOND BY ARC
SEISMOMETER PERIOD
SECONDS
0.1
1.0
1.0
10.
100


SPRENGNETHER
LONG PERIOD HORIZONTAL SEISMOMETER
TILT RESPONSE
BOOM DEFLECTION AT SCALE mm
Ts = 37 sec
Ts = 20 sec
Ts = 10 sec
FIG. 8
GROUND TILT IN SECONDS OF ARC
11 10 9 8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8 9 10 11
8 7 6 5 4 3 2 1 0 1 2 3 4 5 6 7 8
K+E 10 X 10 TO THE CENTIMETER 46 1512
KEUFFEL & ESSER CO.

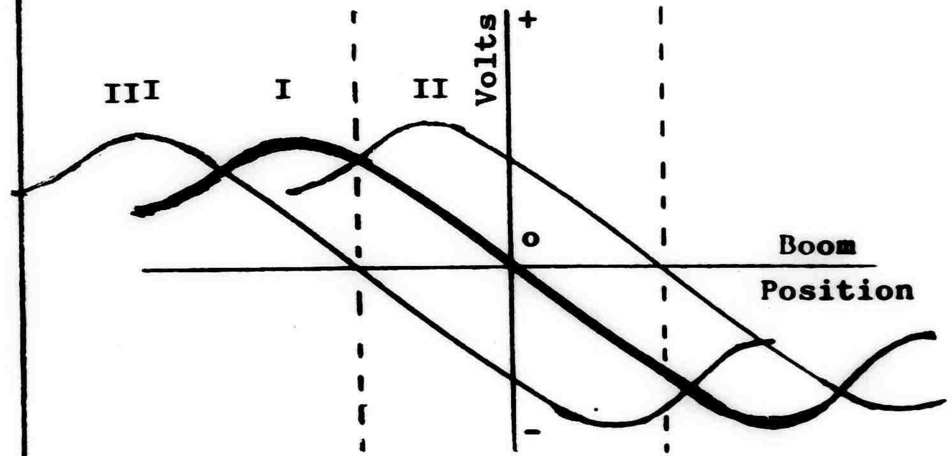
9-A



II Resonance Peaks Inside Operating Range

1 Effect of Increasing L_1 and L_2

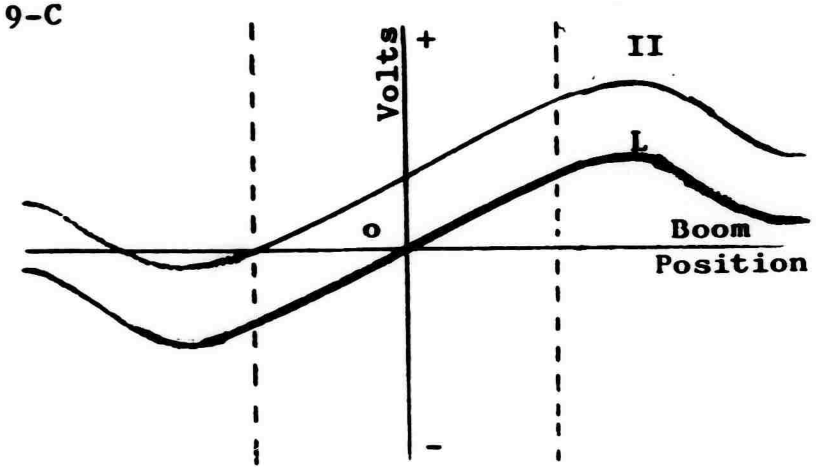
9-B



II or III Discriminator Zero Not in Coincidence with Seismometer Zero

I Zero Coincidence Effected by Reciprocal Adjustment of L_1 and L_2

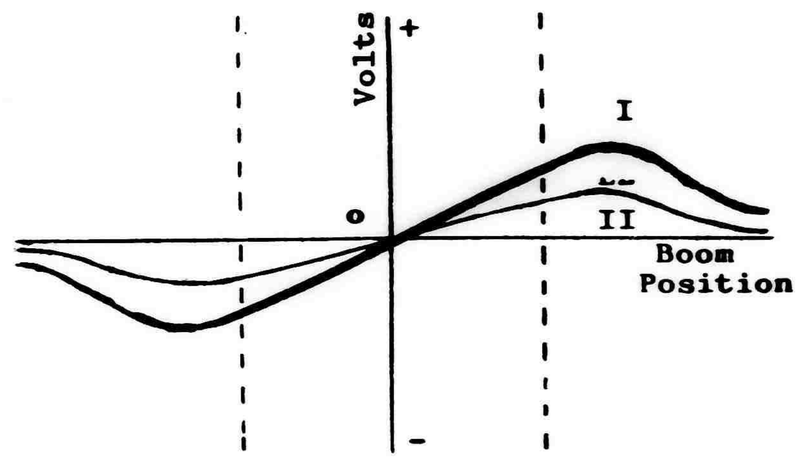
9-C



II Output Zero Shift

I Output Zeroed by Adjustment of R_{15}

9-D



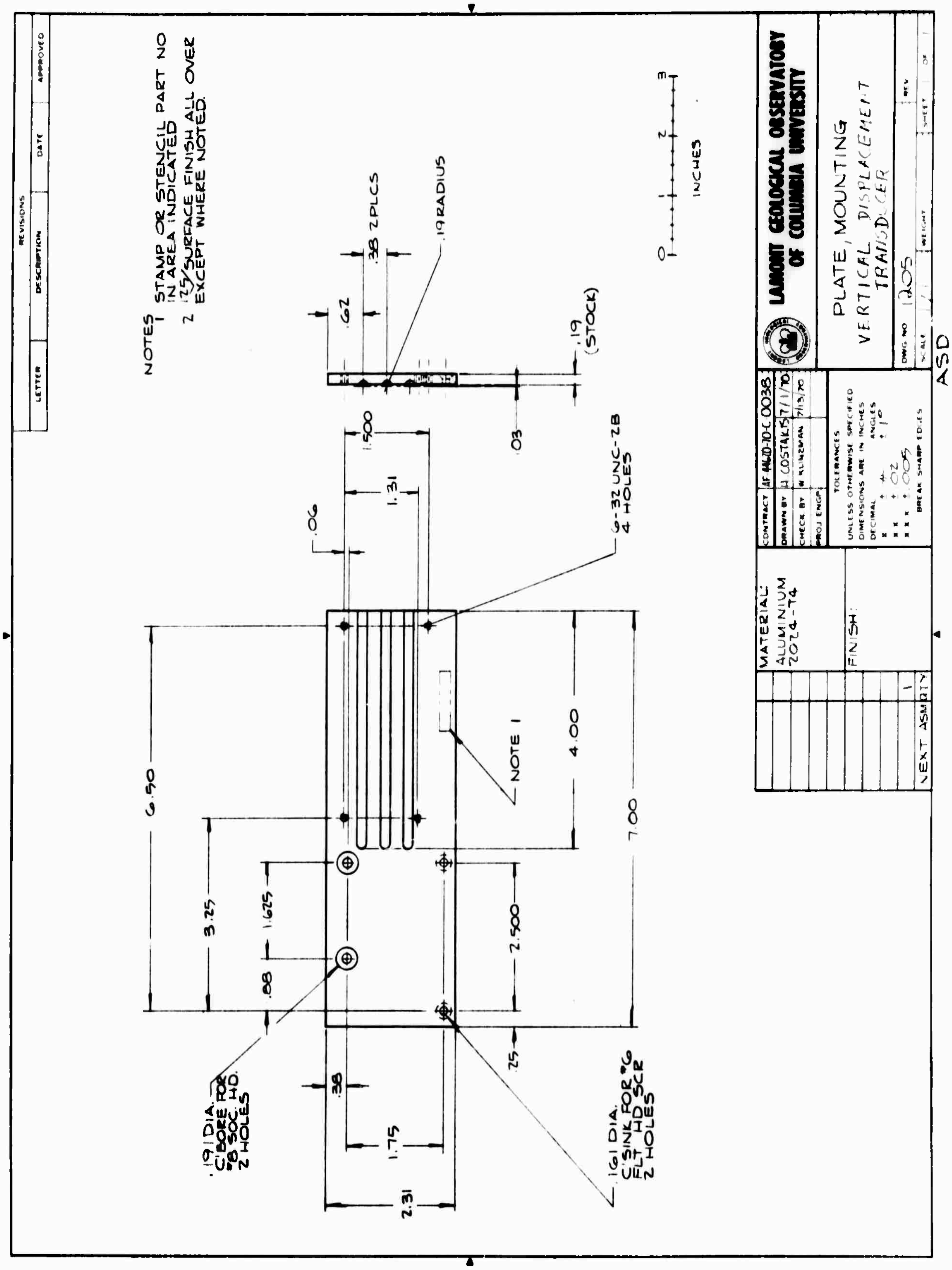
II Amplifier Gain too Low

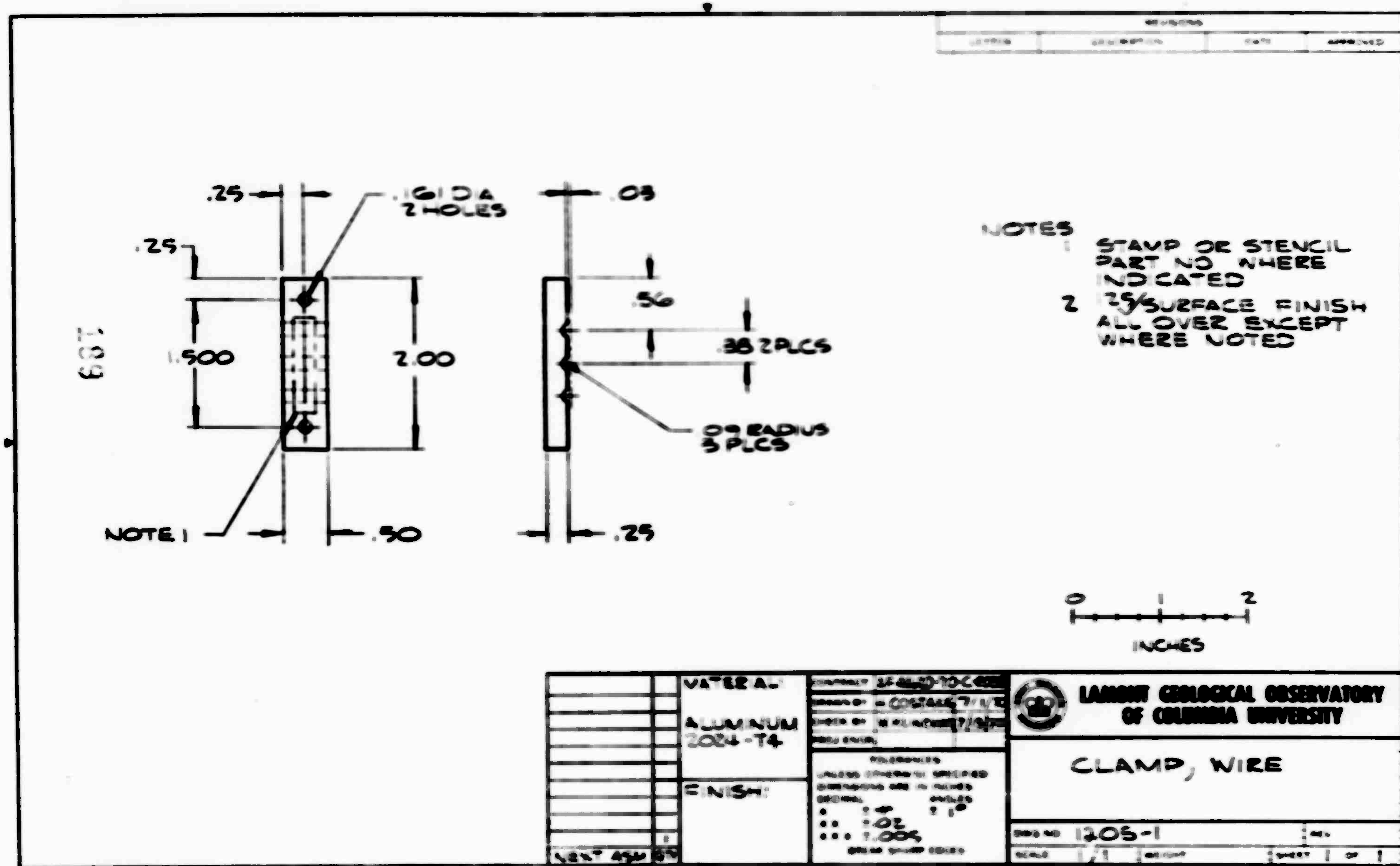
I Gain Set at ± 10 Volts by Adjustment of R_{14}

FIG 9

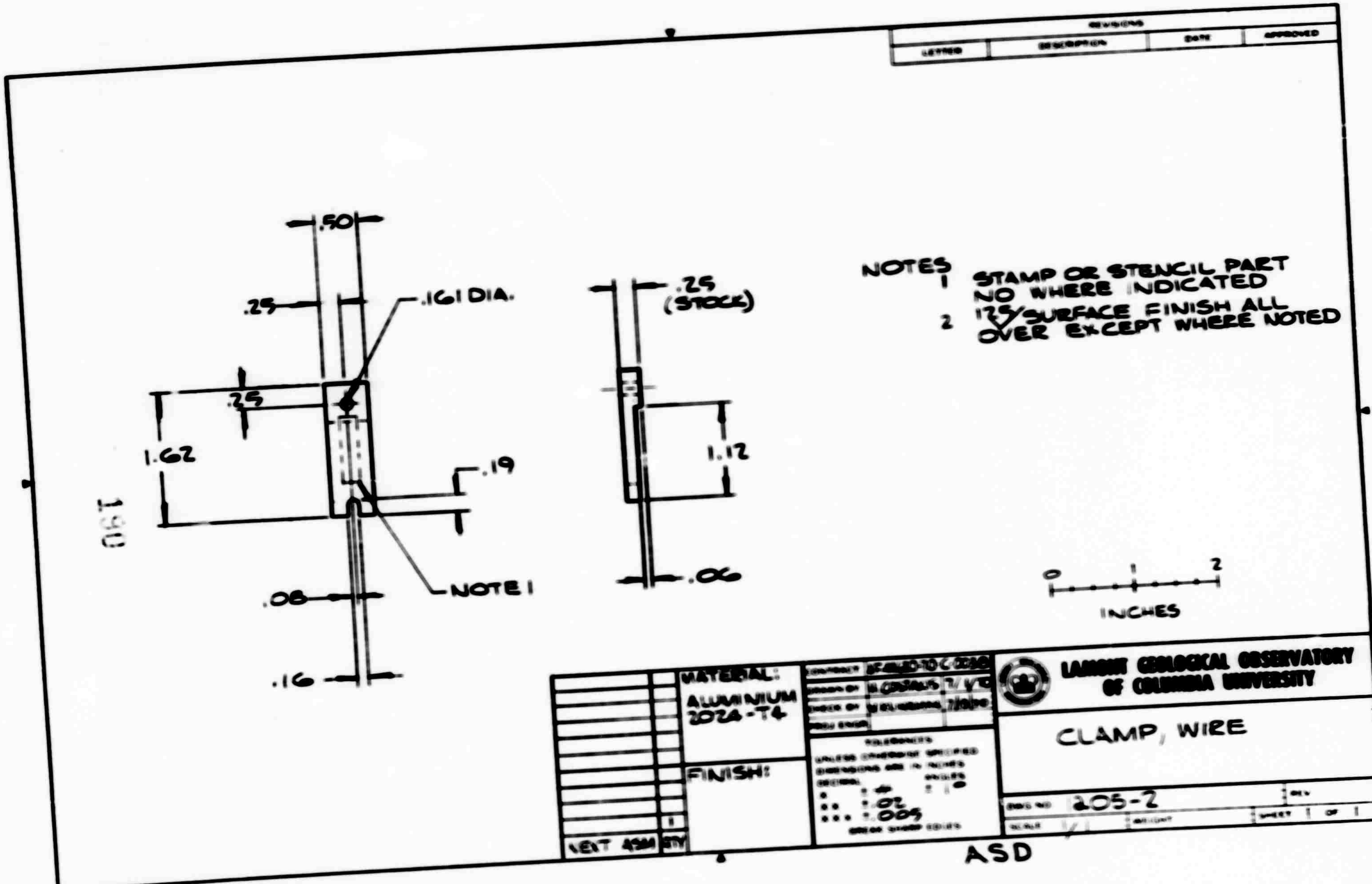
W.F. SPRENGNETHER INSTRUMENT COMPANY, INC.
VCT-201BA CAPACITANCE TRANSDUCER
PARTS LIST

Circuit Reference Designation	Description	Manufacturer
A_1, A_2, A_3	Operational Amplifier, Type UA741C	Fairchild
C_1	Capacitor, 150pf, ± 10%, 1KVDC	Sprague
C_2, C_5	Capacitor, .047 mfd ± 10%, 100 WVDC	Sprague
C_3, C_6	Capacitor, .001 mfd ± 10%, 1KVDC	Sprague
C_4, C_7	Capacitor, .01 mfd ± 10%, 200 WVDC	Sprague
CR_1, CR_2	Diode, IN4148	G.E.
L_1, L_2, L_3	Inductor, Variable, 61-122 uHy, #2060-7	Cambion
R_1, R_9	Resistor, Metal Film, ¼W, 511K ± 1%	Corning
R_2, R_8	Resistor, Metal Film, ¼W, 24.9K ± 1%	Corning
R_3, R_5, R_6	Resistor, Metal Film, ¼W, 10K ± 1%	Corning
R_{10}	Resistor, Metal Film, ¼W, 24.9K ± 1%	Corning
R_{11}, R_{12}	Resistor, Metal Film, ¼W, 10K ± 1%	Corning
R_4	Resistor, Metal Film, ¼W, 4.64K ± 1%	Corning
R_7	Jumper Wire (0 Ohms)	WFS
R_{13}	Open (Infinite Resistance)	N/A
R_{14}	Helipot, Single Turn, 3/4W, 5K ± 10%	Beckman
R_{15}	Helipot, Single Turn, 3/4W, 10K ± 10%	Beckman
TB_1	Terminal Block 3-140-Y	Cinch-Jones
P_1	Cable Plug 91-MC3M	Amphenol
J_1	Receptacle 91-PC3F	Amphenol
P_2, P_3, P_4	Coaxial Plug 309-2225/309-2275	Amphenol
J_2, J_3, J_4	Coaxial Receptacle 309-2175/309-2275	Amphenol
J_6	P.C. Receptacle 006022-022-940-002	Elco
Case	MT11281-063-300	Moorlee
Cover	MT21281-063-010	Moorlee


REVISIONS
LETTER
DESCRIPTION
DATE
APPROVED
NOTES
1 STAMP OR STENCIL PART NO IN AREA INDICATED
2 125/ SURFACE FINISH ALL OVER EXCEPT WHERE NOTED.
0 1 2 3
INCHES
.62
.38 2PLCS
.19 RADIUS
.19 (STOCK)
.03
.06
1.31
1.500
6-32 UNC-2B 4 HOLES
NOTE 1
6.50
3.25
1.625
.88
7.00
4.00
2.500
.75
.38
1.75
2.31
.191 DIA. C'BORE FOR #8 SOC. HD. 2 HOLES
.161 DIA. C'SINK FOR #6 FLT HD SCR 2 HOLES
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
PLATE, MOUNTING
VERTICAL DISPLACEMENT TRANSDUCER
DWG NO 1205
SCALE
WEIGHT
SHEET
OF
REV
CONTRACT
DRAWN BY H COSTAKIS 7/1/70
CHECK BY W KUNZMAN 7/15/70
PROJ ENGR
TOLERANCES
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES
DECIMAL
ANGLES
±1°
±.02
±.005
BREAK SHARP EDGES
MATERIAL: ALUMINIUM 2024-T4
FINISH:
NEXT ASMB QTY
1
ASD

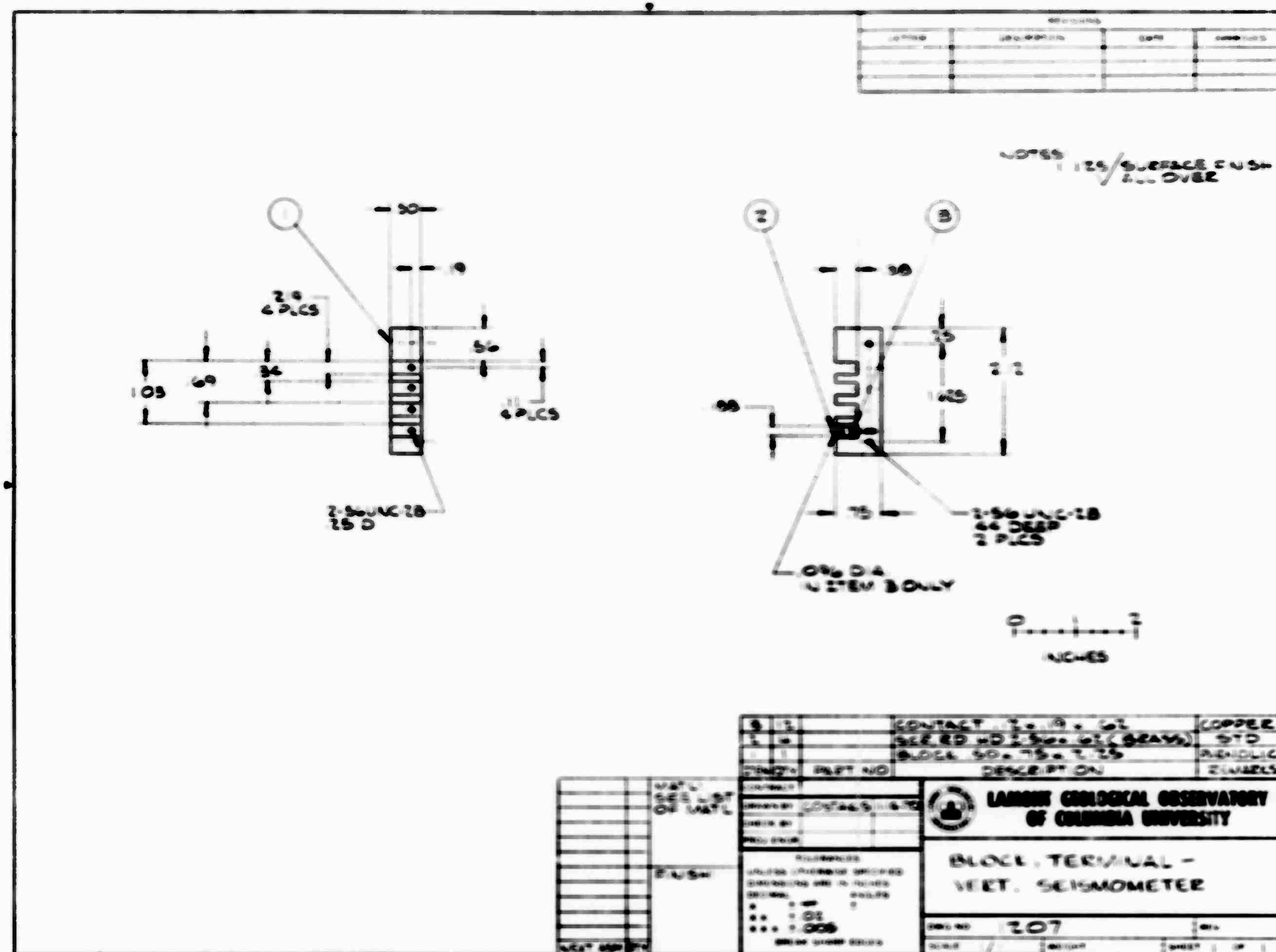

.25
.161 DIA
2 HOLES
.25
1.500
2.00
NOTE 1
.50
.03
.56
.38 2 PLCS
.09 RADIUS
3 PLCS
.25
NOTES
1 STAMP OR STENCIL PART NO. WHERE INDICATED
2 125/ SURFACE FINISH ALL OVER EXCEPT WHERE NOTED
0
1
2
INCHES
MATERIAL
ALUMINUM
2024-T4
FINISH:
LAMONT GEOLOGICAL OBSERVATORY
OF COLUMBIA UNIVERSITY
CLAMP, WIRE
1205-1
1/1
1

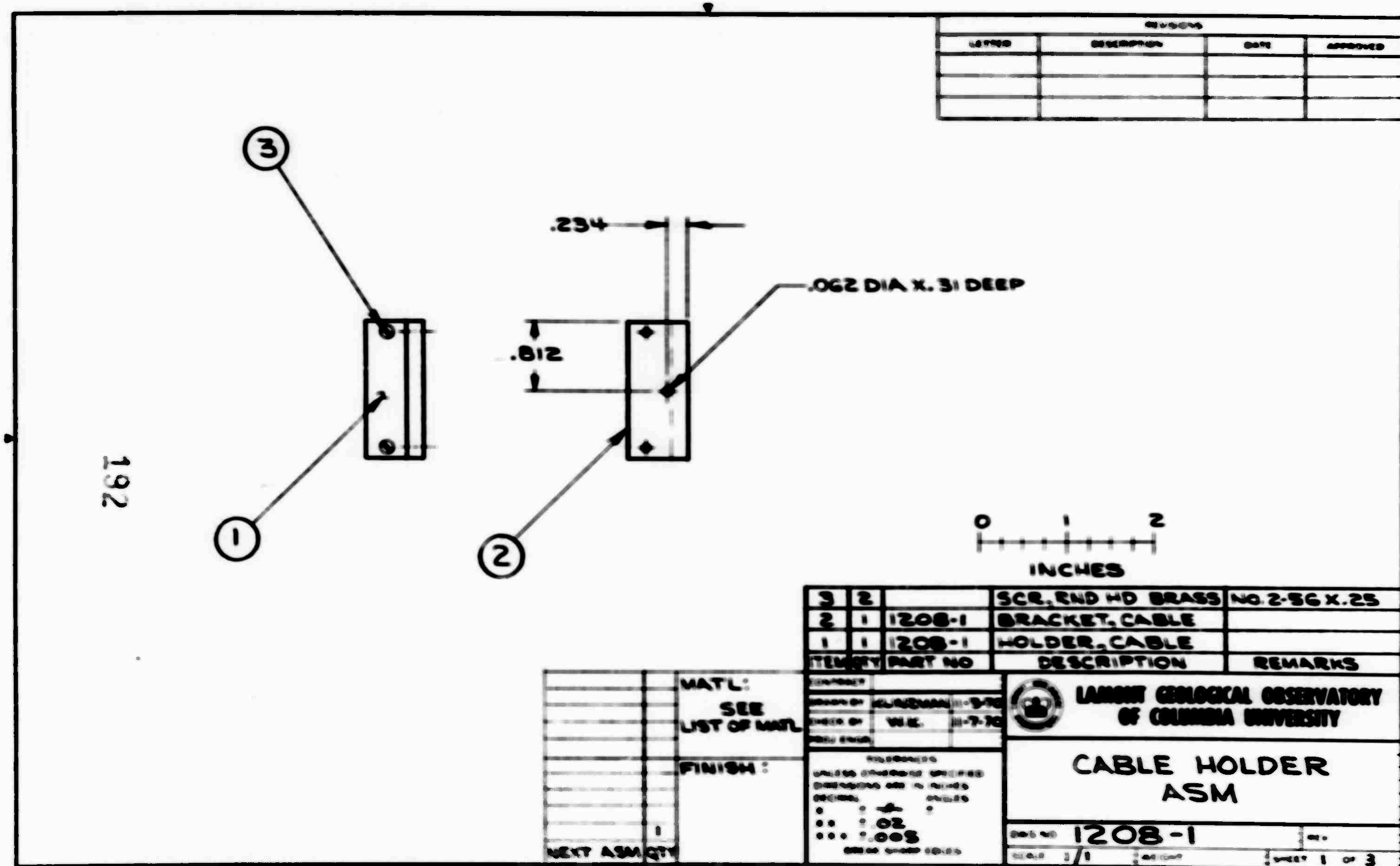
ASD


.50
.25
.161 DIA.
.25
1.62
.19
NOTE 1
.08
.16
.25
(STOCK)
1.12
.06
NOTES
1 STAMP OR STENCIL PART NO WHERE INDICATED
2 125/ SURFACE FINISH ALL OVER EXCEPT WHERE NOTED
0 1 2
INCHES
REVISIONS
LETTER
DESCRIPTION
DATE
APPROVED
MATERIAL:
ALUMINIUM 2024-T4
FINISH:
NEXT ASM
QTY
TOLERANCES
.02
.005
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
CLAMP, WIRE
DWG NO 205-2
SCALE 1/1
SHEET 1 OF 1

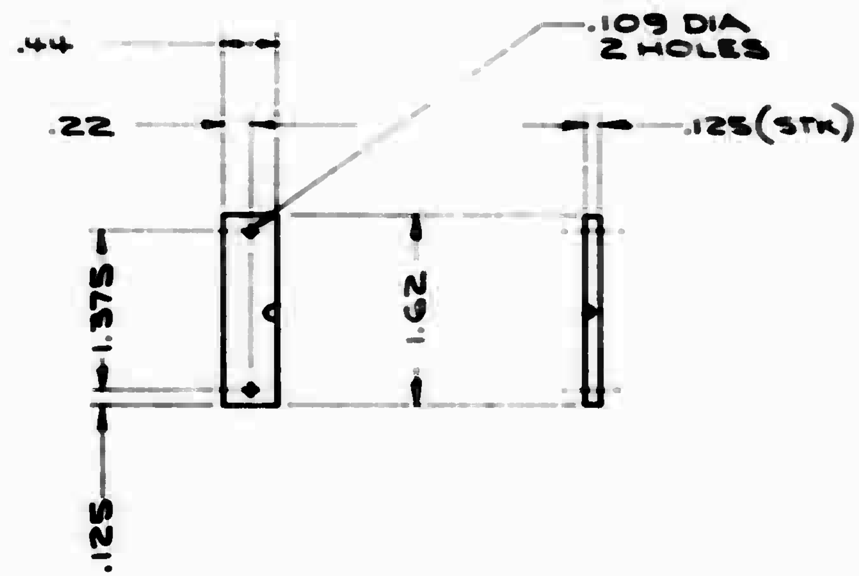
ASD

190


NOTES
125 SURFACE FINISH ALL OVER
2-56UNC-2B .25 D
2-56UNC-2B .44 DEEP 2 PLCS
.096 DIA IN ITEM 3 ONLY
INCHES
CONTACT
SCREW
BLOCK
COPPER
STD
PHENOLIC
PART NO
DESCRIPTION
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
BLOCK, TERMINAL – VERT. SEISMOMETER
1207
FINISH



.234
.812
.062 DIA X .31 DEEP
3
1
2
0 1 2
INCHES
3 2 SCR, RND HD BRASS NO. 2-56 X .25
2 1 1208-1 BRACKET, CABLE
1 1 1208-1 HOLDER, CABLE
ITEM QTY PART NO DESCRIPTION REMARKS
MAT'L: SEE LIST OF MAT'L
FINISH:
NEXT ASM QTY
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
CABLE HOLDER ASM
1208-1
1/1
SHEET 1 OF 3



NOTES:

1. STAMP OR ENGRAVE PART NO. WHERE INDICATED.
2. 125/ SURFACE FINISH ALL OVER

MAT'L:	CLEAR PLASTIC
FINISH:	
NEXT ASSEMBLY	1208

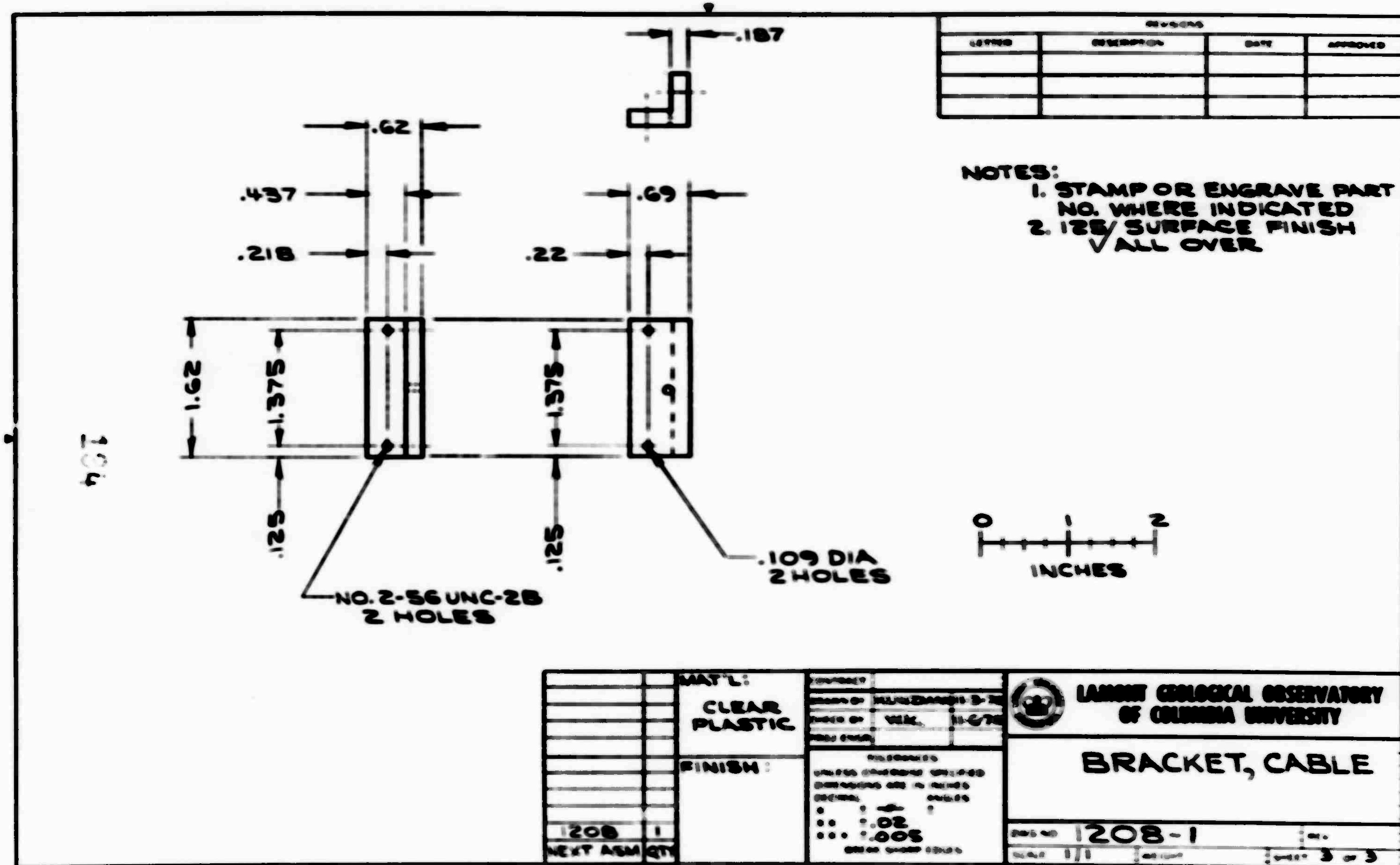
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY

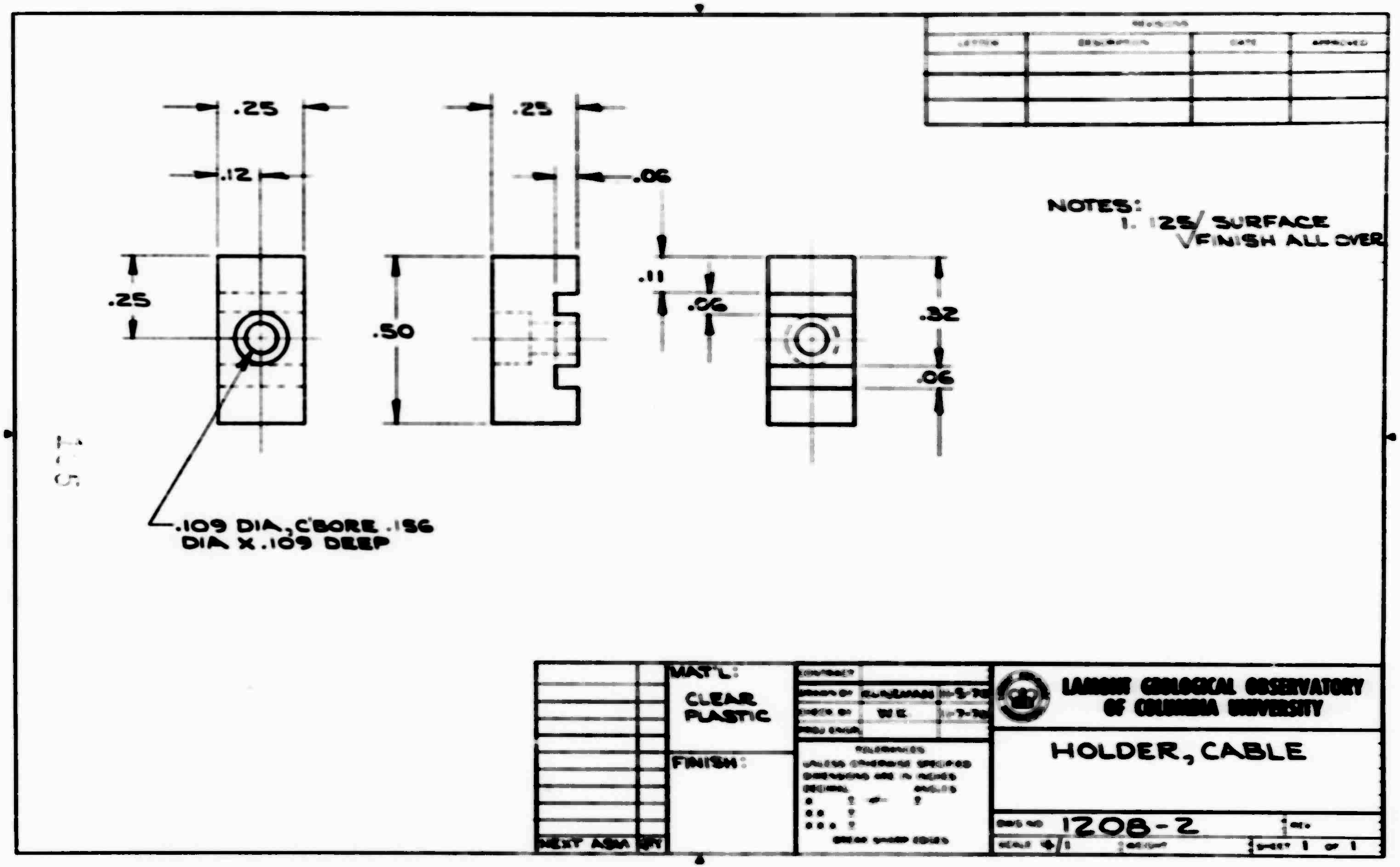
HOLDER, CABLE

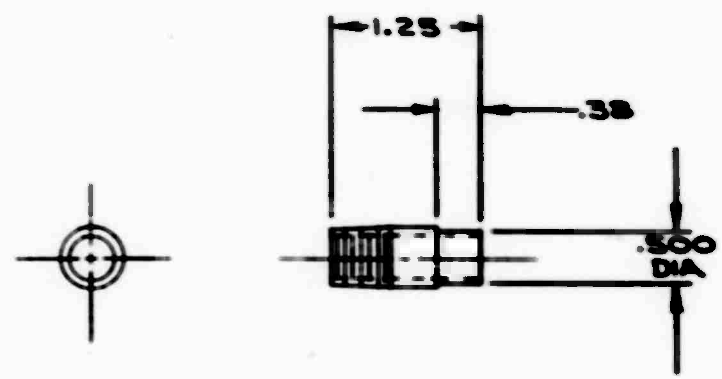
DWG NO. 1208-1

SCALE 1/1

SHEET 2 OF 3


.187
.62
.437
.218
.69
.22
1.62
1.375
1.375
.125
.125
.109 DIA
2 HOLES
NO. 2-56 UNC-2B
2 HOLES
NOTES:
1. STAMP OR ENGRAVE PART NO. WHERE INDICATED
2. 125/ SURFACE FINISH ALL OVER
0
1
2
INCHES
MAT'L:
CLEAR PLASTIC
FINISH:
1208
1
NEXT ASM
QTY
.02
.005
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
BRACKET, CABLE
1208-1
1/1
3 of 3


.25
.12
.25
.25
.06
.50
.11
.06
.32
.06
.109 DIA, C'BORE .156
DIA X .109 DEEP
NOTES:
1. 125/ SURFACE
FINISH ALL OVER
MAT'L:
CLEAR
PLASTIC
FINISH:
LAMONT GEOLOGICAL OBSERVATORY
OF COLUMBIA UNIVERSITY
HOLDER, CABLE
1208-2
NEXT ASM
SHEET 1 OF 1



NOTES:
1. 125/ SURFACE FINISH ALL OVER

MAT'L: 1/4 BRASS PIPE NIPPLE

FINISH:

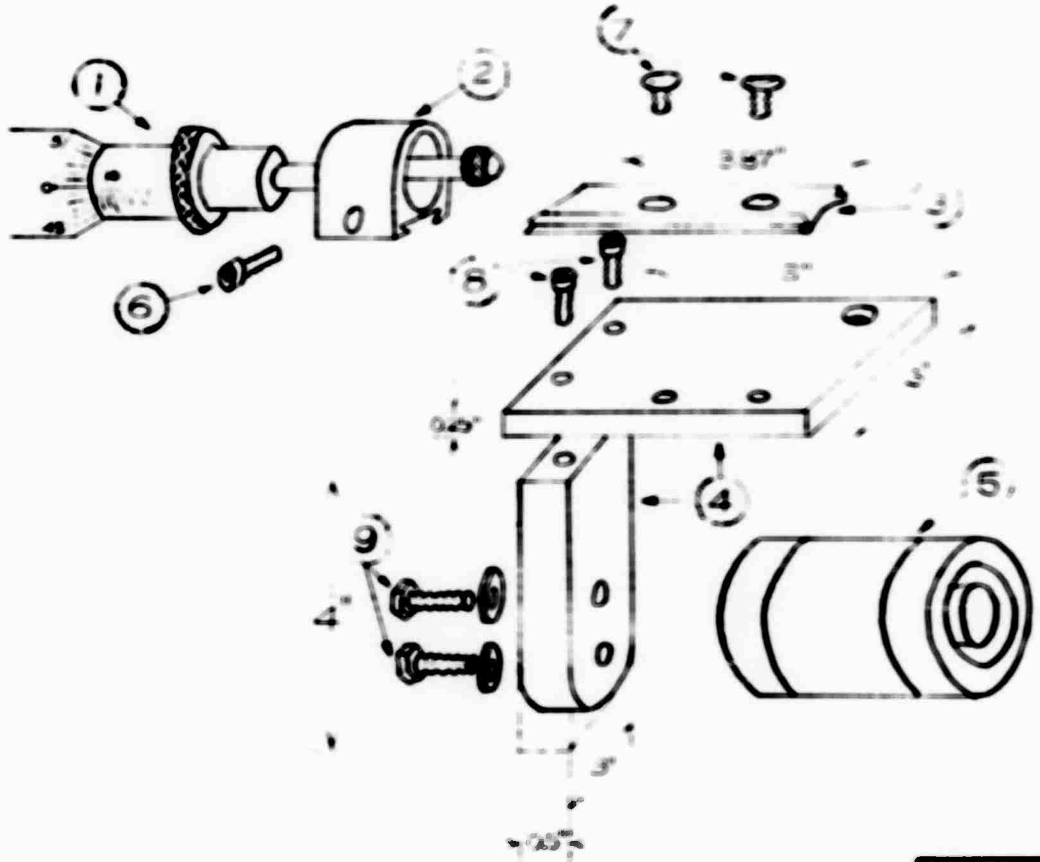
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY

PIPE NIPPLE, MOD.

DWG NO 1209

SCALE 1/1 SHEET 1 OF 1

NEXT ASM QTY



NOTES:

1 STARRETT #263-M MICROMETER
2 CLAMPING YOKE
3 BUSHNELL SCOPE MOUNT
4 ALUMINUM PLATE
5 SIESMOMETER MAGNET
6 CAP SCREW ALLEN HEAD 2×56
7 SCREW FLAT HEAD 8×32 STEEL
8 CAP SCREW ALLEN HEAD 10×32
9 BOLT ¼×28 HEX HEAD BRASS

LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY

MICROMETER MOUNT ASSEMBLY

DWG NO 1211

SHEET 1 OF 1

OPERATION AND MAINTENANCE MANUAL

LONG-PERIOD HORIZONTAL SEISMOMETER, MODEL 8700C

GEOTECH
A Teledyne Company
3401 Shiloh Road
Garland, Texas

27 July 1966
(Revised 6 Sept 1968)

BLANK PAGE

TABLE OF CONTENTS

TABLE OF CONTENTS (Cont'd)

LIST OF ILLUSTRATIONS

LIST OF TABLES

INTRODUCTION

This publication contains technical instructions for Long Period Horizontal Seismometer, Model 8700C, a highly sensitive electromechanical device which converts horizontal motion into electrical signals. The publication consists of seven chapters bound in one volume. Chapter 1 contains general information and leading particulars; the installation phase is covered in Chapter 2; Chapter 3 is not applicable, since the seismometer requires no attention during operation; principles of operation are described in Chapter 4; Chapter 5 provides instructions for maintenance and overhaul; Chapter 6 is the illustrated parts breakdown; Chapter 7 contains complete circuit diagrams for the unit.

The following publications govern the use of abbreviations, symbols, and reference designations in this publication:

Abbreviations for Use on Drawings and in Technical-Type Publications
Electrical and Electronic Symbols
Electrical and Electronic Reference Designations

201

Figure 1-1. Long-Period Horizontal Seismometer, Model 8700C

CHAPTER I

GENERAL INFORMATION

1-1. DESCRIPTION AND PURPOSE.

1-2. Long Period Horizontal Seismometer, Model 8700C, is a highly sensitive electromechanical moving-coil device that converts horizontal motion into electrical signals. The seismometer has a natural period that is adjustable from 10 to 30 seconds. When the cover is properly secured, the seismometer is watertight and will operate under adverse environmental conditions. The seismometer is shown in figure 1-1.

1-3. INFORMATION AND REFERENCE TABLES.

1-4. Tables 1-1 through 1-4 contain information which will be helpful in the operation and maintenance of the seismometer.

Table 1-1. Leading Particulars

A-c power	150 ma, 4.0 v, 60 cps (for Mass Position Monitor) 350 ma, 115 v, 60 cps (for Remote Centering Accessory)
D-c power	22.5 v, 1.5 ma (for Mass Position Monitor) 24 v, 115 ma (for seismometer heater) 24 v, 11.5 amp maximum (for Thermal Jacket Heater)
Dimensions	12 x 15-1/2 x 24 inches
Weight	115 pounds net
Storage and shipping conditions	Mass sections must be removed from suspension arm and suspension system must be locked

Table 1-2. Capabilities and Limitations

Natural period	10 to 30 seconds, adjustable
Weight of inertial mass	10 kilograms
Seismometer:	
Type	Moving coil (velocity)
Damping	Electromagnetic
Maximum flux density	1750 ±100 gauss
Coils:	
Signal Coil:	
Number	2
Effective generator constant	105 volt-sec/m (each coil)

Table 1-2. Capabilities and Limitations (Cont'd)

Signal Coil, continued:	
Resistance	565 ohms ±10 ohms at 25°C (77°F) each coil
Turns	3260 each coil
Wire size	No. 36 AWG
Length of wire	1324 feet
Inductance	Negligible
Calibration Coil:	
Number	2
Resistance	0.2 ohms ±0.05 ohms (each coil) at 25°C (77°F)
Turns	1
Wire size	No. 36 AWG
Effective motor constant	0.032 ±0.002 newtons/amp
Critical damping resistance	80 times the natural period in ohms ±10%
Mass Travel	3 degrees stop-to-stop
Thermal Jacket (Accessory which houses seismometer)	
Inputs	5 (to seismometer) 1 (to Thermal Jacket heater)
Power required	1.5 amp at 24 vdc (max)
Air leak rate	8 hr time constant from 1-1/2 psig differential
Dimensions	36 in. high x 43 in. diameter
Weight	280 lbs, approx.
Pressure	Insensitive to normal atmospheric variations
Humidity	0 to 95%
Mass Position Monitor (accessory mounted on seismometer)	
Outputs	Zero to ±1.5 vdc (max.)
Power required	1.5 ma at 22.5 vdc 150 ma at 4 vac
Dimensions	1-1/4 x 3-1/4 x 1-3/4 inches
Weight	0.25 lb
Remote Centering Motor (Accessory mounted on seismometer)	
Motor Type	Synchronous, single-phase, bidirectional
Number of poles	6
Power required	350 ma at 115 vac, 60 cps
Speed	0.7 rpm

1300-9

Table 1-3. Equipment Supplied

NAME	QUANTITY	DESCRIPTION AND PURPOSE
Long Period Horizontal seismometer, Model 8700C	1	Moving-coil seismometer to convert horizontal motion into electrical signals
Mass Position Monitor Model 10074*	1	A remotely monitored photoelectric device to provide electrical indication of mass position
Remote Centering Accessory Model 10076*	1	Motor-driven leveling device to provide for remote adjustment of inertial mass position
Connector, P101, MS3106A-20-4P	1	4-contact connector to connect external cable to one of the Transducer coils
Connector, P102, MS3106A-20-11S	1	13-contact connector to connect external cable to one of the Transducer coils and the seismometer accessories
Connector, P104, MS3106A-10SL-4S	1	2-contact connector to connect external cable to heater
Cable Clamp MS3057-12	2	
Cable Clamp MS3057-4	1	
Glass Insulation Assemblies, 16954-1, -2, and -3	1 each	Placed under leveling screws to provide insulation
Calibration kit, 10391	1	Used to manually calibrate the seismometer
Wrench, 1118-2	2	Used to adjust and lock leveling screws
Desiccator Breather Assembly, 17025*	1	Used to dehumidify air entering the seismometer
Insulation Cover Kit, P/N 16375	1	Used as insulation to minimize the effects of temperature changes
Plug, Pipe, 1/4 in. PPTF	1	Pressure relief fitting used during shipment
Thermal Jacket, Model 14414*	1	Houses and isolates the seismometer from pressure and temperature changes
Shipping Crate	1	Special carton for shipping seismometer

*Not furnished. Available as optional accessory.

Table 1-4. Equipment Required but not Supplied

QUANTITY	EQUIPMENT	DESCRIPTION
1	Microvoltmeter	Hewlett-Packard 425A or equivalent
1	Wheatstone Bridge	Leeds & Northrup 5300 Type S or equivalent
2	Power Supply	Hewlett-Packard, Model 721A (or equivalent)
1 pkg	Graph paper	10 x 10 divisions/inch (linear), any manufacture
1 pint	Cleaner, soldering	Kester Thinner, Formula 101, or equivalent
1	Amplifier	Geotech Helicorder Amplifier Model 4983 or equivalent
1	Recorder	Geotech Helicorder Model 2484-1 or equivalent
1	D-C Ammeter	Triplett 630A or equivalent (0-1a)
1	Variable Resistor	500 ohms, 2 watt, any manufacturer
1	Decade Resistor	General Radio 1432-N or equivalent
1	Voltage Divider	General Radio 1454-A or equivalent (10 K)
1	Battery	Burgess TW-2 or equivalent
1	Electric Timer	Standard, Model S-1
1	Resistor	100 ohms, 10 watt
1	Stop Watch	Type A-8
1 pint	Flux, soldering	Kester Formula 135 or equivalent (pure resin in alcohol)
1 spool	Solder, thermal free (2 ft.)	Leeds & Northrup 107-1-0-1 or equivalent
1	Phototube Amplifier	Geotech Model 4300 (with 3 cps galvanometer no. 4100-213 and resistive filter)

CHAPTER 2
INSTALLATION

2-1. INTRODUCTION. This chapter provides the information necessary to install the seismometer and to prepare it for operation.

2-2. LOGISTICS.

2-3. UNPACKING. The seismometer is shipped in a specially designed plywood shipping crate (see table 2-1). The Remote Centering Accessory, Desiccator-Breather Assembly, connectors, Glass Insulator Assemblies, wrenches, Insulation Cover Kit, and Thermal Jacket are shipped in separate cartons. To unpack the equipment, proceed as follows:

a. Check packages against table 1-3. Report any missing or damaged packages immediately to the supplying agency.

b. Place the shipping crate containing the seismometer near selected location.

c. Remove the cover of the crate after removing the fourteen retaining bolts.

d. Remove the tape from the waterproof paper and fold the paper.

e. Carefully lift the seismometer out of the crate.

f. If the seismometer appears damaged, send it to the depot for repair.

NOTE

Retain the shipping crate and all the associated packing materials for use in reshipment.

g. Unpack accessories and examine them for damage. If the Remote Centering Accessory appears to be damaged, determine the extent of the damage; and if necessary, send it to the depot for repair.

Table 2-1. Shipping and Receiving Information*

CASE NO.	DIMENSIONS (INCHES)	CONTENTS	VOLUME (CU FT)	WEIGHT (LBS)
1	17-1/4 x 28-3/4 x 20	Long Period Horizontal Seismometer, Model 8700C	6	170
2	12 x 10 x 10	Accessories	0.7	10
3	52 x 52 x 45	Thermal Jacket	70	435
4	30 x 30 x 32	Jacket installation materials	18.8	115
5	14 x 14 x 8	Jacket installation hardware	0.9	22
6	28 x 14-1/4 x 5,	Insulation Cover Kit	1.15	3

* All dimensions, weights and volumes are approximate values

2-4. MATERIAL HANDLING. The seismometer can be transported in a light-duty truck. Two men can handle the unit without special handling equipment. The arm shall be secured as described in paragraph 5-11 while the seismometer is being moved or shipped. The seismometer shall be shipped in the specially designed shipping crate. No other special handling precautions are necessary beyond ordinary care to avoid excessive shock, vibration, or temperature extremes.

2-5. INSTALLATION PROCEDURES.

2-6. To install the seismometer in the selected location, proceed as follows:

a. Insure that Thermal Jacket Model 14414 has been installed in accordance with TI 2W-1-1.

b. Remove right leveling screw (viewed from the window end) from base of seismometer. Retain leveling screw for use when reshipping seismometer.

c. Attach Remote Centering Accessory to base of seismometer as shown in figure 2-1. Secure accessory to base by installing hex screw (supplied) into hole previously occupied by leveling screw.

d. Apply 115 volts a-c between pins A and C of connector P103 on Remote Centering Accessory. The accessory shall lower the right side of the seismometer. Apply 115-volts a-c between pins B and C of P103. The accessory shall raise the right side of the seismometer. Apply 115 volts a-c between pins A and C to bring the accessory back to the center of its range.

e. Place glass insulator assemblies, part no. 16954-1, -2, and -3 on the Thermal Jacket floor as shown in figure 2-2.

f. Place seismometer on glass insulator assemblies, taking care to set leveling screws in insulator cutouts.

g. Brush all loose insulation, dust, and dirt off seismometer cover. Open latches and remove cover. Be careful not to strike internal parts with cover.

CAUTION

Do not allow dirt, dust, or moisture to fall into seismometer when cover is off. The presence of foreign material inside the case may affect operation of the seismometer.

h. Measure the resistance of the coils as described in paragraph 5-12.

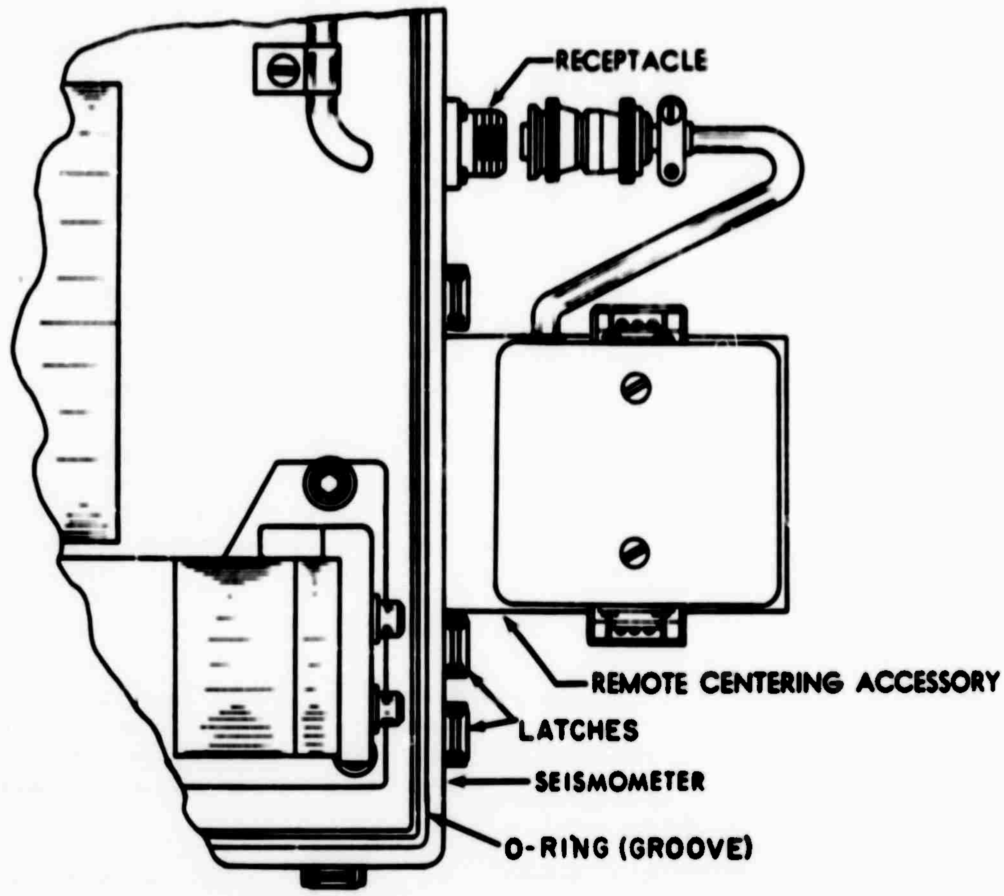


Figure 2-1. Installation of Remote Centering Accessory

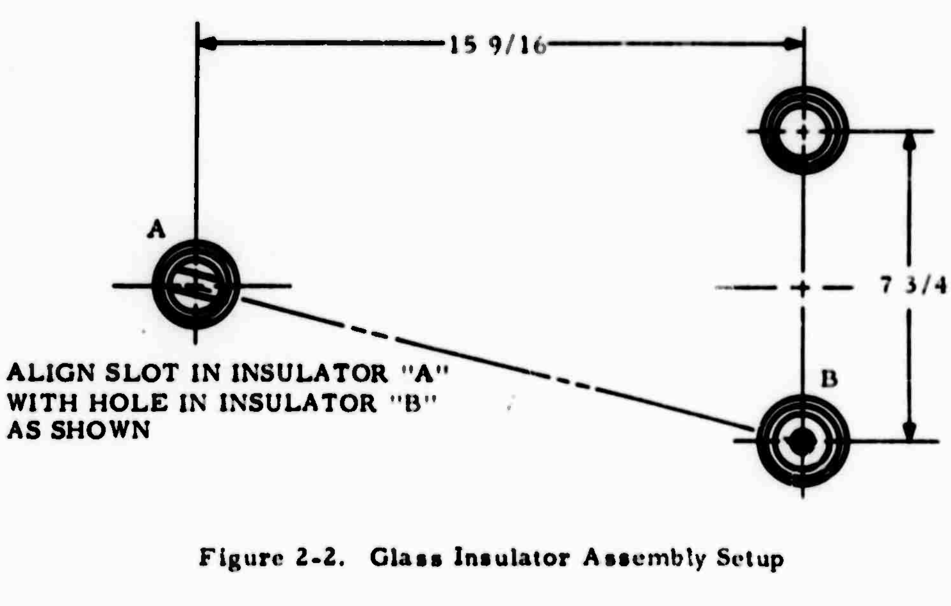


Figure 2-2. Glass Insulator Assembly Setup

Chapter 2
Paragraph 2-6 (Cont'd)

i. Using the wrenches, part no. 1118-2, manually adjust the left leveling screw (viewed from the window end) so that the bubble in the vial is centered between the etchings.

NOTE

Be certain that the Remote Centering Accessory is approximately in the center of its range (extended 3/16"). If not, repeat step d.

j. Unlock the suspension arm by removing 6, 7, 8, & 9 and set the stops (3, figure 5-1) so that the pointer will swing over the entire width (±10mm) of the scale.

k. Check that the suspension arm swings freely from stop to stop without binding or sticking.

l. If the coils stick in either of the magnet assembly air gaps, slightly loosen screws which hold the corresponding magnetic assembly support to base. Shift magnet assembly until suspension arm swings freely from stop to stop without sticking. Tighten screws which hold magnetic assembly securely. With the suspension arm at the center of its travel (pointer on scale zero), the coils shall be centered in the air gaps of the magnet assemblies.

NOTE

When the magnet assembly is in the correct position and the suspension arm is at one of its stops, there is a clearance of approximately 1/64 inch between the coil and the magnet. Therefore, the adjustment of the magnet assembly position described in step m shall be made with care so that the coil will have sufficient clearance at both extremes of its travel.

m. Observe that the black bar on front of each photoresistor in the Mass Position Monitor Accessory is parallel to base.

n. Lock the suspension arm so that the pointer is on scale zero and set up the equipment as shown in figure 5-5. If the microammeter does not read 0, perform test number 3 as described in table 5-4.

o. Repeat step j. Tighten the locking screws (2, figure 5-1).

p. Make certain that the O-ring seal is in its groove and replace the seismometer cover. Secure the latches.

q. Assemble the Desiccator Breather Assembly as shown in figure 6-2.

r. Using the mounting hardware supplied, mount the Desiccator Breather Assembly to the bracket on the inside of the Thermal Jacket. Remove the shipping plug from the seismometer cover (opposite side from window) and insert the male union fitting into this hole. Connect tubing to the fitting. Save the shipping plug for future use.

s. Allow seismometer to reach temperature of its surroundings. This may require as long as 12 hours.

t. Raise the rear of the seismometer by placing a 1/2-inch thick block beneath the rear leveling screw.

u. Connect a jumper wire across binding posts E101 and E102.

v. Observe the pointer through the window on the seismometer cover. If the pointer is more than ±5mm from center scale, either the pointer is bent or the flexure assemblies are out of alignment (see chapter 5 for adjusting flexures). If the pointer is within this tolerance, proceed as follows:

w. Using the wrenches, part no. 1118-2, manually adjust the left leveling screw (viewed from the window end) so that the pointer is as close as possible to scale zero. Lock the leveling screws by tightening the knurled jam nuts, being careful not to disturb adjustment.

x. Make final critical adjustment for pointer to be at scale zero by connecting 115 v a-c to the Remote Centering Accessory. Connecting 115 v a-c between pins A and C of connector P103 causes the pointer to move to the right; between pins B and C causes the pointer to move to the left.

NOTE

The Remote Centering Accessory should be approximately in the center of its range. If not, repeat step d, d, w, and x.

y. Remove the jumper wires previously installed in step v, and connect signal leads to binding posts E101 and E102.

z. Connect Remote Centering Accessory to seismometer by inserting connector plug P103 into connector receptacle J103. Tighten coupling ring securely to assure a watertight installation.

aa. Remove the 1/2-inch block beneath the rear leveling screw.

bb. Perform tests and adjustments described in paragraph 5-13 to assure that the seismometer is in good operating condition.

cc. Connect external cable to connector receptacle J101 by inserting connector plug P101. Tighten coupling nut securely to assure a watertight installation.

dd. Connect external cable to connector receptacle J102 by inserting connector plug P102. Tighten coupling nut.to assure a watertight connection.

ee. Place expanded polystyrene insulation cover over seismometer.

ff. Connect heater external cable to connector receptacle J104 by inserting connector plug P104. Tighten coupling nut to assure a watertight connection.

2-7. PREPARATION FOR RESHIPMENT.

2-8. DISCONNECTING AND LOCKING. If it is necessary to reship the seismometer, proceed as follows before repacking:

a. Remove connector plugs P101 through P104 from respective connector receptacles J101 through J104. Remove external cables from binding posts E101 and E102.

b. Remove insulation cover from seismometer if it is in place. Retain insulation cover for use in repacking.

c. Remove and completely disassemble the Desiccator Breather Assembly, and insert the shipping plug in the hole previously occupied by the male union fitting. Refer to figure 6-2.

NOTE

It is important that the original shipping plug be used. This is a special vented plug to prevent excessive internal pressure build-up during high altitude air shipment.

d. Brush all loose insulation, dust, and dirt off cover. Wipe off any moisture. Open latches and remove cover from seismometer. Be careful that cover does not strike any internal parts.

CAUTION

Do not allow dirt, dust, or moisture to fall into seismometer when cover is off. The presence of foreign material inside the case may affect operation of the seismometer.

e. Fully tighten suspension system as described in paragraph 5-11.

f. Replace cover and secure latches.

g. Disconnect Remote Centering Accessory. Remove accessory from base of seismometer by removing hex screw which secures it.

h. Replace leveling screw which was removed from the left side.

2-9. REPACKING. To repack the seismometer, proceed as follows:

a. Place seismometer in shipping crate, taking care to set leveling screws in cutouts in the insulation.

b. Cover the seismometer with waterproof paper. Seal waterproof paper with waterproof pressure sensitive paper.

c. Replace shipping crate cover and secure it with fourteen bolts.

d. Pack accessories in a cardboard carton.

CHAPTER 3
OPERATION

NOT APPLICABLE

213

BLANK PAGE

CHAPTER 4
PRINCIPLES OF OPERATION

4-1. INTRODUCTION. This chapter contains information that will help the experienced maintenance technician understand the operation of the Horizontal Seismometer. Refer to Chapter 6 for identification of parts. An electrical schematic diagram is in Chapter 7.

4-2. OPERATION OF SEISMOMETER.

4-3. The seismometer converts horizontal motion into electrical signals. Horizontal motion is transmitted through the base to the magnet assemblies. The main coils are located within the field of the magnets and are mounted at the end of the suspension arm. The suspension arm is mounted on flexure pivots and tends to remain stationary. Relative motion between the magnets and the coils generates a voltage in the coils proportional to either the velocity, acceleration, or displacement of the relative motion. Two coils and two magnets are used to minimize "piston effect" and to improve linearity of the instrument.

4-4. SUSPENSION SYSTEM. The suspension system for the inertial mass assembly and the main coils consists of the suspension arm, which is mounted on the mast by two flexure pivot assemblies. The flexure pivot assemblies permit relative motion between the base of the seismometer and the suspension arm in a horizontal direction, but prevent such motion in a vertical direction. Flexure pivot assemblies operate by bending flexure plates of Ni-Span C rather than by a sliding motion of bearing surfaces. Since there is no contact between moving parts of the suspension system, friction is eliminated and mechanical losses are reduced to the relatively small loss of the flexure plates. Gravity and the small net spring action of the flexure plates provide the restoring force in the suspension system.

4-5. NATURAL FREQUENCY. Natural or resonant frequency is the frequency at which the suspension arm would oscillate if it were undamped and set in motion. Natural frequency is determined by the restoring force, the weight of the inertial mass, and the angle between the centerline of the suspension arm and the horizontal. Changing the angle between the centerline of the suspension arm and the horizontal by raising or lowering the rear of the base provides adjustment of natural frequency to any value between 0.033 and 0.1 cps. Stated another way, the natural period, which is the reciprocal of the natural frequency, can be adjusted to any value between 10 and 30 seconds per cycle.

4-6. DAMPING. The voltages induced in the main coils by their motion causes currents to flow through the main coils and the external load. As these currents flow through the main coils operating in the fields of the magnets, they create forces which tend to oppose or damp the motion. Thus, electromagnetic damping is provided in the seismometer by action of the induced currents in the main coil assemblies. The amount of damping is determined by the total resistance in each of the main coil circuits and may be controlled by adjusting the external loads. Critical damping is defined as the amount of damping that will allow the suspension arm to return to the center of its travel in the shortest time without overshoot. The total amount of resistance required to produce this condition is called Critical Damping Resistance (CDR). The amount of resistance external to the seismometer which produces the critical damping condition is called External Critical Damping Resistance (CDRX) at a given natural period. CDRX varies directly with the natural period and must be redetermined when the natural period is changed.

4-7. REMOTE CALIBRATION.

4-8. The calibration coils are wound on the same form as the main coils. A current pulse applied to either of the calibration coils will deflect the suspension arm. The amount and rate of deflection is determined by the current, the characteristics of the deflection system, the amount of damping, and the motor constant of the calibration coils. The output of the main coils caused by this deflection is determined by the generator constant of the main coils. If the current inputs to the calibration coils are known, the outputs of the main coils may be used for remote calibration of the seismometer. Since the characteristics of the seismometer change when the natural frequency is changed, the seismometer must be recalibrated for each new natural frequency. The motor constants of the calibration coils do not vary with natural frequency; this allows remote calibration without knowledge of the natural frequency.

4-9. REMOTE CENTERING.

4-10. Best results are achieved if the inertial mass rests at the center of its travel when it is not deflected by motion. Under these conditions the characteristics of the suspension system and the portions of the magnetic fields traversed by the coils are symmetrical. Large temperature changes, especially during the first few weeks after installation, will cause the inertial mass to rest off center. The inertial mass can be centered by raising or lowering one side of the seismometer. This can be accomplished manually by adjusting the leveling screws, or from a remote point by operating the motor of the Remote Centering Accessory.

4-11. MASS POSITION MONITOR.

4-12. The Mass Position Monitor Accessory produces an electrical indication of the mass position at any time. The accessory consists of a lamp, an aperture, and two photoresistors and two fixed resistors connected as a Wheatstone bridge. The aperture is mounted on the suspension arm and is located in the light path between the lamp and the photoresistors. When the inertial mass is in the center of its travel, the aperture allows an equal amount of light to fall on both photoresistors and the bridge is balanced. When the inertial mass is off center, the aperture allows more light to fall on one photoresistor than on the other, unbalancing the bridge. The amount and direction of unbalance is determined by the amount and direction that the inertial mass is oft center. The unbalance of the bridge can be sensed by connecting a source of 22.5 volts d-c to pins A (+) and B (-) of J102 and a zero-center microammeter or microvoltmeter to the bridge at pins C and D of J101. (See figure 7-1.)

4-13. HEATER ASSEMBLY.

4-14. The seismometer heater (see figure 7-1) consists of three power resistors mounted under the top of the seismometer cover inside of the instrument. This heater assembly is operated from a unit which supplies a 0-24 volt d-c input. The heater serves to stratify the air in the instrument case, thus, minimizing noise produced by air flow caused by temperature inversion.

4-15. THERMAL JACKET

4-16. The Thermal Jacket is a special tank used to house the seismometer. This tank is designed to isolate the seismometer from barometric and temperature changes by: (1.) air stratification within the tank by heating the top of the tank with an internal heater, and by (2.) being nearly air-tight (the leak-rate time constant is 8 hours).

CHAPTER 5

MAINTENANCE

5-1. INTRODUCTION. This chapter contains information necessary to maintain the Horizontal seismometer. Section I covers organizational/field maintenance; section II covers special maintenance.

SECTION I

ORGANIZATIONAL/FIELD MAINTENANCE

5-2. GENERAL. Test equipment for organizational/field maintenance is listed in table 5-1. Performance tests and standards are listed in Section II. All tests listed in Section II, except those specifically indicated as depot tests, may be performed in the field.

NOTE

The characteristics of equipment listed in table 5-1 are the characteristics required to test the seismometer and do not necessarily reflect the full capabilities of the equipment.

Table 5-1. Test Equipment Required for Organizational/Field Maintenance

EQUIPMENT	MANUFACTURER AND MODEL	REQUIRED CHARACTERISTICS
Multimeter	Triplett 630A or equivalent	Ohmmeter range: 0.2 ohms to 0.5 megohms
Battery	Burgess TW-2 or equivalent	12 volts d-c
Power Supply	Hewlett-Packard Model 721A or equivalent (2 ea.)	22.5 volts d-c, at 1.5 milli-amperes; 4-6 volts a-c or d-c, at 150 milliamperes
Potentiometer	Any	500 ohms, 2 watts

5-3. VOLTAGE REQUIREMENTS AND SOURCE.

5-4. Voltages required to test the seismometer and their suggested sources are shown in table 5-2.

Table 5-2. Voltage Requirements and Sources

VOLTAGE	APPLICATION	SUGGESTED SOURCE
115 volts a-c 60 cps	Operating power for remote centering accessory motor	Standard 60 cps source
4.0 volts a-c or d-c at 150 milliamperes	Lamp excitation	Power supply, Hewlett-Packard, Model 721A
22.5 volts d-c	Photoresistor bridge input	Power supply, Hewlett-Packard, Model 721A

5-5. THERMAL FREE SOLDERING PROCEDURE

5-6. A special solder is used in the seismometer coil connections to reduce the generation of thermal voltages. When necessary to resolder a thermal free connection, usually painted bright green, use the following procedure.

a. Use a new soldering tip tinned with thermal free solder. Do not use this tip for any purpose other than soldering with thermal free solder.

b. Use any standard soldering iron from 30 watts to 200 watts, depending on the size of conductors to be soldered.

c. Use a clean and uncontaminated flux and apply with a non-metallic applicator. The flux must be pure rosin in alcohol.

d. Clean and tin all conductors to be soldered. Place as close together as possible to reduce the amount of solder necessary to make the joint.

e. Solder the connection. The joint will not have a bright smooth appearance, but may look like a cold joint. These joints, if properly made, are electrically and mechanically sound.

f. Paint the joint bright green to identify it as a thermal free connection.

g. Do not allow soldering tip to overheat or become badly oxidized. Re-tin as necessary with thermal free solder.

SECTION II

SPECIAL MAINTENANCE

5-7. SPECIAL TOOLS AND TEST EQUIPMENT.

5-8. No special tools or test equipment are required.

5-9. BENCH TEST.

5-10. Refer to table 1-4 for test equipment required for testing the seismometer.

5-11. LOCKING THE SUSPENSION SYSTEM. Lock the suspension system as follows:

a. Remove connector P104 from receptacle J104 and the polystyrene insulation cover from seismometer.

b. Brush all loose dirt, dust, or moisture off seismometer cover.

CAUTION

Do not allow dirt, dust, or moisture to fall into seismometer when cover is off. The presence of foreign material inside the case may affect the operation of the seismometer.

c. Remove cover from seismometer, being careful that cover does not strike internal parts.

d. Refer to figure 5-1 and lock the suspension arm by loosening the locking screws (2) and fully tightening the stops (3) so that the pointer (5) is locked on scale zero. Fully tighten the locking screws (2) for reshipment or moving.

e. Replace seismometer cover.

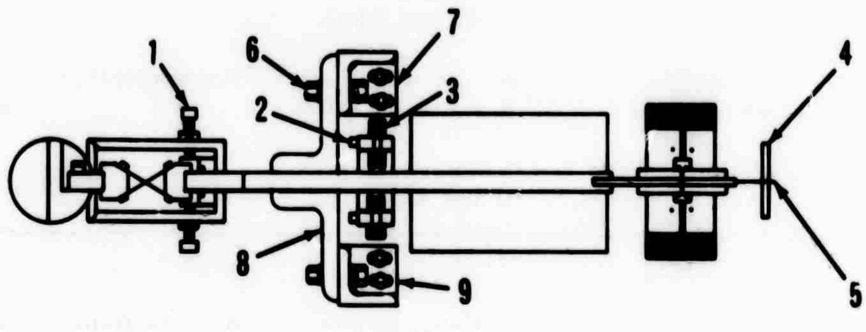


Figure 5-1. Locking the Suspension System

5-12 RESISTANCE OF COILS. This test may be performed in the field as well as the depot. If testing in the field, perform steps 1 and 2 of table 5-3. If the testing is done in the depot, test in accordance with steps 1A and 2A of table 5-3. Do not connect seismometer to a power source for this test. Lock suspension system as described in paragraph 5-11 and perform test in accordance with table 5-3.

NOTE

Measurements in table 5-3 are for data coil connected separately. For data coils in parallel use one-half the standard (or 290 ohms) in steps 1 and 1A.

Table 5-3. Coil Resistance Test

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS	PERFORMANCE STANDARDS
For field use				
1	VOM adjusted to RX100 ohms scale	a. Between pins B and C on J101 b. Between binding posts E101 and E102	Not applicable	Resistance shall measure 580 ±20 ohms
2	VOM adjusted to RX1 ohms scale	a. Between pins A and D on J101 b. Between pins H and J on J102	Not applicable	Resistance shall measure 0.8 ±0.16 ohms
For depot use				
1A	Wheatstone bridge adjusted to measure hundreds of ohms	a. Between pins B and C on J101 b. Between binding posts E101 and E102	Not applicable	Resistance shall measure 580 ±20 ohms
2A	Wheatstone bridge adjusted to measure tenths of ohms	a. Between pins A and B on J101 b. Between pins H and J on J102	Not applicable	Resistance shall measure 0.8 ±0.16 ohms

5-13. INSULATION RESISTANCE. This test may be performed in the field as well as in the depot. Be sure the suspension system is locked as in paragraph 5-11.

Table 5-4. Insulation Resistance (Cont'd)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS	PERFORMANCE STANDARDS
1	Use VTVM on RX1 megohm range	Between pin A on J101 and ground	Not applicable	Resistance shall measure 1 megohm minimum
2	As in step 1	Between B on J101 and ground	Not applicable	Resistance shall measure 1 megohm minimum
3	As in step 1	Between E101 and ground	Not applicable	Resistance shall measure 1 megohm minimum
4	As in step 1	Between pin H on J102 and ground	Not applicable	Resistance shall measure 1 megohm minimum

5-14. PERFORMANCE TESTS

5-15. The performance tests described in the following paragrphs and in table 5-5 shall be performed after installation and after major repairs both in the field and at depot level. If testing facilities are not available in the field, repair of the operating components of the seismometer should not be attempted. This series of independent tests should be performed in the sequence given. Preliminary instructions in a test apply only to that test, but do not restore the seismometer to normal conditions until you have read the instructions for the next test. After complete testing, restore the seismometer to normal condition as described at the end of the table.

5-16. NATURAL FREQUENCY AND DAMPING.

5-17. Measure and adjust the natural frequency; check the damping of the seismometer suspension system as described in the following steps. This test may be accomplished in the field.

NOTE

During the performance of this test, the mass sections must be assembled to the suspension arm, and the suspension system must not be locked.

a. Allow seismometer to reach the temperature of its surroundings. This may require as long as 12 hours if cover is removed.

b. Short binding posts E101 and E102 to damp the suspension.

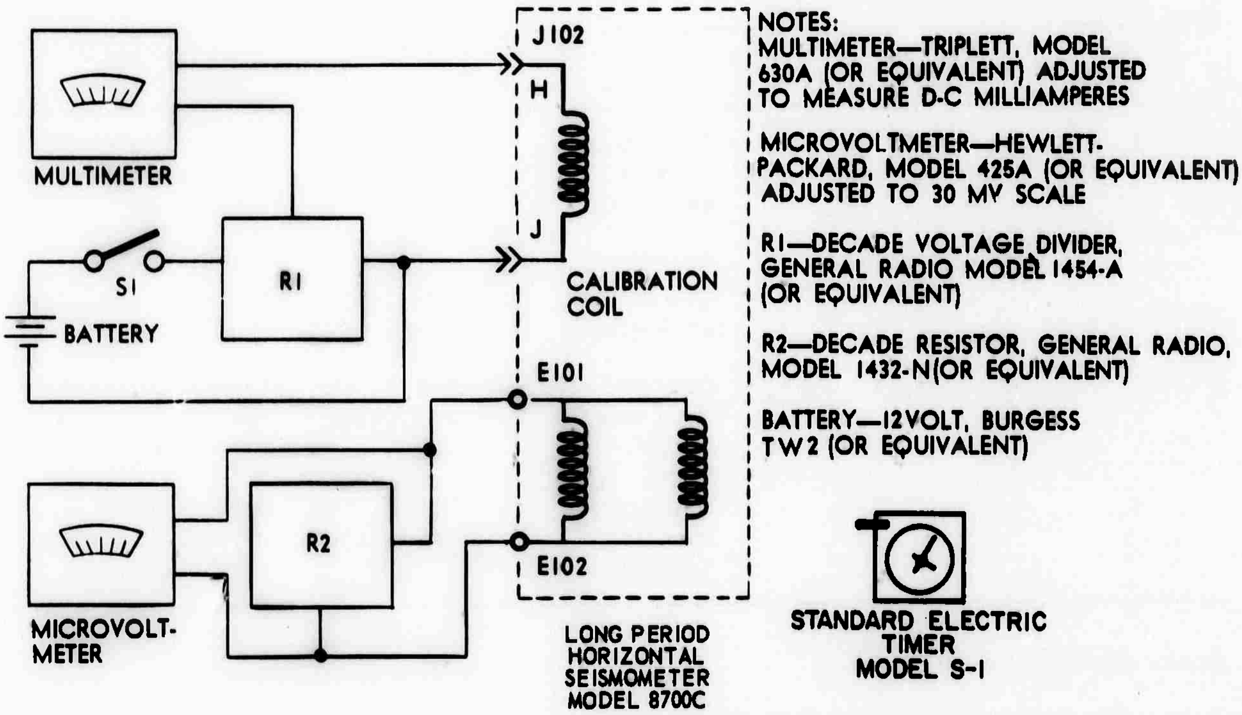
c. Apply heater power (24 volts, d-c) to J104.

d. Perform the final cross-leveling adjustment by adjusting the leveling screws while observing the inertial mass position through the window in the front of the cover. The seismometer is properly cross-leveled when the pointer is centered on its scale.

NOTE

If the Remote Centering Accessory is attached to the seismometer, final cross leveling may be performed by completing step y of paragraph 2-6.

A. PREFERRED METHOD



B. ALTERNATE METHOD

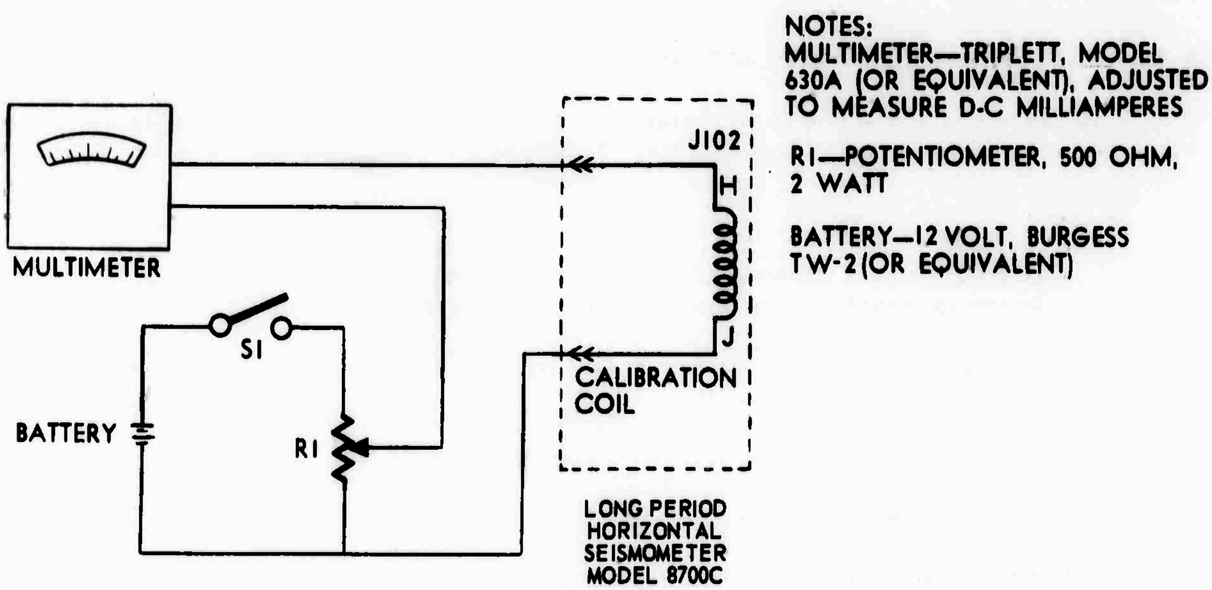


Figure 5-2. Test Setup for Natural Period and Damping

e. Lock leveling screws by tightening knurled jam plates, being careful not to disturb adjustment. Remove short from binding posts E101 and E102.

f. Connect a zero-center microvoltmeter between E101 and E102. Set microvoltmeter to the 30 mv scale.

NOTE

When this test is performed at field level, a microvoltmeter and stop watch may not be available. In that case, the period may be checked with acceptable accuracy by observing the mass position pointer through the window in the front of the cover, and timing with any ordinary watch having a sweep second hand.

g. Connect test circuit shown in figure 5-2. Set the voltage divider or variable resistor for the lowest voltage that will give a usable deflection of the suspension arm when the switch is closed momentarily.

CAUTION

To avoid damage to the seismometer, do not allow the current through calibration coil L2 to exceed 50 ma.

h. Set suspension arm in motion by momentarily closing switch.

i. Using a stop watch, Type A-8, or equivalent, determine the amount of time required for the pointer of the microvoltmeter to swing from zero to maximum, through zero to maximum in the other direction, and back to zero again. If this test is being performed in the field without a zero-center microvoltmeter, determine the time required for the mass position pointer to swing from zero to maximum, through zero to maximum in the other direction, and back to zero again. Refer to the note following step f. This time is the natural period of the seismometer. The correct natural period is between 10 and 30 seconds.

j. Repeat step i several times and average the results. If the excursion of the pointer becomes too small to observe conveniently, apply another pulse to the calibration coil.

k. If the natural period is not correct, adjust the leveling screw at the rear end of the seismometer. Raise the rear end to shorten the period; lower the rear end to lengthen the period.

l. After performing the adjustment described in step k, repeat steps g through j to determine the new period. When the period is correct, lock rear leveling screw by tightening knurled jam plate, being careful not to disturb the adjustment.

NOTE

The suspension system used in this seismometer is subject to drift during the first few days following installation. It may be necessary to center inertial mass and readjust the natural period every day during this initial period. Always center the inertial mass before adjusting the natural period. Once this initial period is past, the seismometer will continue to operate for a long time with only occasional slight readjustments.

m. Calculate reciprocal of natural period. This is the natural frequency and shall be between 0.1 and 0.033 cps.

n. Check electromagnetic damping by repeating step h. After the boom is in motion, short binding posts E101 and E102. The mass position pointer should stop moving immediately, and the pointer of the microvoltmeter should not move after the short is removed.

o. Disconnect test equipment.

5-18 WEIGHT LIFTS.

5-19. When the instructions for a performance test state that weight lifts shall be performed, proceed as follows: (These instructions assume that test equipment has been connected and weight lifts must be recorded.)

a. Adjust seismometer for correct period as described in paragraph 5-17; do not replace the cover after adjusting the period.

b. Remove third latch from the rear on the right side by removing the two screws which hold the latch to the base.

c. Refer to figure 6-1 and attach Calibration Jig Assembly, part no. 10391 by proceeding as follows:

(1) Attach alignment plate 10389 to calibration bar 10388 with two 4-40 x 1/4 screws.

(2) Attach calibration bar to base with alignment plate facing suspension arm. Secure calibration bar in place with two 4-40 x 1/2 screws.

(3) Attach nylon thread between calibration bar and suspension arm. Secure nylon thread to calibration bar with bar cap 10387 and two 4-40 x 3/8 screws. Secure nylon thread to suspension arm with suspension cap 10390 and a 2-56 x 3/8 screw.

(4) Tie test weights (2 each 200 mg weights) in center of the nylon thread. Adjust thread length so that portion between test weight and calibration bar is parallel to diagonal edge of alignment plate. Wait until suspension arm comes to rest before proceeding.

d. Perform weight lift by picking test weights straight up with a small card. Be careful not to touch thread or any part of the seismometer. Measure and record deflection produced.

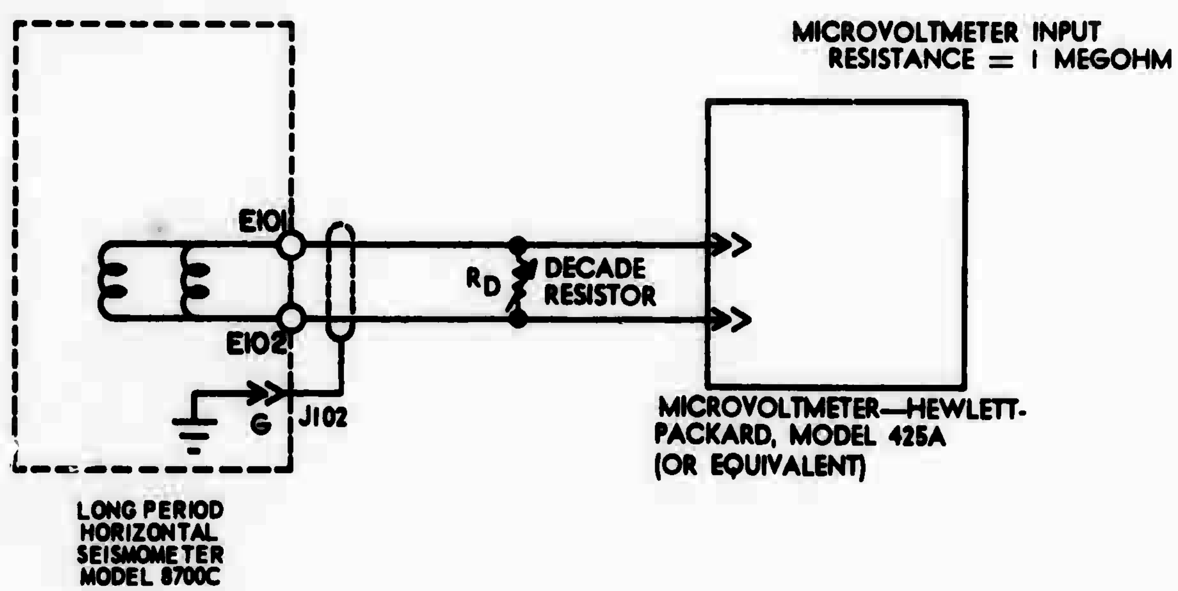
e. Allow the test weights to return to their initial positions. Wait until suspension arm comes to rest, and then repeat step d. Average results of several weight lifts.

Table 5-4. Performance Standards

	Test no. 1. Critical Damping Resistance (CDR)
PRELIMINARY INSTRUCTIONS:	Determine resistance of the main coils as described in paragraph 5-12. Unlock the suspension arm. Determine the natural period, as described in paragraph 5-17. Connect test circuit as shown in figure 5-3.

A. PREFERRED METHOD

$R_T = R_C + R_D$



B. ALTERNATE METHOD

R_A = PHOTOTUBE AMPLIFIER INPUT RESISTANCE

$R_T = R_D + R_A + R_C$

R_C IS THE DC RESISTANCE AT THE TRANSDUCER COILS OUTPUT TERMINALS

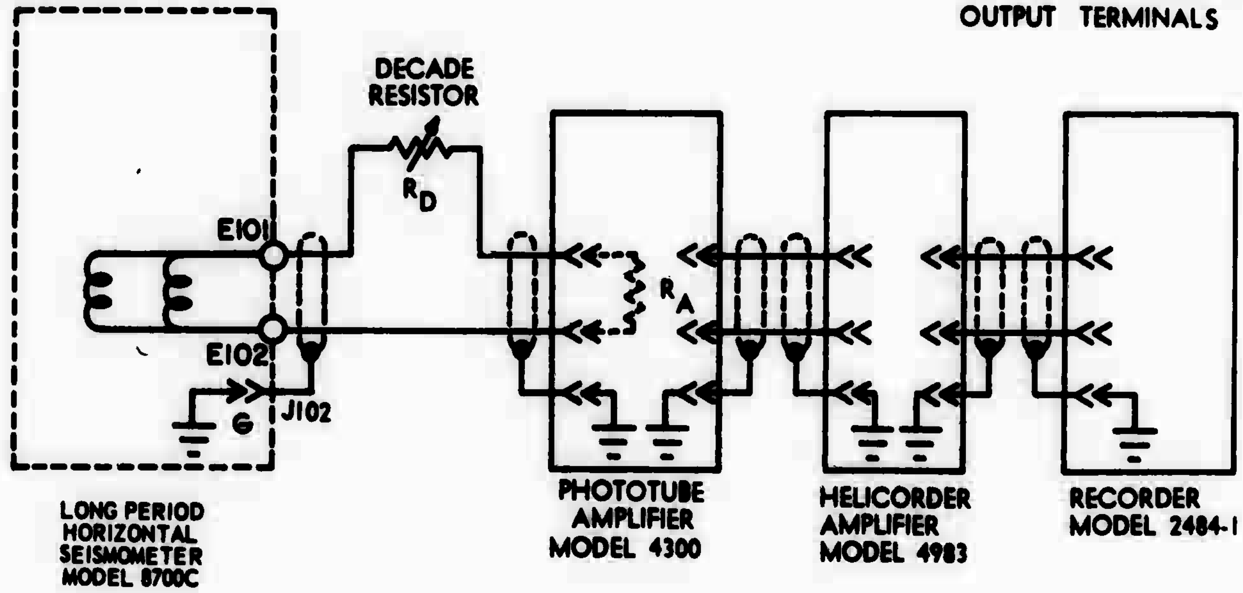
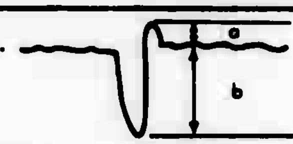


Figure 5-3. Test Setups for Critical Damping Resistance

Table 5-4. Performance Standards (Cont'd)

Test No. 1. Critical Damping Resistance (CDR) (Cont'd)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
1A		E101 and E102	Perform weight lifts as described in paragraph 5-17	a. 
1B	Adjust decade resistor R_D until overshoot is between 20% and 25%	E101 and E102	Repeat weight lifts	a. Percent overshoot = $\frac{a}{b} \times 100$ b. Determine ratio of actual damping to critical damping (λ) from table 5-5
1C	Disconnect test equipment			a. Calculate the critical damping resistance (CDR) using the formula $CDR = R_T \times \lambda$ b. CDR = 80 x natural period ±10% (ohms)

Test No. 2. Calibration Coil Motor Constant (G)

PRELIMINARY INSTRUCTIONS: Connect test circuit as shown in figure 5-4.

NOTE

A north-south seismometer should be installed with the front of the instrument (the end with the mass indicator window) facing west. An east-west seismometer should be installed with the front of the instrument facing north. Viewed from the front, a mass movement to the left (calibration weight off) should generate a negative signal, and a mass movement to the right (calibration weight on) should generate a positive signal. During weight lifts, observe that the polarities of the data coil signal voltages are correct.

Make sure two shunts are installed 180° apart on each magnet case of the magnet assembly.

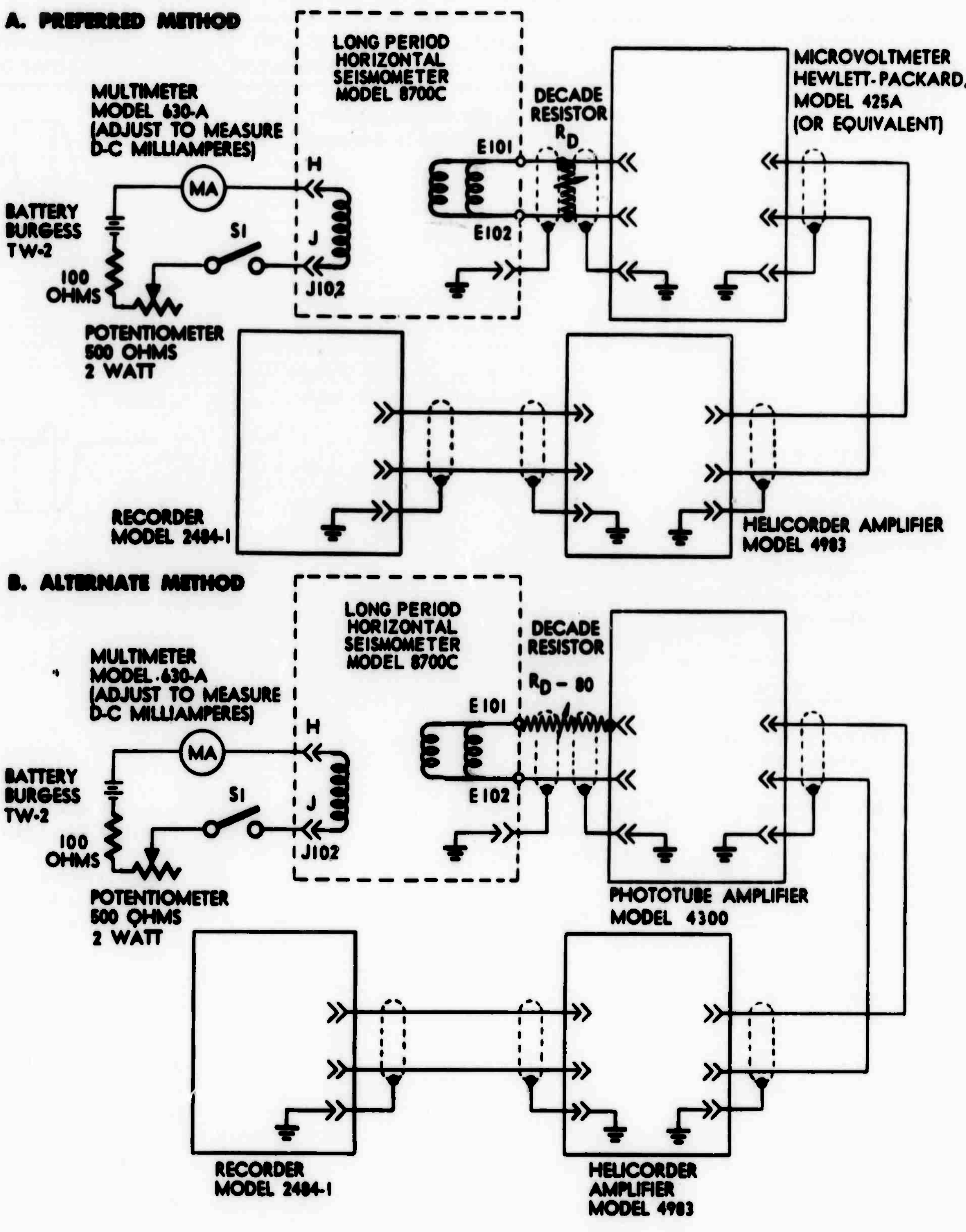
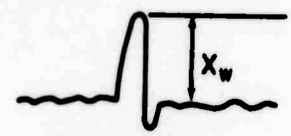
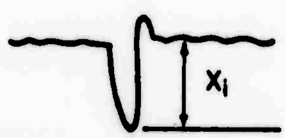


Figure 5-4. Test Setups for Calibration Coil Motor Constant

Table 5-4. Performance Standards (Cont'd)

Test No. 2. Calibration Coil Motor Constant (G) (Cont'd)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
2A		Binding Posts E101 and E102	Perform weight lifts as described in paragraph 5-17	a.  b. Measure and record X_w in millimeters for each weight lift
			NOTE Remove Test Weight before continuing to next step.	
2B	Complete circuit. Close switch and leave switch closed until mass stops moving. Open switch. Measure and record initial deflection.			a. 
	CAUTION Do not allow current to exceed 50 ma			
2C	Adjust variable resistor while opening and closing circuit through calibration coil, until X_i caused by opening circuit is within 10% of X_w	Binding Posts E101 and E102		a. Measure and record X_i in millimeters. b. Record current (i) through calibration coil in amperes
2D	Disconnect the test equipment			a. Calculate the calibration coil motor constant (G) using the formula: $G = \frac{(980 \times 10^{-5})(.04)\frac{X_i}{X_w}}{i}$ G = 0.032 ± 0.002 newtons/ampere

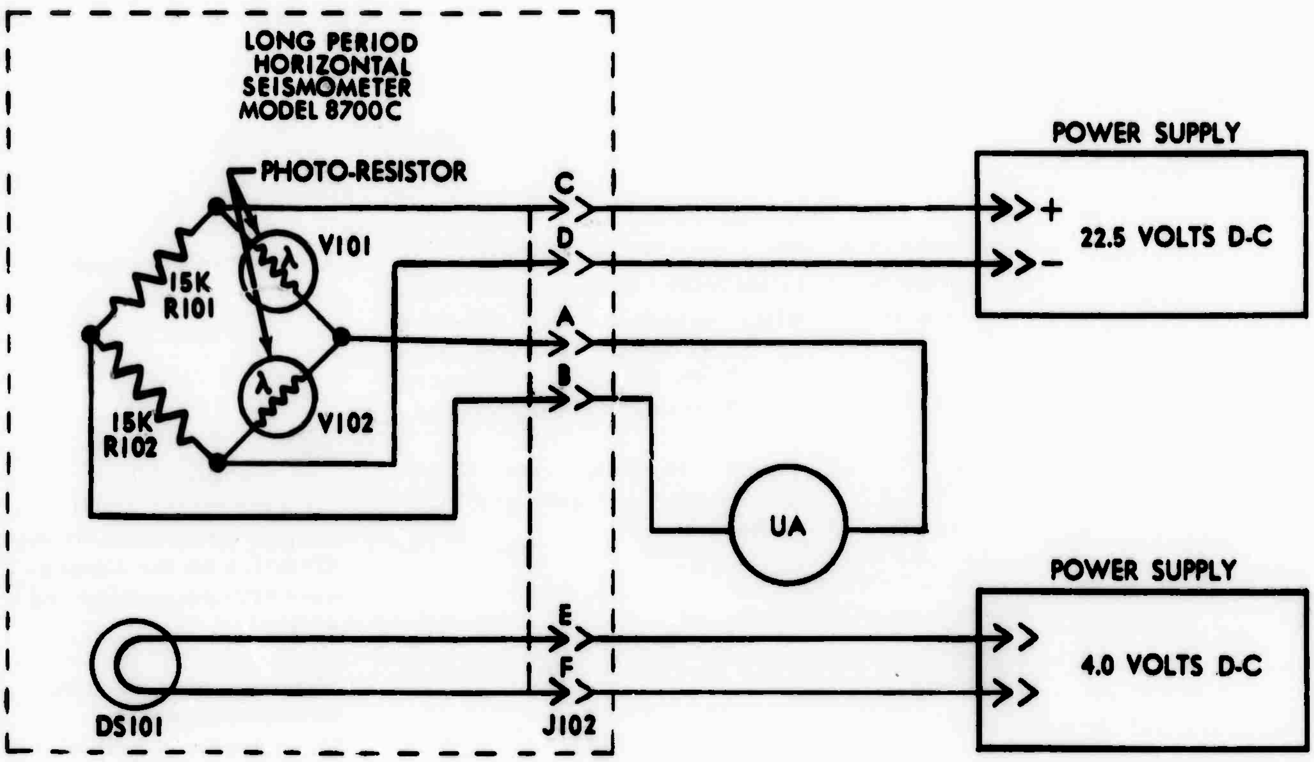


Figure 5-5. Test Setup for Mass Position Monitor Alignment

Table 5-4. Performance Standards (Cont'd)

Test No. 3. Mass Position Monitor Alignment

PRELIMINARY INSTRUCTIONS: Remove cover from seismometer and lock suspension arm as described in paragraph 5-11. Be careful to lock the arm in the center of its travel. Check that the bar on the face of each photoresistor is parallel to the base of the seismometer. Loosen the screw holding the aperture clip to the suspension arm and adjust aperture to be parallel to the face of the photoresistor housing and within 1/32 inch of the face. The aperture must not touch the face of the photoresistor housing at any point in the travel of the suspension arm. Tighten the screw to secure the aperture clip to the arm. Connect test circuit as shown in figure 5-5.

Table 5-4. Performance Standards (Cont'd)

Test No. 3. Mass Position Monitor Alignment (Cont'd)

STEP	OPERATION OF TEST EQUIPMENT	POINT OF TEST	CONTROL SETTINGS AND OPERATION OF EQUIPMENT	PERFORMANCE STANDARD
3A	Set power supplies for voltages shown in diagram. Set microammeter to 100 ua scale.	J102 Pins A and B		
3B	Close test circuits	J102 Pins A and B	Loosen screw holding aperture to aperture clip on the suspension arm. Adjust aperture sideways until microammeter reads zero ua. Tighten screw, being careful not to disturb the adjustment.	Microammeter reads zero ua
3C		J102 Pins A and B	Unlock suspension arm. Carefully swing arm from one stop to the other.	The reading of the microammeter shall increase smoothly in one direction as the suspension arm swings toward a stop. The reading shall then decrease smoothly through zero and increase smoothly in the other direction as the arm swings through center to the other stop.
3D	Disconnect test equipment			

Table 5-5. Ratio of Actual Damping to Critical Damping (λ)

PERCENT OVERSHOOT	λ
20.0	0.455
20.5	0.449
21.0	0.444
21.5	0.439
22.0	0.434
22.5	0.429
23.0	0.424
24.0	0.414
25.0	0.404

5-20. PERIOD VERSUS MASS POSITION TEST.

5-21. Verify that the mass is centered by observing the pointer through the window on the seismometer cover and perform the following steps in the order listed:

a. Time the natural period by performing steps f through i of paragraph 5-17.

b. If the natural period is not between 15 and 20 seconds, adjust the leveling screw at the rear end of the seismometer. Raise the rear end to shorten the period; lower the rear end to lengthen the period.

c. Prepare a chart the same as figure 5-6.

d. Time the natural period for 7 to 10 different points on the scale. These points are obtained by raising or lowering the right or left leveling screw (this changes mass position). Attempt to time each point between approximately the same voltage readings on the voltmeter. One test point should fall under each bracket at the top of figure 5-6.

e. Compute the average period. No test point should vary more than ±10% from the average. The curve should be symmetrical about the scale zero. If the mass position response does not meet the above requirements, the upper pivot assembly should be adjusted as described in paragraph 5-52.

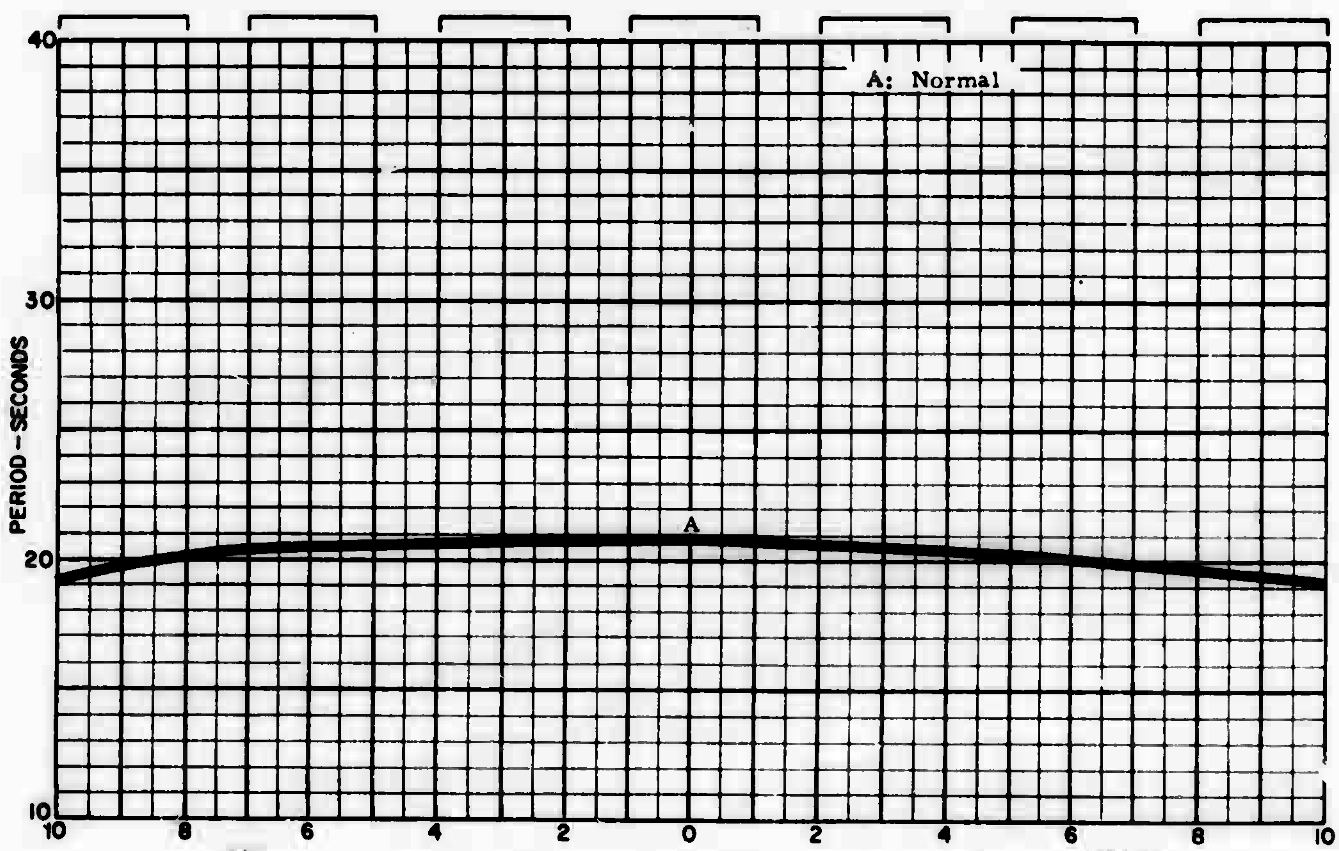


Figure 5-6. Mass Position versus Period Graph

5-22. DISASSEMBLY.

5-23. Disassembly of the seismometer is described in the following paragraphs. Do not proceed any further than is necessary to remove the parts which require cleaning or replacement. Refer to Chapter 6 for identification and location of parts.

230

5-24 REMOVAL OF COVER.

5-25. To remove cover, proceed as follows:

a Brush all loose insulation, dust, and dirt off the cover. Wipe off any moisture.

CAUTION

Do not allow dust, dirt or moisture to fall into seismometer case while cover is off. The presence of foreign matter inside the case may affect the operation of the seismometer.

b. Open latches and lift cover straight up from seismometer. Be careful that cover does not strike any internal parts.

5-26. REMOVAL OF COIL ASSEMBLIES.

5-27. To remove the coil assemblies proceed as follows:

CAUTION

Keep magnetic materials away from magnets. Protect magnet gaps with paper tape when exposed. Do not strike coils while removing magnet assemblies.

a. Remove the magnet assemblies and their supports from the base after removing three capscrews which secure each support to the base.

b. Remove the two pan head screws that hold the coil assemblies and coil bases to coil mount.

c. Remove the coil assemblies and bases. Be careful with the leads.

d. Disconnect the leads from the eight terminal posts of the coil assemblies. Be careful to avoid excess heat; the coil form melts readily.

e. Remove coil assembly from its coil base after removing four flat head screws.

5-28. REMOVAL OF SUSPENSION ARM.

5-29. To remove the suspension arm, proceed as follows:

CAUTION

Do not allow suspension arm to swing through a greater arc than it would with the masses in place.

a. Remove mass sections after removing flathead screws.

CAUTION

Keep magnetic materials away from magnets. Protect magnet gaps with paper tape when exposed. Do not strike coils while removing magnet assemblies.

b. Remove the magnet assemblies after removing cap-head screws holding assemblies to base.

NOTE

The two curved plates attached to the magnet cases are magnet shunts. Do not remove from the cases.

c. Disconnect wires which connect terminal boards TB103 and TB105 to terminal boards TB102 and TB104.

d. Remove the two capscrews (25, figure 5-7) which secure the lower pivot assembly to the mast.

e. Remove the two capscrews on slide mount (14) which secure upper pivot assembly to mast.

f. While supporting suspension arm with one hand, remove shoulder screw (30) from the upper pivot assembly and carefully work lower pivot assembly support off its dowel pins until suspension arm is free.

g. Lay suspension arm down. (Guard against damaging coils.)

h. Inspect both pivot assemblies to be certain the flexure plates (3, 4, 21, and 22, figure 6-3) of each pivot assembly do not touch at the crossing point. Inspect each pivot flexure plate and the horizontal flexure plates (13) to be sure that each is free of nicks, bends, and creases. Replace any defective flexure plate.

5-30. REMOVAL OF PIVOT ASSEMBLIES.

5-31. Refer to figure 5-7 and remove the pivot assemblies, by performing the following steps in the order listed:

a. Remove the two capscrews (29) holding the upper pivot assembly to suspension arm. Remove pivot assembly.

b. Remove two capscrews (31) holding the lower pivot assembly to the suspension arm. Remove pivot assembly.

c. Remove the two capscrews (27) holding the slide mount (14) to the upper pivot assembly. Remove the slide mount.

5-32. DISASSEMBLY OF UPPER PIVOT ASSEMBLY.

5-33. Refer to figure 5-7 and proceed as follows:

a. Remove the 10 capscrews (12) holding the clamping blocks (1 and 2) and flexure plates (3 and 4) in place. Remove the clamping blocks.

b. Carefully work the three flexure plates free from dowel pins.

5-34. DISASSEMBLY OF LOWER PIVOT ASSEMBLY

5-35. Refer to figure 6-3 and proceed as follows:

a. Remove the three capscrews (12) which hold the clamping block (11) and horizontal flexure plates (13) to the flexure bracket (10). Carefully remove the bracket.

b. Remove the three capscrews which hold the clamping block (14) to the horizontal flexure block (15). Carefully work horizontal flexures (13) free from dowel pins.

c. Remove the two capscrews which secure the horizontal flexure block (15) to the lower flexure block (19).

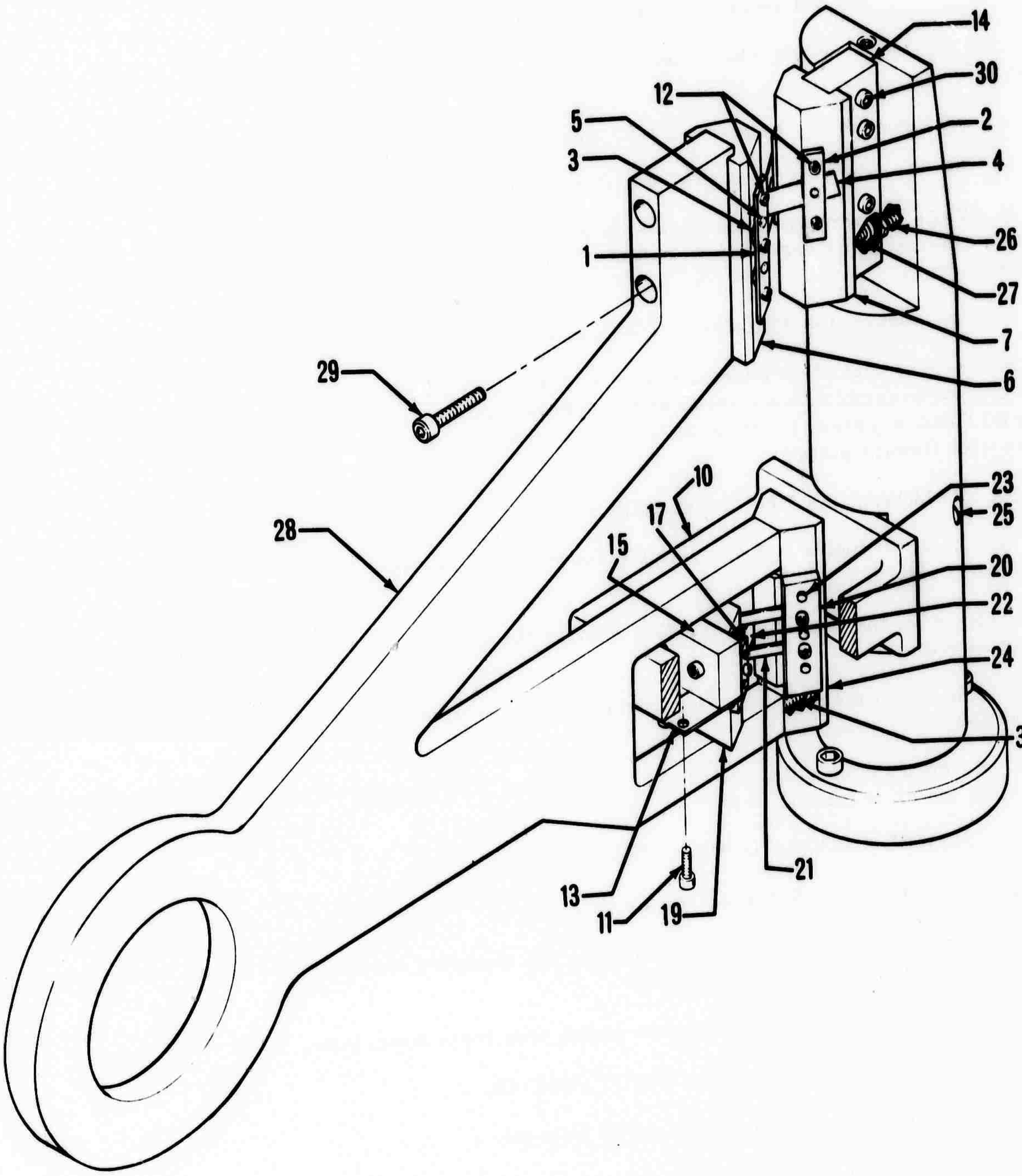


Figure 5-7. Disassembly of the Boom

d. Remove the 10 capscrews holding the clamping blocks (17 and 20) and flexure plates (21 and 22) in place. Remove the clamping blocks.

e. Carefully work the three flexure plates (21 and 22) free from dowel pins.

5-36. CLEANING.

5-37. GENERAL. Cleaning disassembled parts includes refinishing or recoating the parts as necessary. The cleaning methods used must be adequate for the conditions without being harsh or injurious. Painting or coating with corrosion resistant compounds shall be limited to the exterior of the seismometer.

5-38. The seismometer will normally not require extensive cleaning. Normally, wiping the parts carefully with a clean dry cloth, or brushing out any dust with a soft-bristled brush will be sufficient. If a solvent is necessary, use trichloroethylene sparingly and wipe clean of any deposited film. Do not use trichloroethylene or any other solvent on the plastic parts of the seismometer.

WARNING

Trichloroethylene is extremely poisonous. Use only in a well-ventilated area.

5-39. After using trichloroethylene, apply a thin coat of grease (Fiske Bros. Refining Co., Lubriplate 630AA or equivalent) or rust preventive (Humble Oil and Refining Co., Rust-Ban 393, or equivalent) to the clean area. Do not allow any grease or rust preventive to enter magnet air gap.

5-40. CORRODED PARTS. If corrosion is present, it may be removed with very fine sandpaper or steel wool. Do not allow any steel particles to enter the air gap in the magnet assembly. The tolerances of the working parts of the seismometer are extremely close; severly corroded working parts shall be replaced. Do not attempt to sand or otherwise recondition the flexure plates, the coil assembly, or the magnet. Brush or wipe off all foreign particles.

5-41. CLEANING THE AIR GAP. Clean the air gaps in the magnet assemblies before replacing the assemblies on the base of the seismometer. Remove particles using a nonmetallic rod tipped with masking tape, sticky side out. Be careful to avoid causing nicks or burrs in the gap or at its edges. Keep magnetic materials away from air gap.

5-42. REASSEMBLY AND ADJUSTMENT.

5-43. The reassembly instructions in the following paragraphs begin where the disassembly procedures in paragraphs 5-21 through 5-34 stopped. If the seismometer was not disassembled to the extent, begin reassembly at the appropriate paragraph. The procedures must be performed in the order given. Refer to Chapter 6 for identification and location of parts. Perform all the tests and adjustments described in the reassembly procedures. After reassembly, perform the tests and adjustments described in paragraph 5-13. When the seismometer is operating properly, prepare it for reshipment to the field.

CAUTION

To avoid damaging the flexure plates, never move the seismometer with out first locking the suspension arm.

5-44. REASSEMBLY OF LOWER PIVOT ASSEMBLY

5-45. Refer to figure 5-7 and reassemble the lower pivot assembly by performing the following steps in the order listed:

CAUTION

A bent flexure plate will cause improper operation of the seismometer. Be careful not to bend the flexure plate while placing it over the dowel pins.

a. Carefully work flexure plates (21 and 22) over dowel pins on pivot block (24).

b. Install clamping blocks (20 and 17) and clamping screws. Tighten screws until they are snug but not tight.

c. Place a steel rule behind flexure plates, as illustrated in figure 5-8, and adjust the plates until they are perpendicular to the block.

d. Carefully work flexure plates (21 and 22) over the dowel pins in the stationary flexure block (19). Install clamping blocks and screws and tighten.

e. Attach horizontal flexure block (15) to the lower flexure block (19).

f. Carefully work horizontal flexure plates (13) over the dowel pins.

g. Install clamping block (14) and clamping screws (12). Tighten screws until they are snug but not tight.

h. Attach assembly to the flexure bracket (10) by carefully working the horizontal flexure plates over the dowel pins of the bracket. Install clamping block (11) and clamping screws (12). Tighten the screws until they are snug but not tight.

i. Position the horizontal flexure plates (13) so that they are perpendicular to both the flexure block (15) and bracket (10). Use a steel rule. Tighten clamping screws.

5-46. REASSEMBLY OF UPPER PIVOT ASSEMBLY

5-47. Refer to figure 5-7 and reassemble the upper pivot assembly by performing the following steps in the order listed.

CAUTION

A bent flexure plate will cause improper operation of the seismometer. Be careful not to bend the flexure plate while placing it over the dowel pins.

a. Carefully work the flexure plates (3 and 4) over dowel pins in the stationary pivot block (7).

b. Install clamping blocks (1 and 2) and clamping screws. Tighten screws until they are snug but not tight. Install flexure plates and clamps in the movable flexure block in the same manner.

5-48. INSTALLATION OF PIVOT ASSEMBLIES AND SUSPENSION ARM.

5-49. Refer to figure 5-7 and install the pivot assemblies and suspension arm by performing the following steps in the order listed.

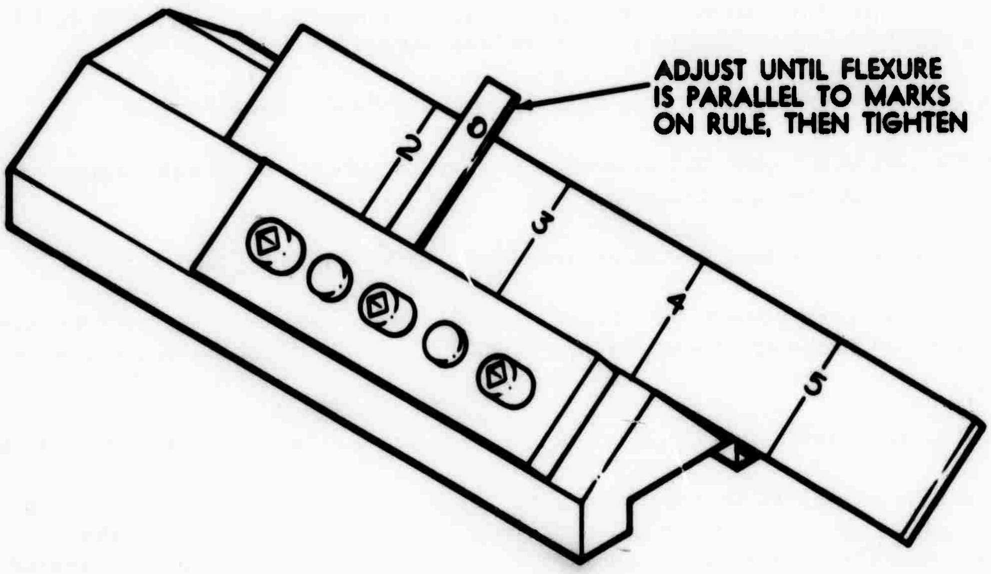


Figure 5-8. Adjustment of Flexure Plate

CAUTION

Exercise extreme care in mounting the pivot assemblies and the suspension arm to avoid bending or damaging the flexure plates.

a. Attach lower pivot assembly to the suspension arm using the two capscrews (31).

b. Attach slide mount (14) to upper pivot assembly with two capscrews.

c. Attach upper pivot assembly to suspension arm with the two capscrews (27).

d. Mount suspension arm on vertical mast by first working the flexure bracket over the dowel pins in the mast. Secure with the shoulder screw (30) then put two capscrews through the slide mount. Secure the lower pivot assembly to the mast with two capscrews (25) holding flexure bracket to vertical mast.

e. Assemble inertial mass sections to suspension arm with the two flat head screws.

f. Inspect both pivot assembles to be sure that the flexure plates of each pivot assembly do not touch at the crossing point.

g. Connect the fine wires between terminal boards TB103 and TB105 on the suspension arm and terminal boards TB102 and TB104 on the seismometer base. Use the schematic diagram in Chapter 7 to determine the correct connections.

5-50. INSTALLATION OF COIL AND MAGNET ASSEMBLIES.

5-51. To install the coil assemblies, proceed as follows:

a. Connect leads to the four terminal posts of each coil assembly. Use schematic diagram in Chapter 7 to determine the correct connections. Avoid excess heat; the plastic coil form melts readily. Use thermal free soldering procedure (see paragraph 5-6).

b. Attach coil assemblies to the coil bases with the eight flat head screws.

c. Assemble coil bases with coil assemblies to coil mount at end of suspension arm. Secure the coil bases together with two pan head screws.

d. Clean air gaps in the magnet assemblies as described in paragraph 5-41.

e. Place magnet assemblies and supports in the correct position on the seismometer base with coil assemblies centered in the air gaps. Secure magnet assembly supports to the base with the six capscrews.

f. Check that suspension arm swings freely from stop to stop without binding, sticking or friction.

g. If coil sticks in magnet assembly air gaps, slightly loosen the capscrews securing magnet assembly support to seismometer base. Shift magnet assembly until suspension arm swings freely from stop to stop without sticking. Tighten the capscrews securely. With suspension arm at the center of travel, coils must be centered in air gaps.

NOTE

When magnet assembly is in the correct position and suspension arm is at one limit of its travel, there is only approximately 1/64 inch of clearance between coil and magnet; therefore, the adjustment of magnet assembly position must be made with care so that coil will have sufficient clearance at both extremes of its travel.

5-52. ADJUSTMENT OF UPPER PIVOT ASSEMBLY.

5-53. The upper pivot should be adjusted whenever the mass position versus period test fails (paragraph 5-19) or whenever the pivot assembly has been removed. Refer to figure 5-7 and adjust the upper pivot assembly by performing the following steps in the order listed. Base should be level.

CAUTION

Never make any adjustments to the pivot assemblies unless the clamping screws are loose. Always let the suspension arm with attached masses swing several times when making setscrew adjustments to let the flexures find their least stressed position.

a. Slightly loosen the 10 clamping screws (12) the shoulder screw (30) and two capscrews until they are snug, but not tight.

b. Unlock the suspension arm and set the stops (3, figure 5-1) so that the arm travels from +10 to -10 on the scale.

c. Raise the rear by placing a 1/2-inch thick plate beneath the rear leveling screw. Let the arm swing freely between the stops.

d. Lock the suspension arm on zero.

e. Using vernier calipers, set the upper pivot assembly so that the flexure blocks are parallel to each other. This may be accomplished by rotating the mast post setscrew (26) which pivots the slide mount (14) on the shoulder screw. When the blocks are parallel, tighten the shoulder screw (30) and capscrews. Lock the jam nut of the mast post set screw (26).

f. Unlock the boom and let the suspension arm swing freely. Relock the arm on zero.

g. Tighten clamping screws (12) in the order shown in figure 5-9. Clamps should be as flat as possible over the flexures. Do not tighten screws excessively, but aim for the same torque on each screw.

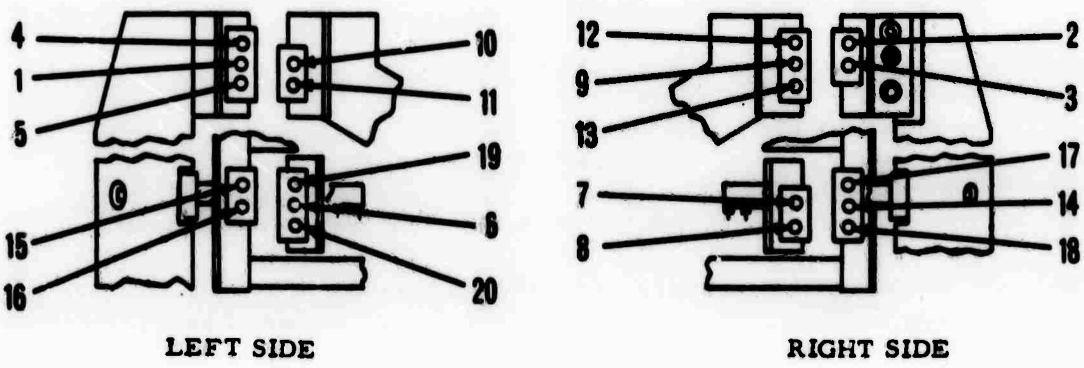


Figure 5-9. Securing Flexure Plates

h. Unlock boom and set stops so pointer will swing over the entire scale. Let pointer come to rest. If pointer does not fall on the scale zero ±3mm, center the boom with the set screws, (1, figure 5-1) on the lower pivot assembly. Run in the proper setscrew until the pointer moves, then back the screw out. Repeat until pointer is within ±3mm of zero. Make only small adjustments with these setscrews.

i. Remove 1/2-inch block from rear.

j. Rotate rear leveling screw approximately four revolutions to elevate that end of the seismometer level. Time the period and make adjustments on rear leg until period is between 15 and 20 seconds and stable. Lock rear leg.

k. Perform the period versus mass position test as described in paragraph 5-19.

5-54. REPAIR OF MASS POSITION MONITOR ACCESSORY.

5-55. REPLACEMENT OF LAMP.

5-56. To replace the lamp located in the mass position monitor accessory lamp housing, proceed as follows:

a. Remove the bayonet-base lamp from its socket by using a pair of tweezers and working through the aperture in the side of the lamp housing.

b. When the lamp is free, hold the open lamp end of the housing downward and allow the lamp to slide out.

c. If it is necessary to remove the lamp socket, use a pencil or similar object to push the socket and retaining ring out of socket end of the housing. Otherwise, install a new lamp using the tweezers as in step a. Note that the lamp can only be installed in the socket when the socket is inside the housing.

5-57. REPLACEMENT OF PHOTORESISTORS.

5-58. If it becomes necessary to replace one photoresistor both must be replaced by a matched pair.

To replace photoresistors, proceed as follows:

a. Remove photoresistor bridge assembly from base by lifting it out of mounting clip. Be careful not to damage leads.

b. Remove cover surrounding housing to gain access to photoresistor leads.

c. Disconnect photoresistor leads and remove both photoresistors from housing.

d. Install two matched replacement photoresistors in housing. The light-sensitive face of each photoresistor shall be flush with the front of housing; black bar of face of each photoresistor shall line up with bar on other photoresistor.

e. Perform test No. 3 described in Table 5-4 to insure proper aperture alignment.

f. Solder photoresistor leads to terminals in housing. Avoid excessive heat. Hold lead with pliers while soldering to conduct heat away from the photoresistor. See figure 7-1 for correct connections.

g. Slide cover back into place around housing, covering connections.

h. Install photoresistor bridge assembly on base by snapping it into mounting clip. Black bar on face of each photoresistor shall be horizontal.

i. Perform test No. 3 of Table 5-4 to check that photoresistors are operating and that aperture is adjusted.

5-59. MAINTENANCE OF REMOTE CENTERING ACCESSORY.

5-60. LUBRICATION.

5-61. The remote centering accessory requires no lubrication.

5-62. REPLACEMENT OF PARTS.

5-63. Disassembly and reassembly of the remote centering accessory requires no special instructions. Refer to Chapter 6 for identification and location of parts.

5-64. When the remote centering accessory is disassembled, inspect the thrust bearing for excessive wear. Clean and lubricate as needed with light machine oil. If the thrust bearing is replaced, lubricate lightly with Lubriplate 630AA (Fiske Bros. Refining Co.) or equivalent.

BLANK PAGE

CHAPTER 6
ILLUSTRATED PARTS BREAKDOWN

SECTION I

INTRODUCTION TO ILLUSTRATED PARTS BREAKDOWN

6-1. GENERAL.

6-2. This illustrated parts breakdown lists and illustrates parts for the LONG PERIOD HORIZONTAL SEISMOMETER, Model 8700C. This breakdown will be used for requisitioning, stocking, issuing, identifying parts and for illustrating assembly and disassembly relationship.

6-3. Related publications: None.

6-4. MAJOR SECTIONS.

SECTION I	Introduction
SECTION II	Numerical Index
SECTION III	Reference Designation Index
SECTION IV	Group Assembly Parts List

6-5. NUMERICAL INDEX.

6-6. The numerical index contains all parts that appear in the Group Assembly Parts Lists, superseded parts, parts that are riveted or welded, altered vendors parts and commercial hardware to which no part number has been assigned.

6-7. PART NUMBER SEQUENCE.

6-8. Parts numbers are listed in alpha-numerical order. Commercial hardware parts are listed in sequence, considering the identifying noun as the part number.

6-9. STOCK NUMBERS.

6-10. Stock numbers are not included in this manual.

6-11. FIGURE AND INDEX NUMBER COLUMN.

6-12. Figure and index numbers in this column key part numbers to their location in the Group Assembly Parts List.

6-13. QUANTITY PER ARTICLE COLUMN.

6-14. The quantity shown in this column is the total quantity required per article.

6-15. REFERENCE DESIGNATION INDEX.

6-16. This section contains reference designations, indexed to the Group Assembly Parts List, figure and index numbers, stock numbers, when available, and the part numbers of the reference designated parts. All reference designations established for any electrical or electronic parts listed in the Group Assembly Parts List are included in this section.

6-17. GROUP ASSEMBLY PARTS LIST.

6-18. The Group Assembly Parts List provides the parts identification drawing and parts list.

6-19. PART NUMBERING SYSTEM.

6-20. The manufacturer's part number consists of a group of letters and digits assigned chronologically and has no particular significance.

6-21. ATTACHING PARTS.

6-22. Attaching parts appear in the Group Assembly Parts List following the item they attach. The symbol ****** indicates the end of attaching parts.

6-23. VENDORS' PARTS OR ASSEMBLIES.

6-24. Vendor's items are listed by the vendor part number. The vendor's code is listed in the MFR CODE column. See Vendors' Code List at the end of Section I to determine vendor's name and address.

6-25. UNITS PER ASSEMBLY.

6-26. The quantity listed in this column is the total quantity used at that location and is not necessarily the total quantity used in the equipment.

6-27. USABLE ON CODE.

6-28. The Usable On Code column does not apply for this equipment.

6-29. The symbol ** preceeding the Mfr Part Number designates reference to a footnote. The footnote will be located at the end of the figure.

6-30. HOW TO USE THIS ILLUSTRATED PARTS BERAKDOWN.

6-31. HOW TO FIND THE PART NUMBER.

a. Locate the part and its index number on the illustration.

b. Find the index number on the Group Assembly Parts List to determine the part number or complete description.

6-32. HOW TO FIND THE ILLUSTRATION IF THE PART NUMBER IS KNOWN.

a. Refer to the numerical index (Section II) and find the part number.

b. Turn to the Group Assembly Parts List (Section IV) and find the first figure and index number indicated in the Numerical Index for that part. If this figure shows the part in a location other than the one desired, refer to the other figure numbers listed in the Numerical Index.

c. On the face of the illustration, find the index number determined in step b.

VENDORS' CODE LIST*

Code Number	Vendor's Name and Address
00334	Humidial Co. Colton, California
01528	Cal-Ohm Laboratories, Inc. San Diego, California
03797	Eldema Corp. El Monte, California
03911	Clairex Corp. New York, New York
07829	Bodine Electric Co. Chicago, Illinois
11503	Keystone Mfg. Co. Warren, Michigan
12139	Pic Design Corp. Van Nuys, California
24455	General Electric Co., Lamp Division of Consumer Products Group Nela Park (Cleveland), Ohio
30342	Imperial Metal Products Co. Grand Rapids, Michigan
70331	Alpha Wire Corp. New York, New York
70903	Belden Mfg. Co. Chicago, Illinois
71041	Boston Gear Works, Division of Murray Co. of Texas Quincy, Massachusetts
71279	Cambridge Thermionic Corp. Cambridge, Massachusetts
71753	Smith, A. O. Corp, Crowley Division
71762	Culligan, Inc. Northbrook, Illinois
72653	G. C. Electronics Mfg. Co. Rockford, Illinois
77820	Bendix Corp, Scintilla Division Sidney, New York
81168	Linear, Inc. Philadelphia, Pennsylvania
85780	Moyer, W. A., and Sons Parkers Landing, Pennsylvania
86579	Precision Rubber Products Corp Dayton, Ohio
88245	U. S. Engineering Co. Glendale, California
95987	Weckesser Co. Chicago, Illinois
97197	Edmund Scientific Corp. Barrington, New Jersey
98003	Nielson Hardware Corp. Hartford, Connecticut

*Teledyne Industries, Geotech Division, Garland, Texas, as prime contractor is not listed.

SECTION II

NUMERICAL INDEX

PART NO.	STOCK NO.	FIG. AND INDEX NO.	QTY PER ART.	S/C
A010		6-4-16	1	
B68-4	(See 11465)			
B8262E1800C	(See 12782)			
CL603		6-5-6	2	
CTC2041C		6-5-5	4	
DESSICANT		6-2-3	2	
D4-375		6-3-5	16	
		6-3-12		
		6-3-16		
		6-3-18		
		6-3-23		
D4-500		6-4-13	2	
G1-80	(See 11467)			
G3-32		6-4-17	1	
HS179286-2SS		6-1-14	20	
H310F		6-5-8	1	
JAR		6-2-1	1	
MC250		6-1-16	3	
MS20003-1		6-2-4	1	
MS3057-12		6-1-23	2	
		6-1-28		
MS3057-3		6-1-10	1	
MS3102C10SL4P		6-1-12	1	
MS3102C20-11S		6-1-31	1	
MS3102C20-4S		6-1-26	1	
MS3106A10SL4S		6-1-11	1	
MS3106A20-11P		6-1-29	1	
MS3106A20-4P		6-1-24	1	
PC02C8-3P		6-1-33	1	
PC06A8-3S		6-4-6	1	
PIN		6-1-59	2	
PVC105-10		6-1-	AR	
PVC105-5		6-1-	AR	
		6-4-		
		6-5-2		
PVC105-7		6-1-	AR	
PVC105-8		6-5-	AR	
		6-5-1		
P89D679		6-4-2	1	
RC20GF153J		6-5-4	2	
RC42GF351J		6-4-3	1	
SCB179286		6-4-9	2	
SCB83314-2		6-1-35	22	
		6-4-1		
THREAD		6-1-	AR	
TUBE		6-2-5	1	
VIAL		6-1-46	1	
WEIGHT		6-1-77	1	
WIRE		6-1-	AR	
		6-4-		
		6-5-		
1K5742		6-5-11	1	
10074		6-1-74	1	
		6-5-		
10076		6-1-73	1	
		6-4-		
10203		6-1-65	1	
10387		6-1-80	1	
10388		6-1-79	1	
10389		6-1-76	1	
10390		6-1-78	1	
10391		6-1-	1	
1041C		6-4-7	1	

PART NO.	STOCK NO.	FIG. AND INDEX NO.	QTY PER ART.	S/C
10765		6-5-	1	
10766		6-5-	1	
10767		6-5-12	1	
10768		6-5-9	1	
10769		6-5-7	1	
10770		6-5-	1	
10771		6-5-15	1	
10772		6-5-14	1	
10775		6-5-3	1	
11-013		6-1-34	1	
11-016		6-1-13	1	
11-024		6-1-27	2	
1118-2		6-1-5	2	
11459		6-4-12	1	
11460		6-4-25	1	
11461		6-4-8	1	
11462		6-4-10	1	
11464		6-4-14	1	
11465		6-4-11	1	
11466		6-1-	1	
		6-4-24		
11467		6-4-15	1	
11468		6-4-19	1	
11702		6-4-5	1	
11703		6-4-	1	
11704		6-1-45	1	
11718		6-4-	1	
12		6-5-10	1	
12782		6-4-13	1	
1418B		6-4-4	3	
14587		6-1-75	1	
15738		6-3-2	2	
15739		6-3-1	2	
15757-1		6-3-21	2	
15757-2		6-3-22	1	
15757-3		6-3-3	2	
15757-4		6-3-4	1	
15783		6-3-6	1	
15784		6-3-7	1	
15785		6-3-24	1	
15786		6-3-19	1	
15824		6-1-71	3	
15921		6-1-21	1	
15934		6-3-13	2	
15935		6-1-70	1	
15936		6-1-69	1	
15939-2		6-1-47	2	
15940		6-1-61	2	
15941		6-1-	2	
15943-1		6-1-41	2	
15943-2		6-1-64	2	
15944		6-1-	1	
15945		6-1-68	1	
15946		6-1-50	1	
16159		6-4-23	1	
16187		6-4-22	1	
16299		6-3-17	2	
16300		6-3-20	2	
16301		6-3-15	1	
16325		6-1-67	1	
		6-3-		
16327		6-1-66	1	
		6-3-		

PART NO.	STOCK NO.	FIG. AND INDEX NO.	QTY PER ART.	S/C
16360		6-1-	1	
16361		6-1-62	1	
16373		6-1-6	1	
16374		6-1-8	1	
16375		6-1-	1	
16433		6-1-	1	
16434		6-1-	1	
16435		6-1-17	2	
16436		6-1-18	1	
16437		6-1-19	1	
16438		6-1-20	1	
16441		6-1-	2	
16444		6-1-	1	
16554		6-1-	16	
16695		6-1-40	1	
16696		6-1-	2	
16722		6-1-42	1	
16792		6-1-	4	
16801		6-1-	1	
16954-1		6-1-2	1	
16954-2		6-1-3	1	
16954-3		6-1-4	1	
16955		6-1-52	1	
17025		6-1-1	1	
		6-2-		
17041		6-1-7	2	
17203		6-1-1	1	
		6-2-		

PART NO.	STOCK NO.	FIG. AND INDEX NO.	QTY PER ART.	S/C
17235-2		6-2-11	1	
17438		6-2-10	1	
266N		6-2-6	1	
268N		6-2-8	2	
269N		6-2-7	1	
3/16-6R		6-1-25	4	
		6-1-30		
398-7184		6-1-22	1	
4950		6-1-72	1	
5706C		6-1-43	1	
6543		6-1-37	1	
6544		6-1-38	2	
6545		6-1-39	1	
6546		6-1-36	1	
66PP		6-2-9	AR	
8484	(See 16361)			
8700C		6-1-	1	
9059		6-1-53	2	
91		6-5-13	2	
9157		6-1-51	1	
9172		6-3-11	2	
		6-3-14		
9174		6-1-63	1	
9175		6-1-60	2	
9631-3		6-3-10	1	
9642		6-1-48	1	
9661		6-1-49	1	

SECTION III

REFERENCE DESIGNATION INDEX

REF DESIG-NATION	FIG. AND INDEX NO.	STOCK NO.	PART NO.
B201	6-4-18		12782
C201	6-4-2		P89D679
DS101	6-5-10		12
E101	6-1-		16696
E102	6-1-		16696
J101	6-1-26		MS3102C20-4S
J102	6-1-31		MS3102C20-11S
J103	6-1-33		PC02C8-3P
J104	6-1-12		MS3102C10SL4P
L1	6-1-61		15940
L2	6-1-61		15940
P101	6-1-24		MS3106A20-4P
P102	6-1-29		MS3106A20-11P
P103	6-4-6		PC06A8-3S
P104	6-1-11		MS3106A10SL4S

REF DESIG-NATION	FIG. AND INDEX NO.	STOCK NO.	PART NO.
R1	6-1-16		MC250
R2	6-1-16		MC250
R3	6-1-16		MC250
R101	6-5-4		RC20GF153J
R102	6-5-4		RC20GF153J
R201	6-4-3		RC42GF351J
TB101	6-1-42		16722
TB102	6-1-41		15943-1
TB103	6-1-64		15943-2
TB104	6-1-41		15943-1
TB105	6-1-64		15943-2
V101	6-5-6		CL603
V102	6-5-6		CL603
XDS101	6-5-11		1K5742

SECTION IV

GROUP ASSEMBLY PARTS LIST

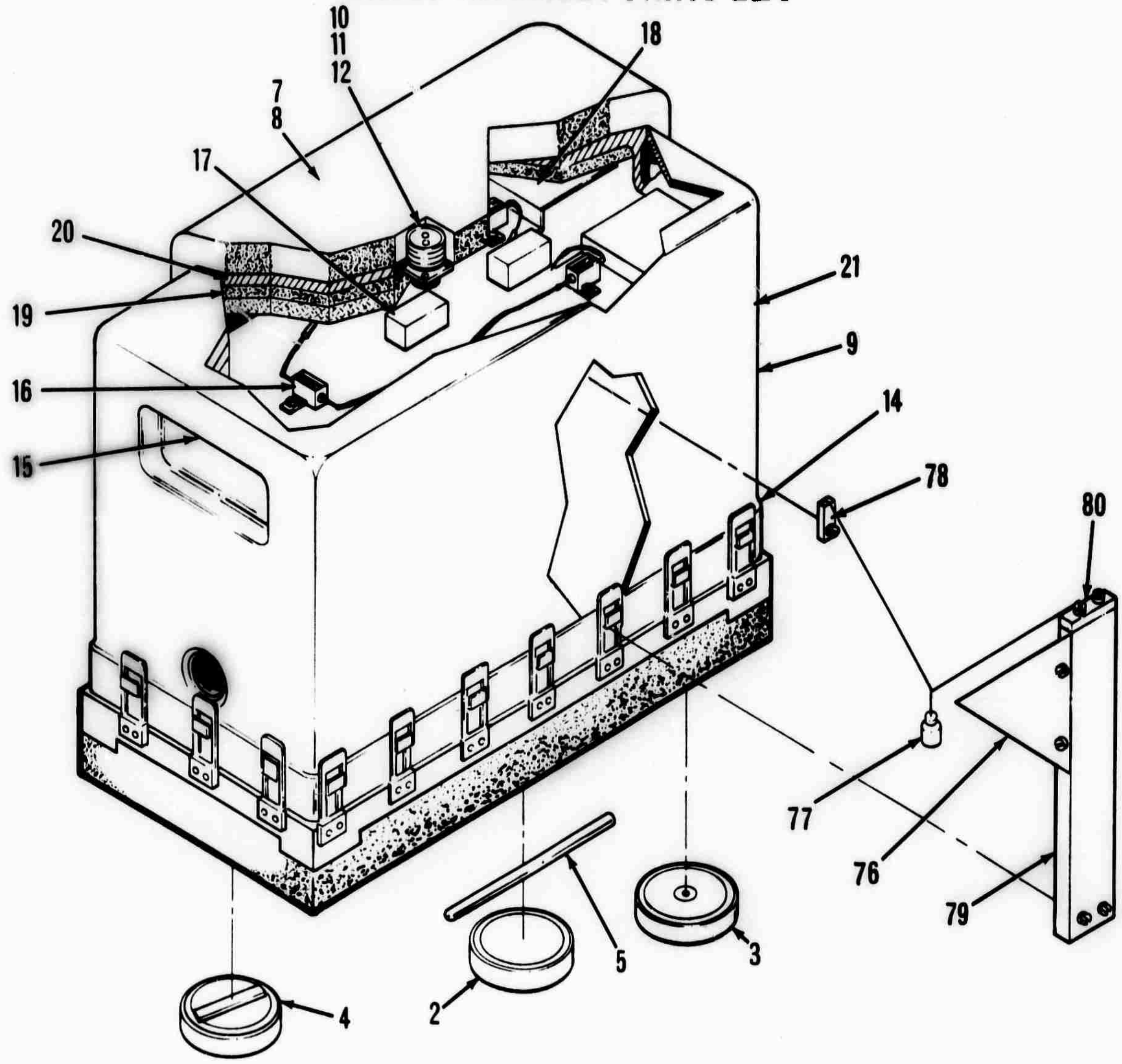


Figure 6-1. Long-Period Horizontal Seismometer 8700C (sheet 1 of 2)

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-1-	8700C	HORIZONTAL SEISMOMETER, Long Period		1	
-1	17203	. DESICCATOR BREATHER ASSY (See figure 6-2 for breakdown)		1	
-2	16954-1	. INSULATOR ASSY, Glass		1	
-3	16954-2	. INSULATOR ASSY, Glass		1	
-4	16954-3	. INSULATOR ASSY, Glass		1	
-5	1118-2	. CAPSTAN WRENCH		2	
	16375	. COVER ASSY KIT, INSULATION (ACCESSORY)		1	
-6	16373	. . COVER, PLUG		1	
-7	17041	. . COVER, PLUG		2	
-8	16374	. . COVER, INSULATION		1	
-9	17801	. PLUG, SHIPPING		1	
-10	MS3057-3	. CLAMP, CABLE		1	
-11	MS3106A10SL4S	. CONNECTOR, PLUG, ELECTRICAL		1	
	16433	. COVER ASSY		1	

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-1-12	MS3102C10SL4P	. . CONNECTOR, RECEPTACLE, ELECTRIC		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 4-40 thd size by 1/4 in., sst		4	
	COML	. . WASHER, LOCK, Int tooth, no. 4, sst		4	
		******			
-13	11-016	. . PACKING, PREFORMED, O-ring	81168	1	
-14	HS179286-2SS	. . STRIKE	98003	20	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 4-40 thd size by 1/4 in., sst		40	
		******			
-15	2196	. . WINDOW	97197	1	
	16434	. . HEATER ASSY		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 8-32 thd size by 7/16 in., sst		2	
	COML	. . WASHER, LOCK, Int tooth, no. 8, sst		2	
		******			
-16	MC250	. . . RESISTOR, FIXED, WIRE WOUND, Power, 70 ohms, 25 W, ± 1%	01528	3	
		(ATTACHING PARTS)			
	COML	. . . NUT, PLAIN, HEX., 4-40 thd size, sst		6	
	COML	. . . WASHER, LOCK, Int tooth, no. 4, sst		6	
	COML	. . . SCREW, MACHINE, Pan hd, 4-40 thd size by 5/16 in., sst		6	
		******			
-17	16435	. . . INSULATOR, STANDOFF		2	
		(ATTACHING PARTS)			
	COML	. . . SCREW, MACHINE, Pan hd, 6-32 thd size by 5/16 in., sst		4	
	COML	. . . WASHER, LOCK, Int tooth, no. 4, sst		4	
		******			
-18	16436	. . . PLATE, MOUNTING, Heater		1	
	**COML	. . . WIRE, ELECTRICAL, Tinned copper, awg 18, solid, 0.010 in. polyvinylchloride ins., 600 V, temp rtng -55°C, + 105°C		AR	
-19	16437	. . INSULATION, Lower heater		1	
-20	16438	. . INSULATION, Upper heater		1	
-21	15921	. . COVER		1	
-22	398-7184	. PACKING, PREFORMED, O-ring	86579	1	
-23	MS3057-12	. CLAMP, CABLE		1	
-24	MS3106A20-4P	. CONNECTOR, PLUG, ELECTRICAL		1	
	16444	. CABLE ASSY		1	
		(ATTACHING PARTS)			
-25	3/16-6R	. CLAMP, CABLE	95987	1	
	COML	. SCREW, MACHINE, Pan hd, 6-32 thd size by 1/4 in., sst		1	
	COML	. SCREW, MACHINE, Pan hd, 4-40 thd size by 1/4 in., sst		4	
		******			
-26	MS3102C20-4S	. . CONNECTOR, RECEPTACLE, ELECTRIC		1	
	PVC105-10	. . TUBING, PLASTIC	70331	AR	

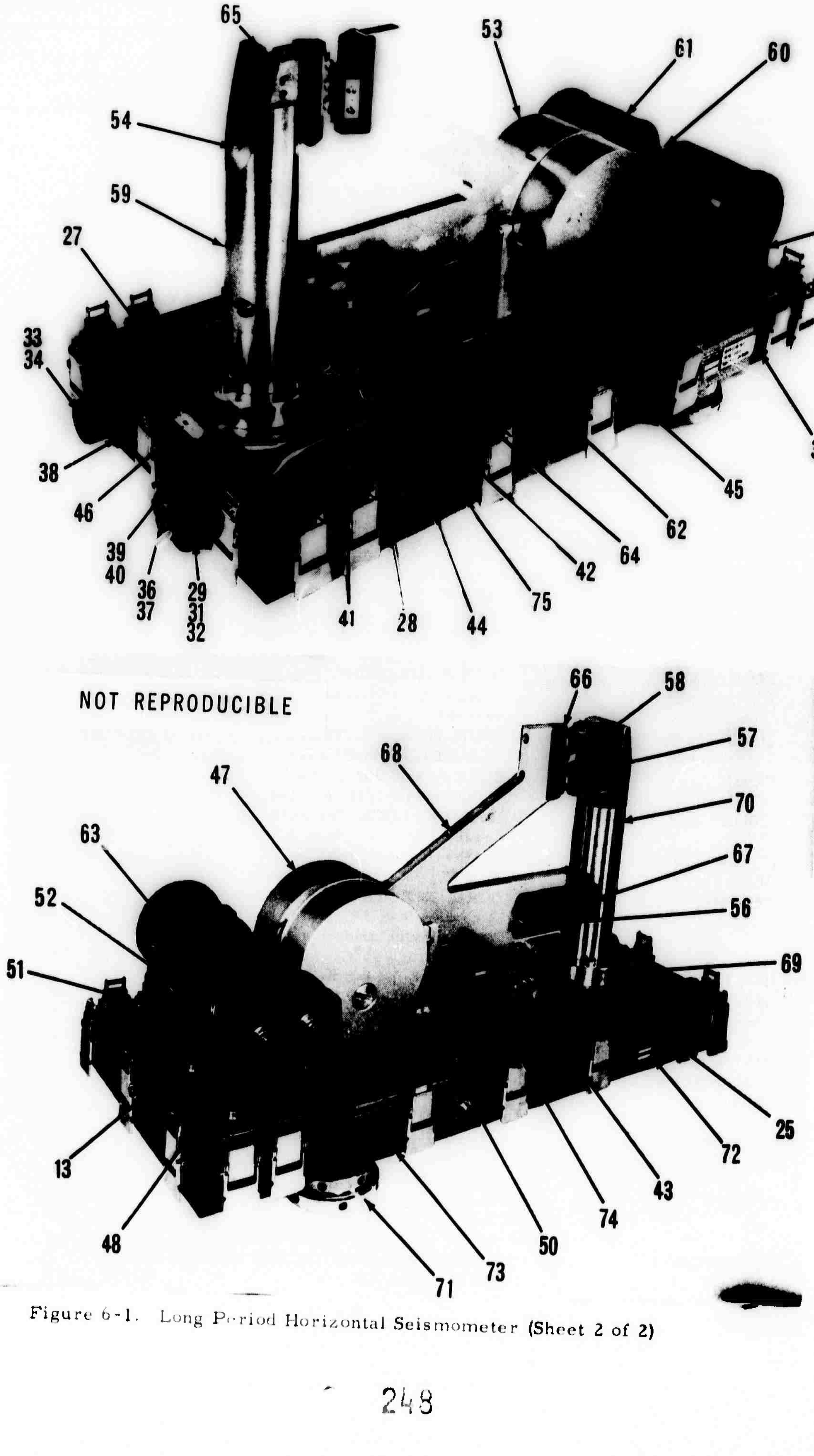


Figure 6-1. Long Period Horizontal Seismometer (Sheet 2 of 2)

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-1-	**COML	. . WIRE, ELECTRICAL, Tinned copper, awg 20, strd 7/28, 0.010 polyvinylchloride ins., 5 conductors, OD 0.190 in., 600 V, temp rtng -55°C, + 105°C		AR	
-27	11-024	. PACKING, PREFORMED, O-ring	81168	1	
-28	MS3057-12	. CLAMP, CABLE		1	
-29	MS3106A20-11P	. CONNECTOR, PLUG, ELECTRICAL		1	
	16360	. CABLE ASSY (ATTACHING PARTS)		1	
-30	3/16-6R	. CLAMP, CABLE	95987	3	
	COML	. SCREW, MACHINE, Pan hd, 6-32 thd size by 1/4 in., sst		3	
	COML	. SCREW, MACHINE, Pan hd, 4-40 thd size by 1/4 in., sst		4	
		******			
-31	MS3102C20-11S	. . CONNECTOR, RECEPTACLE, ELECTRIC		1	
	PVC105-5	. . TUBING, PLASTIC	70331	AR	
	PVC105-7	. . TUBING, PLASTIC	70331	AR	
	**COML	. . WIRE, ELECTRICAL, Tinned copper, awg 22, strd 7/30, 0.010 polyvinylchloride ins., 600 V, temp rtng -55°C, + 105°C		AR	
	**COML	. . WIRE, ELECTRICAL, Tinned copper, awg 26, strd, 7/34, 0.010 polyvinylchloride ins., 600 V, temp rtng - 55°C, + 105°C		AR	
-32	11-024	. PACKING, PREFORMED, O-ring	81168	1	
-33	PC02C8-3P	. CONNECTOR, RECEPTACLE, ELECTRIC (ATTACHING PARTS)	77820	1	
	COML	. SCREW, MACHINE, Pan hd, 4-40 thd size by 1/4 in., sst		4	
		******			
-34	11-013	. PACKING, PREFORMED, O-ring	81168	1	
-35	SCB83314-2	. CATCH (ATTACHING PARTS)	98003	20	
	COML	. SCREW, MACHINE, Pan hd, 4-40 thd size by 1/4 in., sst		40	
		******			
	16696	. BINDING POST ASSY		2	
-36	6546	. . SCREW, THUMB		1	
-37	6543	. . NUT, CONNECTOR		1	
-38	6544	. . BUSHING		2	
-39	6545	. . BOLT, CONNECTOR		1	
-40	16695	. . SCREW, CAPSTAN		1	
-41	15943-1	. TERMINAL BOARD ASSY (ATTACHING PARTS)		2	
	COML	. SCREW, MACHINE, Pan hd, 2-56 thd size by 5/8 in., sst		2	
		******			
	COML	. . SCREW, MACHINE, Pan hd, 2-56 thd size by 3/8 in., sst		4	
	16554	. . CLAMP, TERMINAL		8	
	15941	. . TERMINAL BOARD		1	
	**COML	. WIRE, ELECTRICAL, Type TF, untinned copper, 18 awg, solid, polyvinylchloride ins.		AR	

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-1-42	16722	. TERMINAL BOARD (ATTACHING PARTS)		1	
	COML	. SCREW, MACHINE, Pan hd, 4-40 thd size by 5/8 in., sst		4	
		******			
-43	5706C	. TERMINAL, LUG, No. 4	72653	1	
-44	1915-2	. INSULATOR, STANDOFF	71279	4	
-45	11704	. PLATE, COVER (ATTACHING PARTS)		1	
	COML	. SCREW, MACHINE, Pan hd, 4-40 thd size by 1/4 in., sst		4	
		******			
-46	VIAL	. VIAL, LEVEL, 0.320 in. dia. by 1 in. 1 g, no. 2 PGMS GRAD, 25-35 sec. SENS. (ATTACHING PARTS)	85780	1	
	COML	. SCREW, MACHINE, Sch, 4-40 thd size by 3/16 in., sst		4	
		******			
-47	15939-2	. MAGNET ASSY* (ATTACHING PARTS)		2	
	COML	. SCREW, CAP, SCH, 1/4-28 thd size by 3/4 in., sst		2	
	COML	. WASHER, FLAT, No. 1/4, sst		2	
		******			
-48	9642	. SUPPORT, MAGNET, RH (ATTACHING PARTS)		1	
	COML	. SCREW, CAP, SCH, 1/4-28 thd size by 3/4 in., sst		3	
	COML	. WASHER, FLAT, No. 1/4, sst		3	
		******			
-49	9661	. SUPPORT, MAGNET, LH (ATTACHING PARTS)		1	
	COML	. SCREW, CAP, SCH, 1/4-28 thd size by 3/4 in., sst		3	
	COML	. WASHER, FLAT, No. 1/4, sst		3	
		******			
-50	15946	. SUSPENSION ARM LOCK ASSY (ATTACHING PARTS)		1	
	COML	. SCREW, CAP, SCH, 1/4-28 thd size by 3/4 in., sst		1	
		******			
	COML	. . SCREW, MACHINE, Hex. sch set, oval point, 1/4-28 thd size by 3/4 in., sst		2	
	COML	. . SCREW, MACHINE, Sch, 6-32 thd size by 3/4 in., sst		2	
	16441	. . CLAMP, SUSPENSION ARM LOCK (ATTACHING PARTS)		2	
	COML	. . SCREW, MACHINE, Sch, 10-32 thd size by 1/2 in., sst		4	
		******			
	15944	. . BASE, SUSPENSION ARM LOCK		1	
-51	9157	. YOKE, POSITION (ATTACHING PARTS)		1	
	COML	. SCREW, MACHINE, Pan hd, 10-27 thd size by 3/8 in., sst		1	
		******			
-52	16955	. POINTER		1	

*May include 2 ea. shunts, magnet, part number 13313E

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-1-53	9059	. MASS		2	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Flat hd, 1/2-13 thd size by 2-1/4 in., sst		2	
		******			
	16801	. SUSPENSION ARM ASSY		1	
		(ATTACHING PARTS)			
-54	COML	. SCREW, CAP, SCH, 10-32 thd size by 1-5/8 in., sst		1	
-55	COML	. SCREW, CAP, SCH, 10-32 thd size by 1/2 in., sst		1	
-56	COML	. NUT, PLAIN, HEX., 10-32 thd size, sst		1	
-57	COML	. SCREW, CAP, SCH, 1/4-28 thd size by 7/8 in., sst		2	
-58	COML	. SCREW, SHOULDER, Sch, 0.5 shoulder length, 1/4-20 thd size by 15/16 in., sst		1	
		******			
-59	COML	. PIN, STRAIGHT, HEADLESS, 3/32 in. dia. by 3/8 in. lg, sst		2	
-60	9175	. . BASE, COIL		2	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 10-32 thd size by 5/8 in., sst		2	
		******			
-61	15940	. . COIL ASSY, 580 ± 20 ohms		2	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Flat hd, 2-56 thd size by 3/8 in., sst		8	
		******			
-62	16361	. . COIL HARNESS (Made from 70903 part no. 8484)		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 2-56 thd size by 1/4 in., sst		4	
	16792	. . CLAMP, CABLE		4	
		******			
-63	9174	. . MOUNT, COIL		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, CAP, SCH, 4-40 thd size by 3/8 in., sst		2	
		******			
-64	15943-2	. . TERMINAL BOARD ASSY		2	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 2-56 thd size by 5/8 in., sst		4	
	COML	. . WASHER, FLAT, No. 2, sst		4	
		******			
	COML	. . . SCREW, MACHINE, Pan hd, 2-56 thd size by 3/8 in., sst		4	
	16554	. . . CLAMP, TERMINAL		8	
	15941	. . . TERMINAL BOARD		1	
-65	10203	. . MOUNT, SLIDE		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, CAP, SCH, 10-32 thd size by 3/4 in., sst		2	
		******			

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-1-66	16327	. . PIVOT ASSY, UPPER (See figure 6-3 for breakdown)		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, CAP, SCH, 10-32 thd size by 3/4 in., sst		2	
		******			
-67	16325	. . PIVOT ASSY, LOWER (see figure 6-3 for breakdown)		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, CAP, SCH, 10-32 thd size by 5/8 in., sst		2	
		******			
-68	15945	. . SUSPENSION ARM		1	
-69	15936	. BASE, POST		1	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, SCH, 1/4-28 thd size by 1-1/4 in., sst		3	
		******			
-70	15935	. POST		1	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, SCH, 1/4-28 thd size by 7/8 in., sst		3	
		******			
-71	15824	. SCREW ASSY, LEVELING		3	
-72	4950	. NAMEPLATE		1	
-73	10076	. REMOTE CENTERING ACCESSORY (See figure 6-4 for breakdown)		1	
		(ATTACHING PARTS)			
	11466	. SCREW, HEX. (See figure 6-5)		Ref	
		******			
-74	10074	. MONITOR, MASS POSITION (See figure 6-5 for breakdown)		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Binder hd, 10-32 thd size by 3/8 in., sst		2	
		******			
-75	14587	. BASE		1	
	10391	. CALIBRATION JIG ASSY		1	
-76	10389	. . PLATE, ALIGNMENT		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 4-40 thd size by 1/4 in., sst		2	
		******			
-77	COML	. . WEIGHT, 200 mg		2	
	COML	. . THREAD, NYLON, Class C		AR	
-78	10390	. . SUSPENSION CAP		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 2-56 thd size by 3/8 in., sst		1	
		******			
-79	10388	. . BAR, CALIBRATION		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 4-40 thd size by 1/2 in., sst		1	
		******			

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-1-80	10387	. . BAR, CAP		1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Pan hd, 4-40 thd size by 3/8 in., sst		2	
		******			
		** All coml wire may be purchased from 70331 or 70903. Specify color when ordering.			
6-2-	17025	DESICCATOR BREATHER ASSY (See figure 6-1 for NHA)		Ref	
-1	COML	. JAR, MASON, Quart size, glass, standard mouth		1	
-2	17439	. GASKET		1	
-3	DESSICANT	. DESSICANT, ACTIVATED, 4-unit bags per MIL-D-3464	71762	2	
-4	MS20003-1	. INDICATOR, HUMIDITY	00334	1	
-5	COML	. TUBE, ALUMINUM, 3/8 in. OD by 0.022 in. wall thickness by 5-1/2 in. lg		1	
-6	266N	. UNION, PIPE TO PIPE, Female 3/8 by 1/4 in., nylon	30342	1	
-7	269N	. ELBOW, PIPE TO TUBE, Male, 3/8 by 1/4 in., nylon	30342	1	
-8	268N	. UNION, TUBE, Male, 3/8 by 1/4 in., nylon	30342	2	
-9	66PP	. TUBE, "TYGON", 3/8 in. OD	30342	AR	

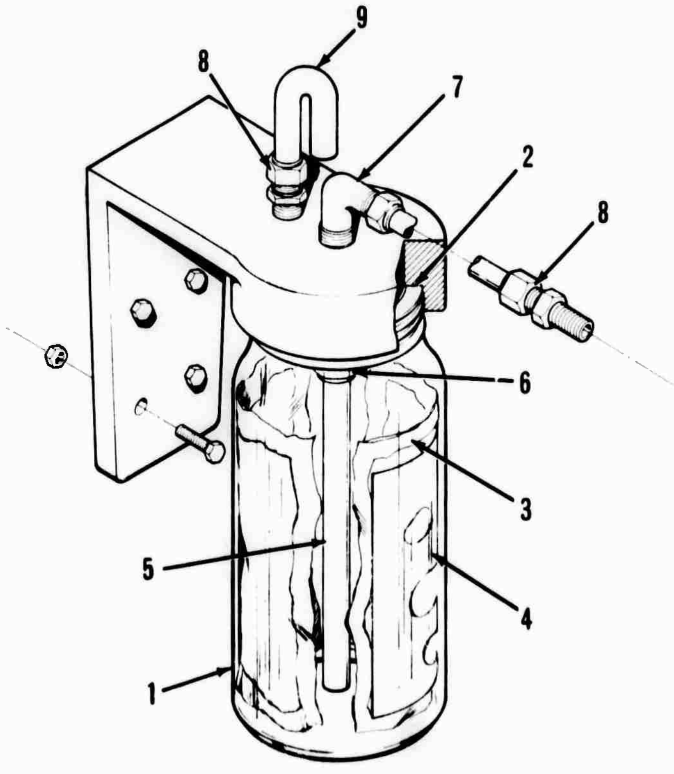


Figure 6-2. Disiccator Breather Assembly

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-2-10	17438	. TUBE, AIR		1	
-11	17235-2	. HOLDER, DESICCANT		1	
-12	COML	. SCREW, MACHINE, Hex. hd, 1/4-20 thd size by 3/4 in., sst		4	
-13	COML	. NUT, PLAIN, HEX., 1/4-20 thd size, sst		4	
6-3-	16327	PIVOT ASSY, UPPER (see figure 6-1 for NHA)		Ref	
-1	15739	. CLAMP, FLEXURE		2	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, SCH, 6-32 thd size by 5/16 in., sst		4	
		******			
-2	15738	. CLAMP, FLEXURE		2	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, SCH, 6-32 thd size by 5/16 in., sst		6	
		******			
-3	15757-3	. FLEXURE		2	
-4	15757-4	. FLEXURE		1	
-5	D4-375	. PIN, STRAIGHT, HEADLESS, 0.0938 in. dia by 3/8 in. lg	12139	6	
-6	15783	. BLOCK, UPPER FLEXURE		1	
-7	15784	. BLOCK, UPPER FLEXURE		1	
	16325	PIVOT ASSY, LOWER (See figure 6-1 for NHA)		Ref	
-8	COML	. SCREW, CAP, SCH, 4-40 thd size by 5/8 in., sst		2	
-9	COML	. NUT, PLAIN, HEX., 4-40 thd size, sst		2	
-10	9631-3	. BRACKET, FLEXURE		1	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, SCH, 2-56 thd size by 5/16 in., sst		2	
		******			
-11	9172	. BLOCK, CLAMPING		1	
-12	D4-375	. PIN, STRAIGHT, HEADLESS, 0.0938 in. dia by 3/8 in. lg	12139	2	
-13	15934	. PLATE, FLEXURE, Horizontal		2	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, SCH, 2-56 thd size by 5/16 in., sst		3	
		******			
-14	9172	. BLOCK, CLAMPING		1	
-15	16301	. BLOCK, FLEXURE, Horizontal		1	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, SCH, 5-40 thd size by 1/2 in., sst		2	
		******			
-16	D4-375	. PIN, STRAIGHT, HEADLESS, 0.0938 in. dia by 3/8 in. lg	12139	2	
-17	16299	. CLAMP, FLEXURE		2	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, SCH, 4-40 thd size by 5/16 in., sst		4	
		******			
-18	D4-375	. PIN, STRAIGHT, HEADLESS, 0.0938 in. dia by 3/8 in. lg	12139	2	
-19	15786	. BLOCK, LOWER FLEXURE, 50°		1	

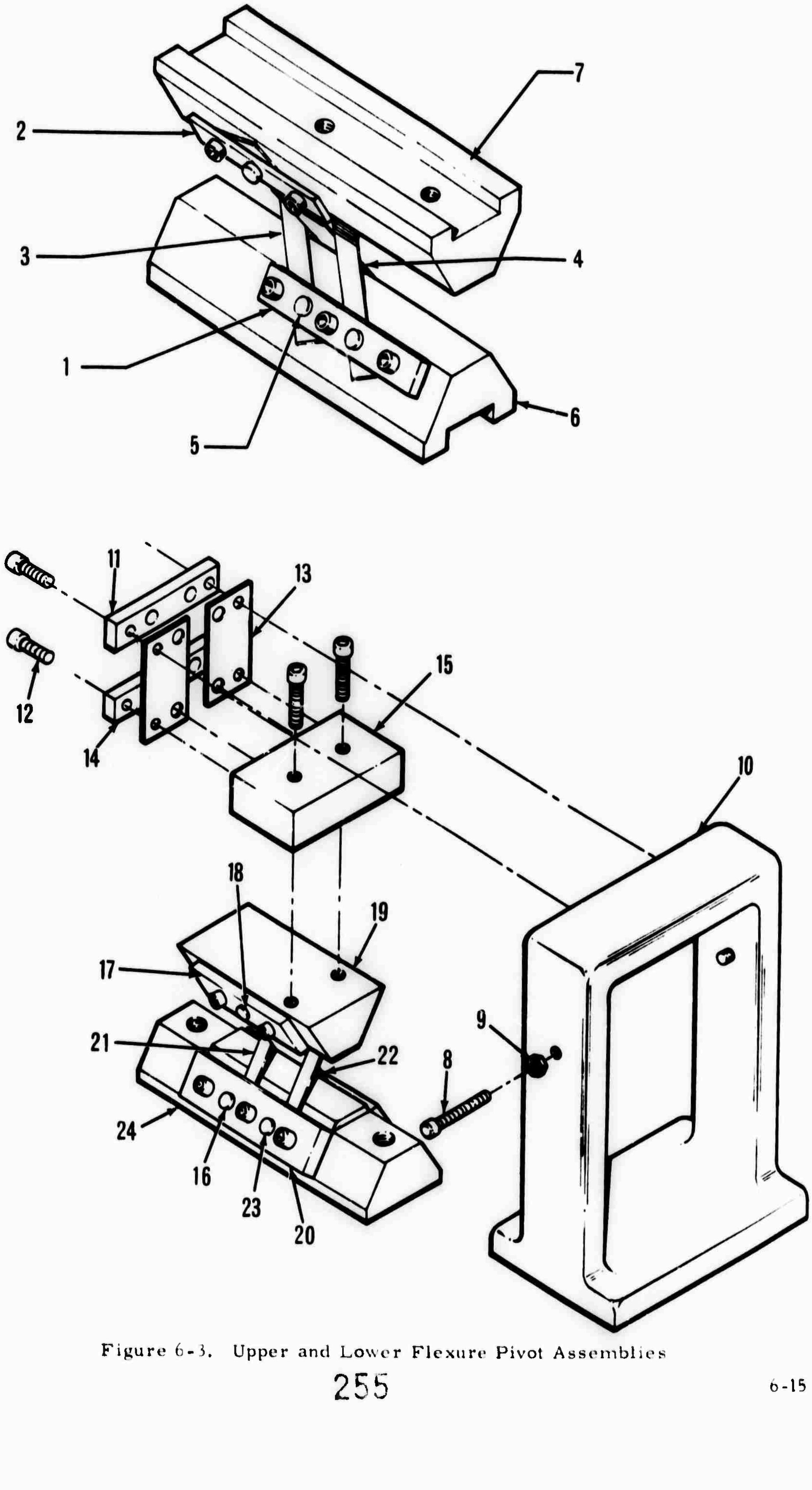


Figure 6-3. Upper and Lower Flexure Pivot Assemblies

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-3-20	16300	. CLAMP, FLEXURE		2	
		(ATTACHING PARTS)			
	COML	. SCREW, CAP, SCH, 4-40 thd size by 5/16 in., ost		6	
-21	15757-1	. FLEXURE		2	
-22	15757-2	. FLEXURE		1	
-23	D4-375	. PIN, STRAIGHT, HEADLESS, 0.0936 in. dia by 1/8 in. lg	12139	4	
-24	15765	. BLOCK, LOWER FLEXURE, 60°		1	
6-4-	10076	REMOTE CENTERING ACCESSORY (See figure 6-1 for next higher assembly)		Ref	
-1	SCB-1114-2	. CATCH	90003	2	
		(ATTACHING PARTS)			
	COML	. NUT, PLAIN, HEX., 4-40 thd size, ost		4	
	COML	. WASHER, LOCK, Int tooth, no. 4, ost		4	
	COML	. SCREW, MACHINE, Binder hd, 4-40 thd size by 3/16 in., ost		4	
		******			
	11703	. TERMINAL BOARD ASSY		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Binder hd, 4-40 thd size by 1/4 in., ost		2	
	COML	. WASHER, LOCK, Int tooth, no. 4, ost		2	
		******			

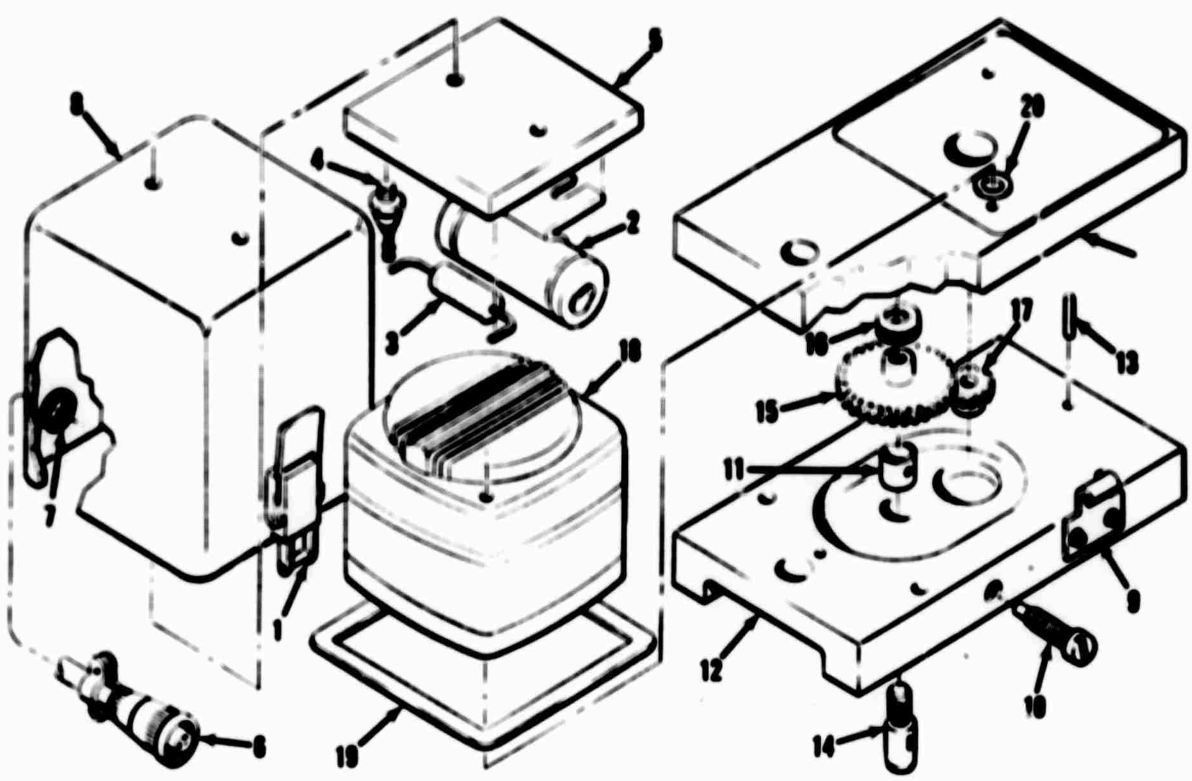


Figure 6-4. Remote Centering Accessory

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR. CODE	UNITS PER ASSY	USABLE ON CODE
6-4-2	P89D679	. . CAPACITOR, 0.85 uf, 220 vac	71753	1	
		(ATTACHING PARTS)			
	COML	. . SCREW, MACHINE, Binder hd, 10-32 thd size by 1/4 in., sst		1	
		******			
-3	RC42GF351J	. . RESISTOR, FIXED, COMPOSITION, 350 Ohm, 2W, ± 5%		1	
-4	1418B	. . TERMINAL	80245	3	
-5	11702	. . TERMINAL BOARD		1	
	11710	. HARNESS ASSY		1	
-6	PC06A8-3S	. . CONNECTOR, PLUG, ELECTRICAL	77820	1	
	PVC105-5	. . TUBING, PLASTIC		AR	
	**COML	. . WIRE, ELECTRICAL, Tinned copper, awg 24, strd 7/32 0.010 polyvinylchloride ins, 600V, temp rtng -55°C, + 105°C		AR	
-7	1041C	. GROMMET, RUBBER	72653	1	
-8	11461	. COVER, Motor		1	
-9	SCB179266	. STRIKE	96003	2	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Binder hd, 4-40 thd size by 3/8 in., sst		4	
	COML	. WASHER, LOCK, Int tooth, no. 4, sst		4	
		******			
-10	11462	. SCREW, LOCK, Fillister hd, 10-32 thd size by 1/4 in., sst		1	
-11	11465	. BEARING (Altrd from 77820 part no. B85-4)		1	
-12	11459	. COVER, Base		1	
		(ATTACHING PARTS)			
	COML	. SCREW, MACHINE, Flat hd, 10-32 thd size by 1 in., sst		4	
		******			
-13	D1-500	. PIN, STRAIGHT, HEADLESS	12139	2	
-14	11464	. FOOT, Remote leveling		1	
-15	11467	. GEAR, Threaded (Altrd from 12139 part no. G1-80)		1	
-16	A010	. BEARING, THRUST	71041	1	
-17	G1-32	. GEAR	12139	1	
-18	12782	. MOTOR, 0.7 Rpm (Altrd from 07829 part no. B8262E1800C)		1	
-19	11468	. GASKET		1	
-20	COML	. WASHER, FLAT, 1/2 in. OD x 3/16 in. ID x 1/32 thk, sst		2	
-21	COML	. SCREW, MACHINE, HEX., socket hd, 3/8-24 thd size by 1/2 in., flat point, sst		1	
-22	16187	. SPRING		1	
-23	16159	. PISTON		1	
-24	11466	. SCREW, HEX		1	
-25	11460	. BASE, Motor		1	

** All coml wire may be purchased from 70331 or 70903. Specify color when ordering.

FIG. & INDEX NO.	PART NUMBER	DESCRIPTION 1 2 3 4 5 6 7	MFR CODE	UNITS PER ASSY	USABLE ON CODE
6-5-	10074	MASS POSITION MONITOR (See figure 6-1 for next higher assembly)		Ref	
-1	PVC105-8	. TUBING, PLASTIC	70331	AR	
-2	PVC105-5	. TUBING, PLASTIC	70331	AR	
	10765	. PHOTO-RESISTOR BRIDGE ASSY		1	
-3	10776	. . COVER		1	
-4	RC20GF153J	. . RESISTOR, FIXED, COMPOSITION, 15K, 1/4W, ± 5%		2	
-5	CTC2041C	. . TERMINAL	71279	4	
-6	CL603	. . PHOTO RESISTOR	03911	2	
-7	10769	. . HOUSING		1	
	**COML	. . WIRE, ELECTRICAL, Tinned copper, awg 26, strd 7/34, 0.010 polyvinylchloride ins. 600V, temp rtng -55°C, + 105°C		AR	
	10766	. LAMP AND HOUSING ASSY		1	
-8	H310F	. . PLUG, Hole	72653	1	
-9	10768	. . RING		1	
-10	12	. . BULB	24455	1	
-11	1K5742	. . SOCKET	03797	1	
-12	10767	. . HOUSING		1	
	PVC105-8	. . TUBING, PLASTIC	70331	AR	
	**COML	. . WIRE, ELECTRICAL, Tinned copper, awg 26, strd 7/34, 0.010 polyvinylchloride ins. 600V, temp rtng -55°C, + 105°C		AR	
	10770	. BASE ASSY		1	
-13	91	. . CLIP	11503	2	
-14	10772	. . SUPPORT		1	
-15	10771	. . PLATE		1	

** All coml wire may be purchased from 70331 or 70903. Specify color when ordering.

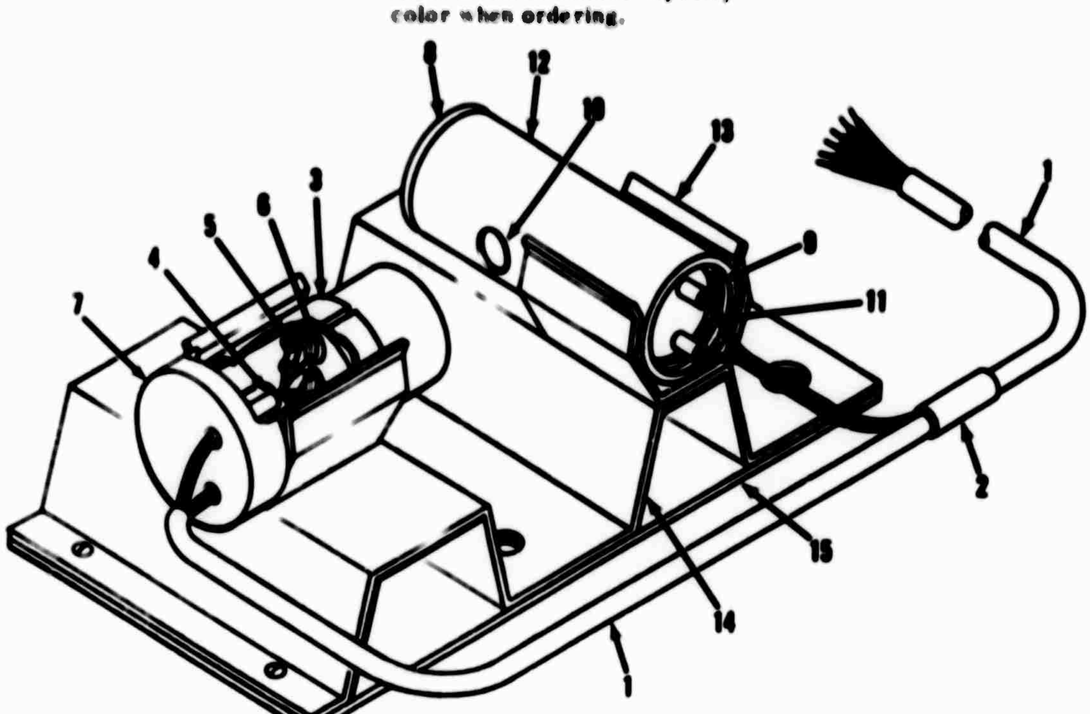


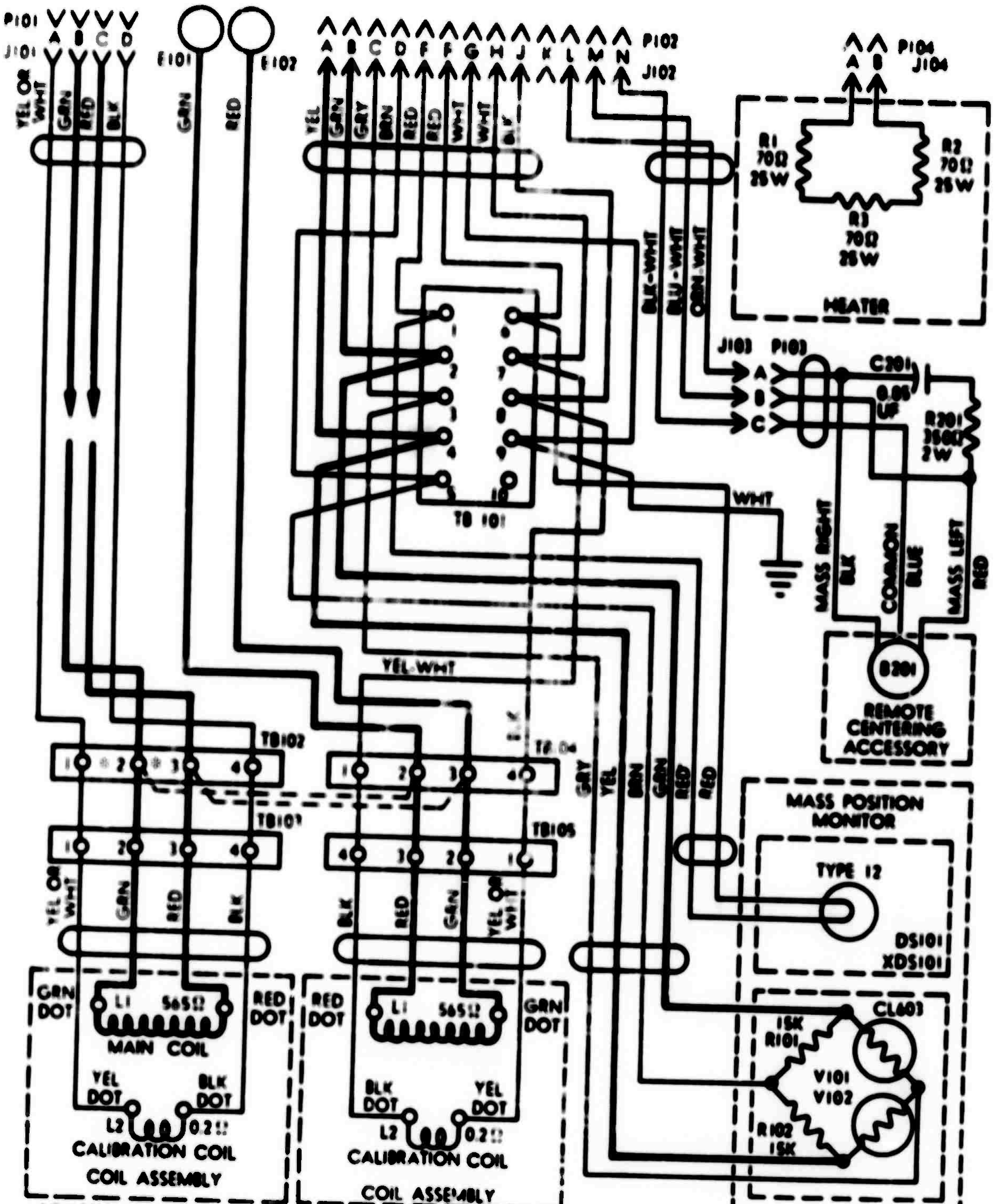
Figure 6-5. Mass Position Monitor

CHAPTER 7

CIRCUIT DIAGRAMS

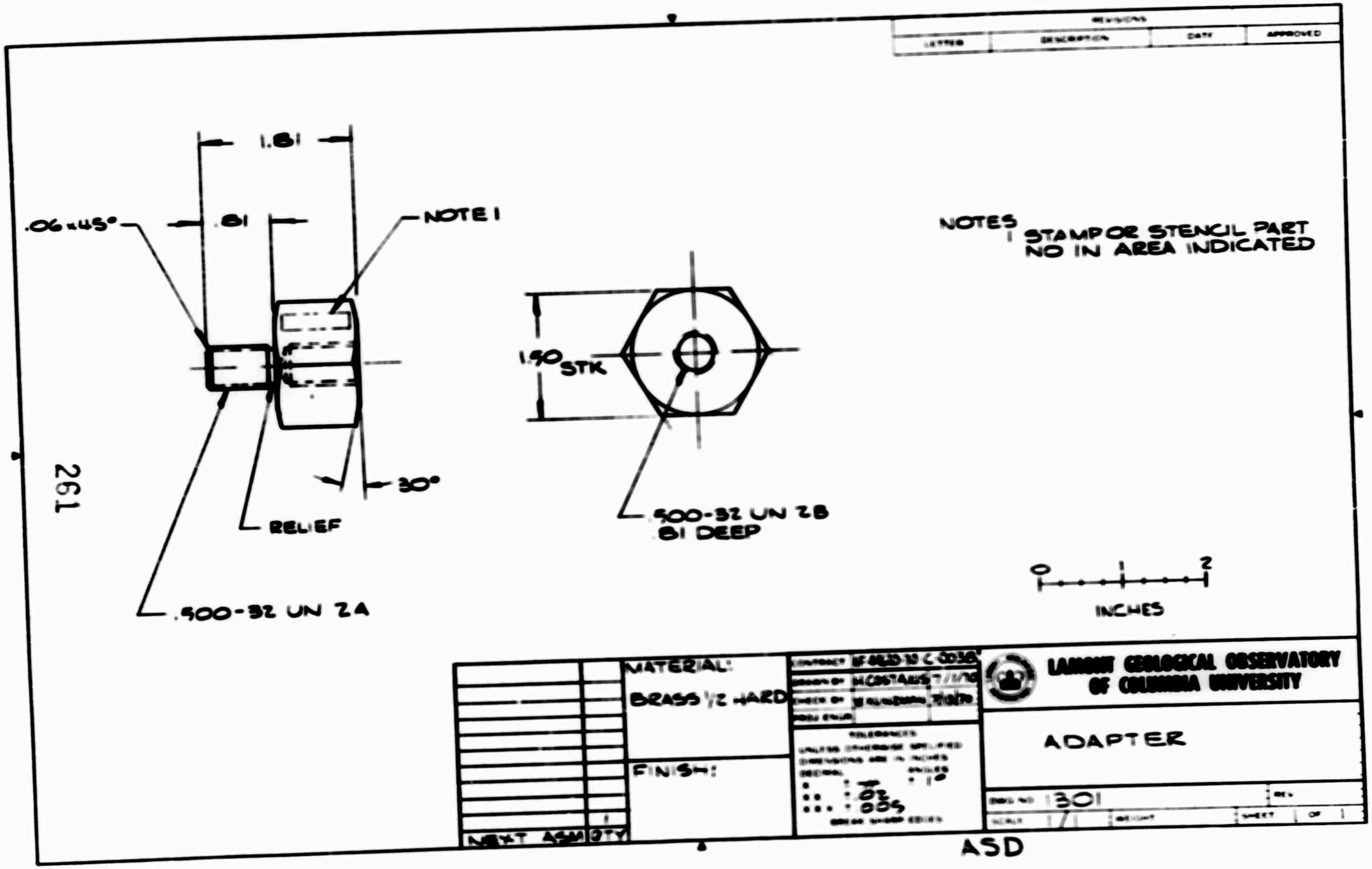
7-1. INTRODUCTION. This chapter contains the schematic diagram of the Seismometer.

259



*CONNECTIONS FOR PARALLEL DATA COILS

Figure 7-1. Schematic Diagram


REVISIONS
LETTER
DESCRIPTION
DATE
APPROVED
1.81
.06 x 45°
.81
NOTE 1
1.50 STK
NOTES
1 STAMP OR STENCIL PART NO IN AREA INDICATED
30°
RELIEF
.500-32 UN 2A
.500-32 UN 2B
.81 DEEP
0
1
2
INCHES
MATERIAL:
BRASS 1/2 HARD
FINISH:
NEXT ASM
QTY
LAMONT GEOLOGICAL OBSERVATORY
OF COLUMBIA UNIVERSITY
ADAPTER
1301
1/1
ASD

SPRENGNETHER MODEL S-5018

REMOTE CENTERING CONTROL

MODIFIED FOR USE WITH THE

GEOTECH S-12 LONG PERIOD HORIZONTAL SEISMOMETER

Specifications:

Total Wedge Excursion	=	2 Inches
Taper	=	0.004 In/In
Total Vertical Displacement	=	0.01 Inch
Total Tilt	=	180 Sec of Arc
Tilt Control	=	2.25 Sec Arc/Turn
Adjusting Rate	=	1 RPM
	=	2.25 Sec Arc/Min

Power:

Voltage	=	12 VDC
Current	=	Approx. 40MADC
Weight	=	8-1/2 Lbs.

Installation Instructions:

The unit is shipped bolted to a wooden block.

Retain shipping assembly including bolts and nuts in case of future shipping requirements.

The stainless steel washers are to be used when securing the unit on the seismometer.

Unpack the two mounting bolts.

Place seismometer in final location on pier and raise it onto wooden blocks with the two front leveling screws free.

Remove both front leveling screws.

Install the centering control unit with the motor projecting to the right and the wedge position scale visible from the front. Secure with the special bolts provided. These bolts mate into the seismometer leveling screw holes.

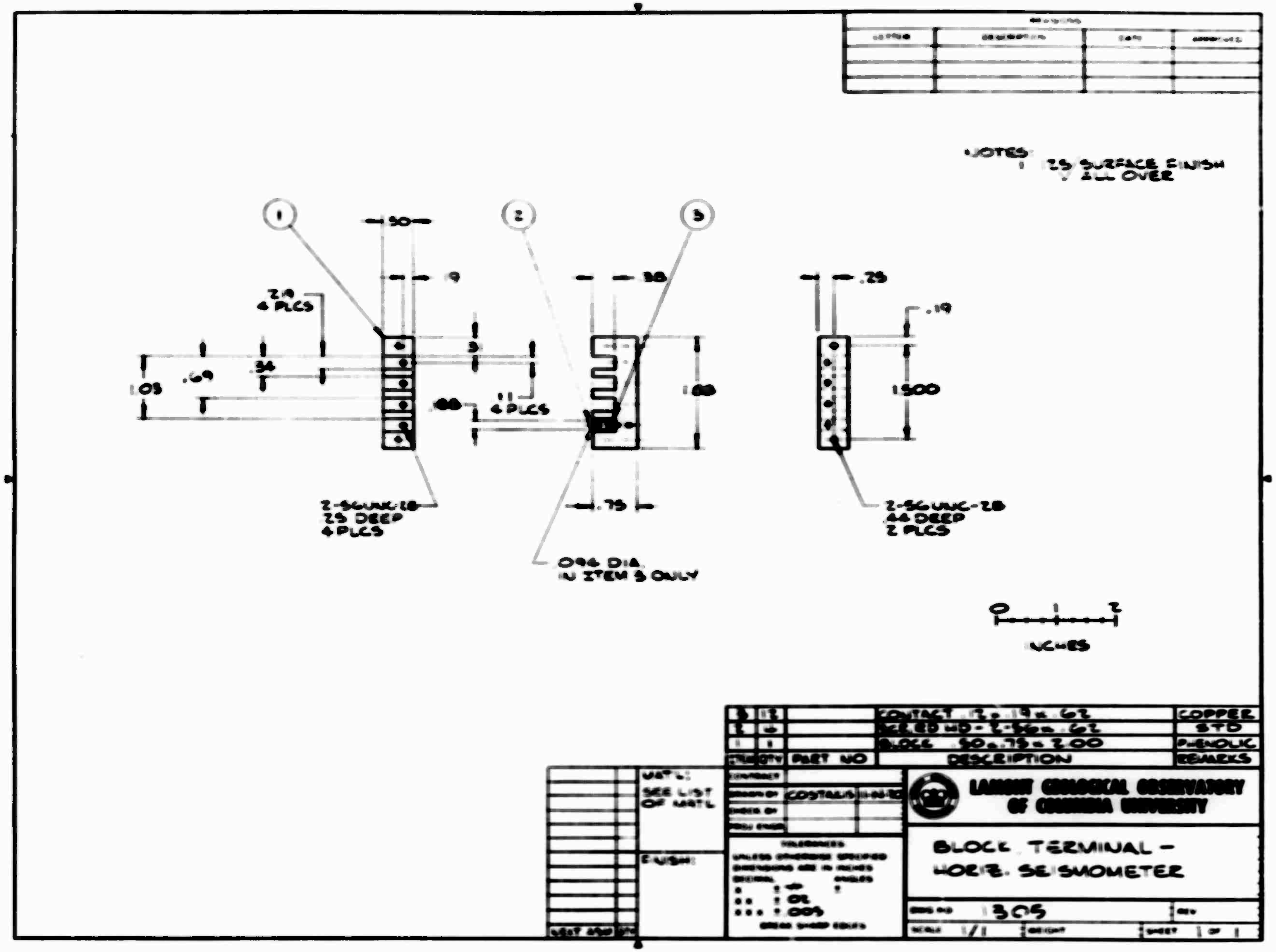
Thread one of the leveling screws into the hole provided at the lower left end of the unit.

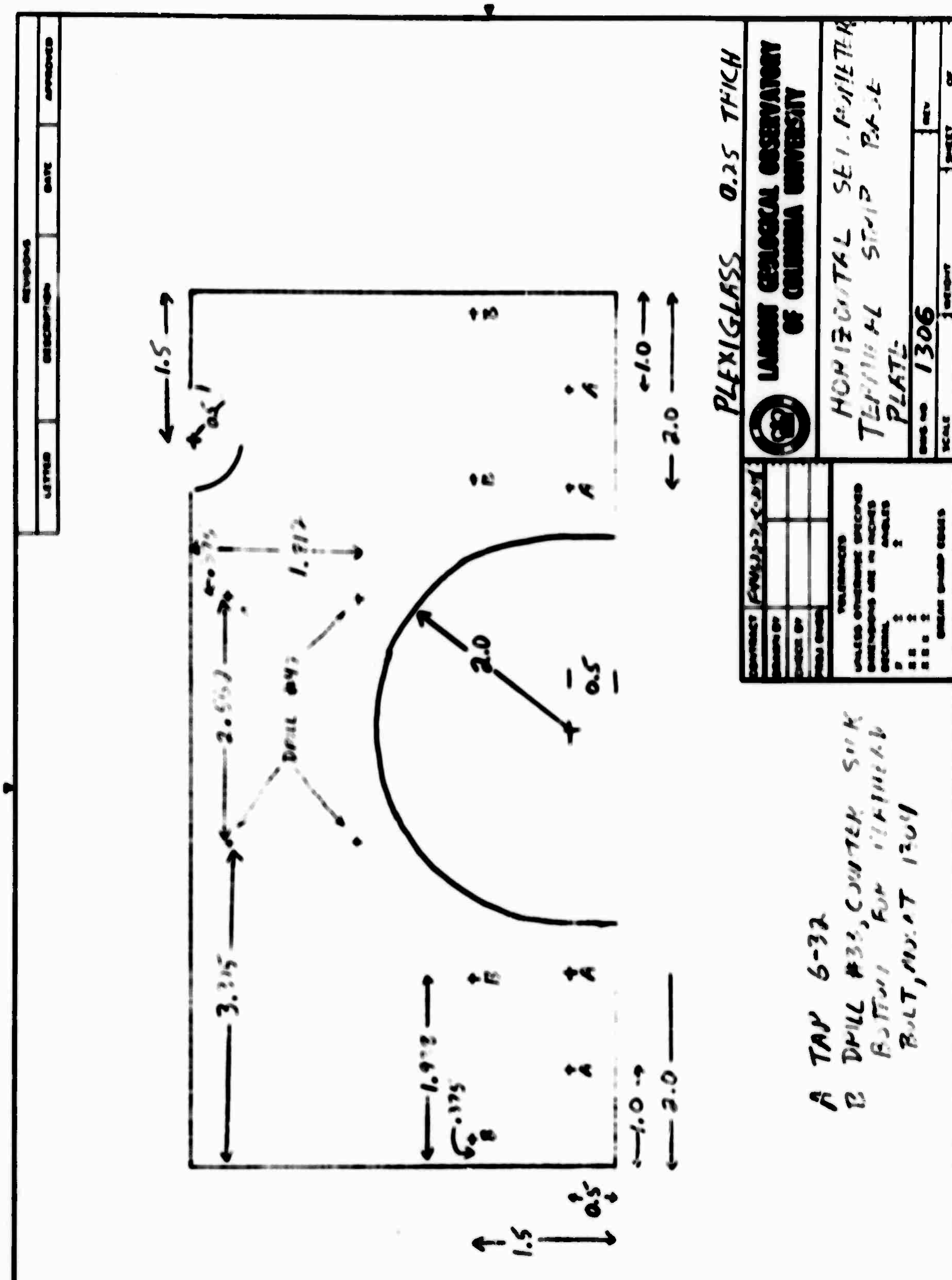
Lower the seismometer gently to final position on the pier.

CAUTION: Excessive stress or shock will damage or distort the inclined surface or the wedge contact faces, thereby destroying linearity and producing an erratic motion characteristic. Place a one inch thick metal block under the rear leveling screw to compensate for the thickness of the centering unit.

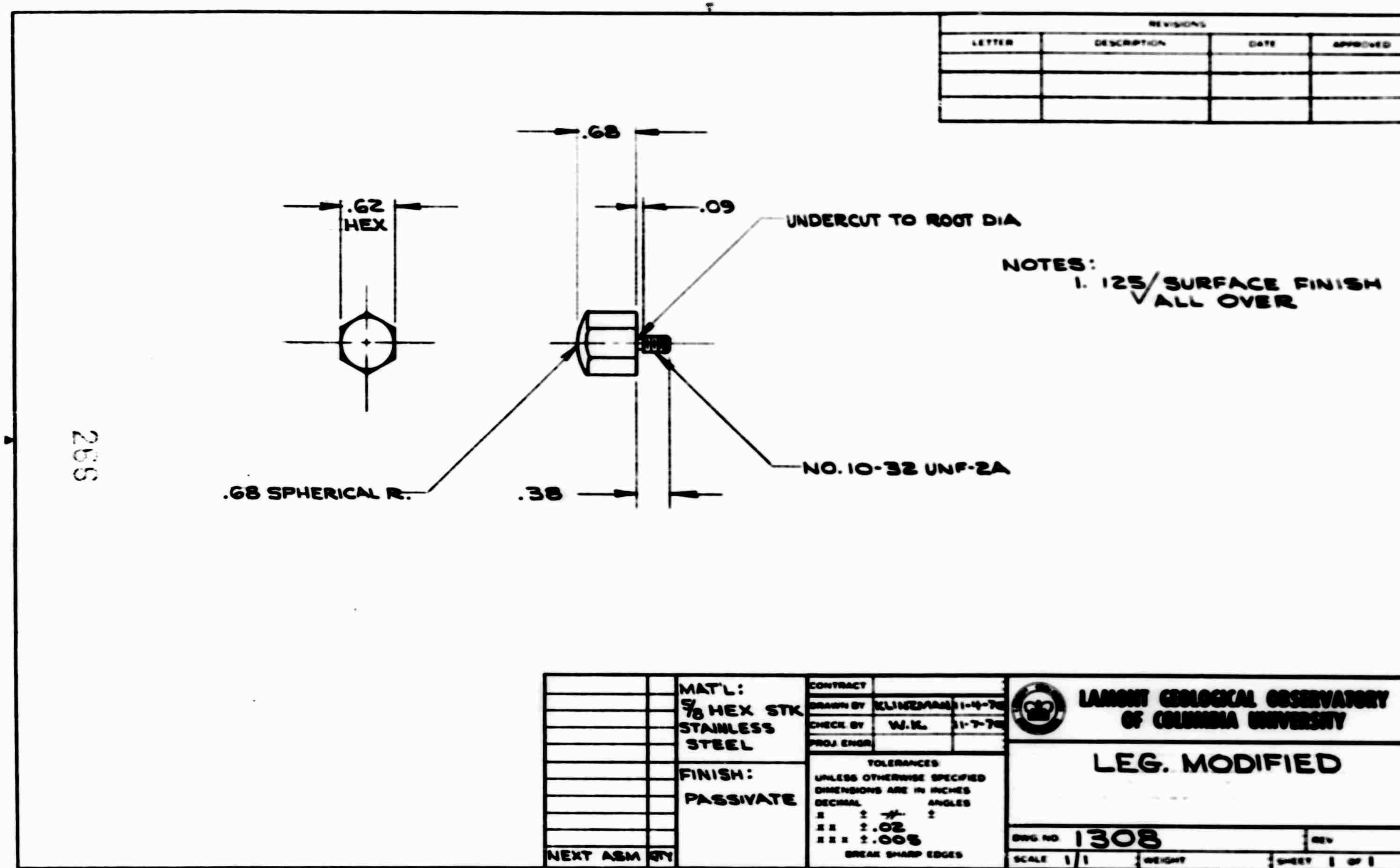
The motor requires 12 volts, DC power. The drive is approximately one RPM, with a total wedge excursion of ± one inch which requires approximately 40 minutes travel time to either end from a center position.

CAUTION: If the wedge is permitted to travel until it jams against the stop, the drive gear will be damaged. Therefore, during remote operation, it is necessary to keep a continuous log of (±) wedge travel.


NOTES:
1. 25 SURFACE FINISH ALL OVER
.50
.19
.219 4 PLCS
.34
.69
1.03
.11 4 PLCS
.188
.38
1.88
.25
.19
1.500
.75
2-56UNC-2B .25 DEEP 4 PLCS
.094 DIA. IN ITEM 3 ONLY
2-56UNC-2B .44 DEEP 2 PLCS
0 1 2
INCHES
CONTACT .12 x .19 x .62 COPPER
SCREW HD - 2-56 x .62 STD
BLOCK .50 x .75 x 2.00 PHENOLIC
QTY PART NO DESCRIPTION REMARKS
MAT'L: SEE LIST OF MAT'L
FINISH:
COSTAKIS
TOLERANCES
.X ±.03 .XX ±.01 .XXX ±.005
LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY
BLOCK TERMINAL - HORIZ. SEISMOMETER
DWG NO 1305
SCALE 1/1
SHEET 1 OF 1



NOT REPRODUCIBLE


REVISIONS
LETTER
DESCRIPTION
DATE
APPROVED
.68
.62
HEX
.09
UNDERCUT TO ROOT DIA
NOTES:
1. 125/SURFACE FINISH
ALL OVER
NO. 10-32 UNF-2A
.68 SPHERICAL R.
.38
MAT'L:
5/8 HEX STK
STAINLESS
STEEL
FINISH:
PASSIVATE
NEXT ASM
QTY
CONTRACT
DRAWN BY
KLINEDMAN
CHECK BY
W.K.
PROJ ENGR
TOLERANCES
UNLESS OTHERWISE SPECIFIED
DIMENSIONS ARE IN INCHES
DECIMAL
ANGLES
.XX ±.02
.XXX ±.005
BREAK SHARP EDGES
LAMONT GEOLOGICAL OBSERVATORY
OF COLUMBIA UNIVERSITY
LEG. MODIFIED
DWG NO 1308
REV
SCALE 1/1
WEIGHT
SHEET 1 OF 1

2100-1

M-5240B

OPERATION AND MAINTENANCE MANUAL

PHOTOTUBE AMPLIFIER, MODEL 5240B

GEOTECH
A TELEDYNE COMPANY
3401 Shiloh Road
Garland, Texas

15 April 1967

BLANK PAGE

CONTENTS

268

CONTENTS, Continued

ILLUSTRATIONS

BLANK PAGE

OPERATION AND MAINTENANCE MANUAL

PHOTOTUBE AMPLIFIER, MODEL 5240B

1. GENERAL INFORMATION

1.1 PURPOSE OF THE EQUIPMENT

The Phototube Amplifier, Model 5240B, is a galvanometer-phototube amplifier designed to amplify very low-level voltages or currents in the long-period region of the seismic spectrum.

1.2 DESCRIPTION OF THE EQUIPMENT

1.2.1 Special features of this amplifier include a sealed optical-photoelectric assembly, separate power supply, low-power consumption, and ability to operate for long periods unattended except for centering of the galvanometer.

1.2.2 Figure 1 is a front view of the Phototube Amplifier, Model 5240B, the Power Supply, Model 4304, and connecting cables. The sealed amplifier must be mounted on a concrete pier isolated from local disturbing vibrations in order to obtain low-noise levels. The power supply can be located separately to avoid transmission of power-line frequency vibrations to the galvanometer or to the associated optical components.

1.2.3 The ESD GL261 galvanometer and a variety of plug-in filter components are offered by the Geotech Division of Teledyne Industries, for use in the amplifier. The information contained in this manual applies to amplifiers equipped with the GL261 galvanometer and a bandpass filter with half-power points at 0.001 Hz and 0.04 Hz. Supplementary information is included when special galvanometer-filter combinations are shipped. Figure 2 shows the galvanometer frequency response for various values of damping.

1.3 SPECIFICATIONS

Input:	Direct input to galvanometer.
Output:	Single-ended referenced to dummy cathode follower. Maximum linear output - 30 volts peak-to-peak into an open circuit; 16 volts into 10K ohms (recommended minimum load resistance for negligible loss in gain). Cathode-follower output impedance less than 1000 ohms. Will drive HELICORDER Amplifier, Model 4983, plus galvanometer in Film Recorder, Model 1301A, and certain galvanometers in the DEVELOCORDER, Model 4000.

Figure 1. Phototube Amplifier, Model 5240B, Power Supply, Model 4304, and connecting cables, front view

G 2503

272

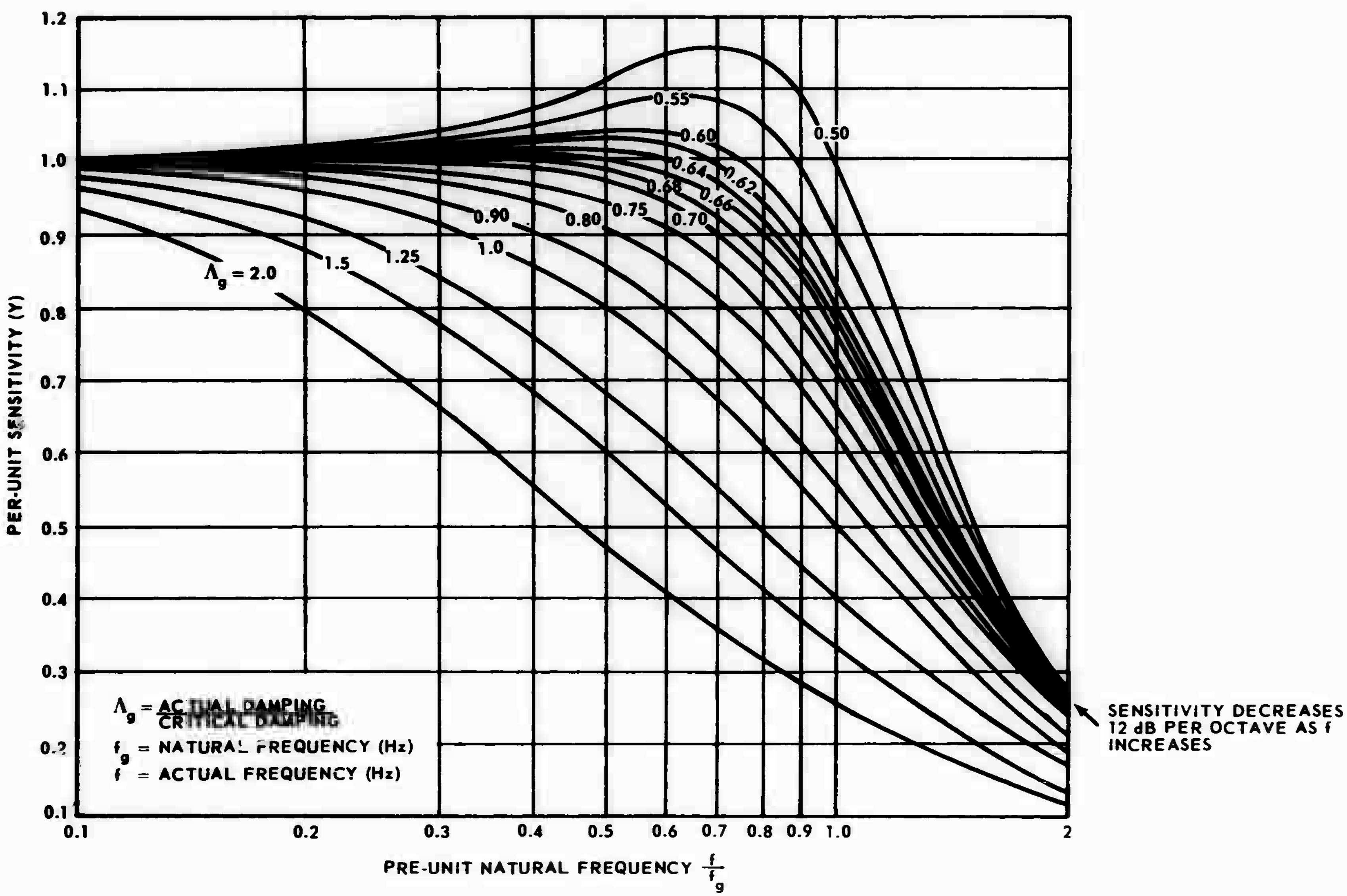


Figure 2. Galvanometer sensitivity vs per-unit natural frequency for several values of damping

G 2504

273

Gain: From 750K to 4 million, depending on the galvanometer used.

$$\text{gain} = \text{approx} \frac{0.5}{\text{galvo sensitivity in amperes/mm at 1 m} \times \text{coil resistance}}$$

$$\text{or} \quad \frac{500}{\text{galvo sensitivity in V/rod}}$$

Noise level: As low as 5 mV peak-to-peak at output depending on seismic motion at installation and galvanometer installed.

Hum: 1.5 mV peak-to-peak at output.

Dynamic range: Will be at least 60 dB from noise level to clipping level.

Linearity: ±2% from noise level to 80% of clipping level. (Based on the best straight line with 0.01 Hz sinusoidal signal.)

Temperature: Will operate within 40° to 100°F.

Humidity: Will operate within above specifications from 20% to 99% relative humidity.

Adjustments: Will operate within above specifications with adjustments at intervals of not less than 6 months except for centering of the galvanometer.

Power: Operates on 115 volts, 50-400 Hz. Power required is less than 7 watts at 115 volts, 60 Hz.

Power line variation: A change of ±10% in supply voltage outside the passband will produce a change in gain not greater than 2%.

Size and weight: The power supply is 5" by 9-1/2" by 10" and weighs 9 pounds. The phototube amplifier is 11-1/2" by 20" by 18-1/2" and weighs 50 pounds.

Shipping weight: Approximately 80 pounds.

1.4 EQUIPMENT SUPPLIED

1.4.1 Standard

1 Phototube Amplifier, Model 5240B, with Galvanometer, Model GL261
1 Power Supply, Model 4304
1 Filter, White Instrument Labs. No. 1452 (cutoff frequencies .001 Hz and .04 Hz)
1 Power Supply Cable, No. 5126A
1 A C Power Cord, Belden No. 12293

2 Desiccant, Eagle Chemical Co. No. 852, 4-unit bag, sealed.
1 Operation and Maintenance Manual

1.4.2 Optional

Galvanometer, Model GL261, can be supplied with undamped natural frequency from 0.01 to 0.033 Hz (100-30 sec period)
Filters, to customer's requirements. Range of bandpass frequencies is .0004 Hz to 10 Hz.

2. INSTALLATION

2.1 UNPACKING

The Phototube Amplifier, Model 5240B, the GL261 galvanometer, and the Power Supply, Model 4304, are packaged separately. Amplifier, power supply, and the accessories are packed together in a heavy carton for shipment. After the amplifier and power supply have been unpacked, they should be examined carefully. A report should be made immediately of any damage noted or any missing part or component.

2.2 INITIAL SETUP

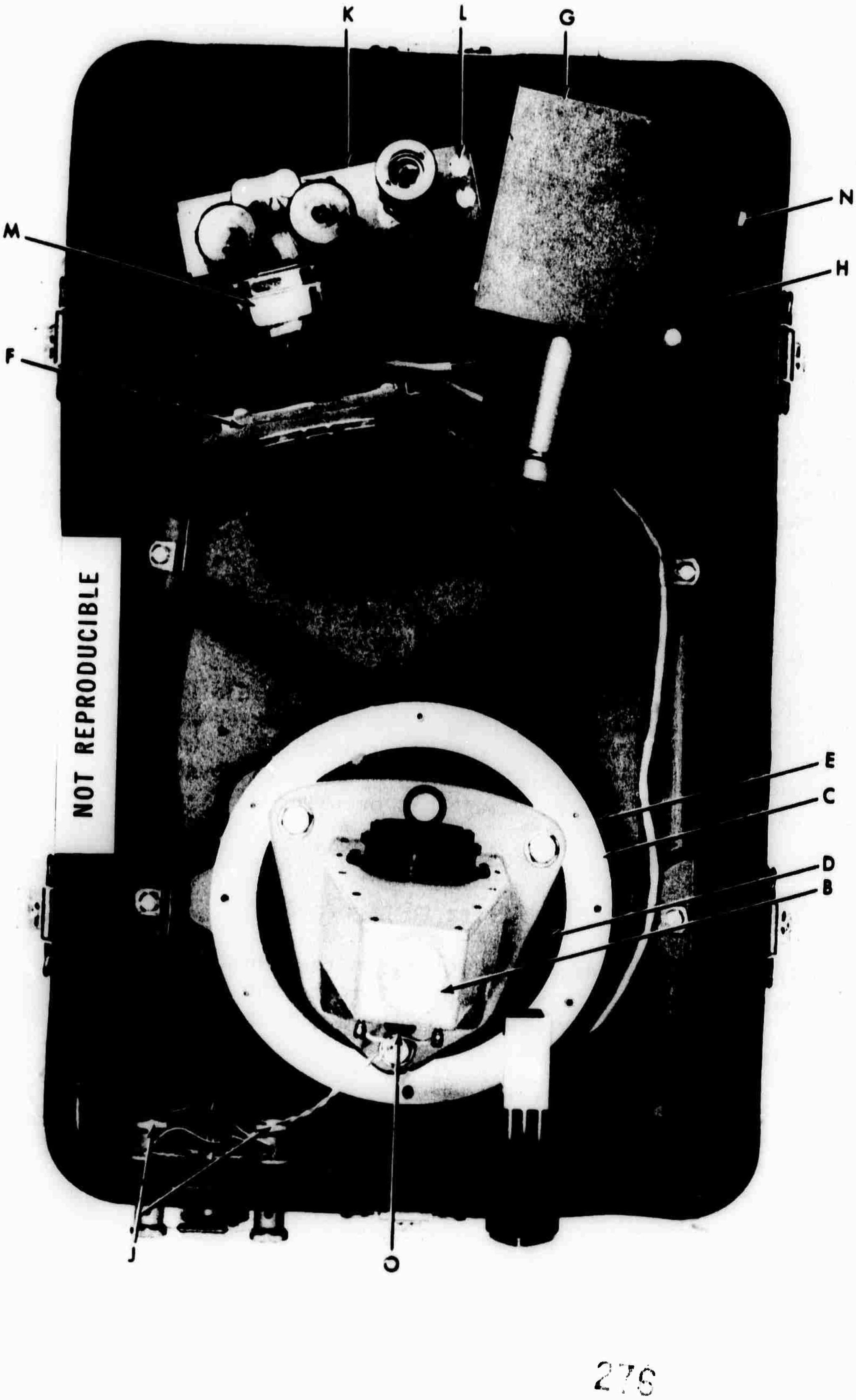
Remove the top cover from the power supply and plug the filter into the 11-pin octal-style socket. See than V201 and V202 are plugged in securely and replace the cover. Remove the top cover from the amplifier (figure 3). Be careful not to damage the gasket. If possible, avoid opening the case in a moist atmosphere. Check the parts to see that no damage has occurred and that all components are secure.

2.3 GALVANOMETER INSTALLATION (Refer to figure 3)

2.3.1 To install the Galvanometer, GL261 in the amplifier, check to ensure that the galvanometer suspension is locked by turning the knurled coil lock (O) clockwise. Install the galvanometer on the galvanometer base (D), using the mounting bolts furnished.

At the base of the installed galvanometer, check to ensure that the brass zero-adjust drive gear is mounted on its shaft and can be turned with the fingers. If the gear cannot be turned, loosen the hold-down ring by backing the ring-mounting screws 1/8 turn from the "tight" position.

2.3.2 The right-angle drive (A) of the external zero-adjust is attached to the drive gear by a two-axis coupling. The alignment of the right-angle drive axis and the drive gear shaft is not critical and can be easily adjusted by loosening the set screws holding the dowel pins.



278

Figure 3. Top view of Phototube Amplifier, Model 5240B, with cover removed

G 2505

CAUTION

Do not touch any lens, exciter light, or phototube glass with the fingers. Chemical deposits on these surfaces may cause improper operation of the amplifier.

2.4 AMPLIFIER INSTALLATION

2.4.1 The mounting surface for the amplifier should be carefully selected. The sealed case must be located on a concrete pier or other massive structure. The structure must be free from vibrations whose frequencies fall within the band of interest. Strong vibrations outside the band may excite the galvanometer and cause noise within its passband. The feet on the sealed case also serve as leveling screws. A bubble level is provided on the galvanometer base. When the amplifier has been placed in the desired position, it should be leveled by adjusting the feet on the case before the cover is replaced on the sealed section.

2.4.2 Unlock the galvanometer suspension by turning the knurled coil in a counterclockwise direction (viewing the galvanometer from the back). The galvanometer suspension should be unlocked only when the amplifier is ready for use. The galvanometer suspension can be locked by turning the knurled coil lock in a clockwise direction. Remove the two desiccant bags from the sealed envelope and place loosely in the bottom of the amplifier case. Replace the cover carefully by seating it on the gasket in the same position as received.

2.4.3 The power supply can be mounted in any convenient location within the range of the connecting power cable. Avoid placing the power supply in such a position that it will transmit vibrations to the amplifier. The location selected should be free from dampness, drafts of air, or radical changes in temperature. If the location is subject to sudden temperature changes because of diurnal or meteorological effects, it is recommended that an insulated housing be provided for the amplifier and power supply. The amplifier and power supply should not be located near heating or air conditioning outlets or machines where temperature is controlled by cycling.

2.5 ELECTRICAL CONNECTIONS

Figure 4 is a block diagram of the phototube amplifier showing all necessary connections and cables.

2.5.1 Signal Input

The input cable is not supplied as part of the equipment. The input connectors are made of solid copper in order to reduce thermoelectric potentials. The internal input circuit is of all-copper construction. The cable should be twisted-pair signal wire with high-quality insulation. The minimum conductor size should be 24 gauge. The external galvanometer-damping resistor should be mounted directly on the copper input terminals. Make certain that all copper

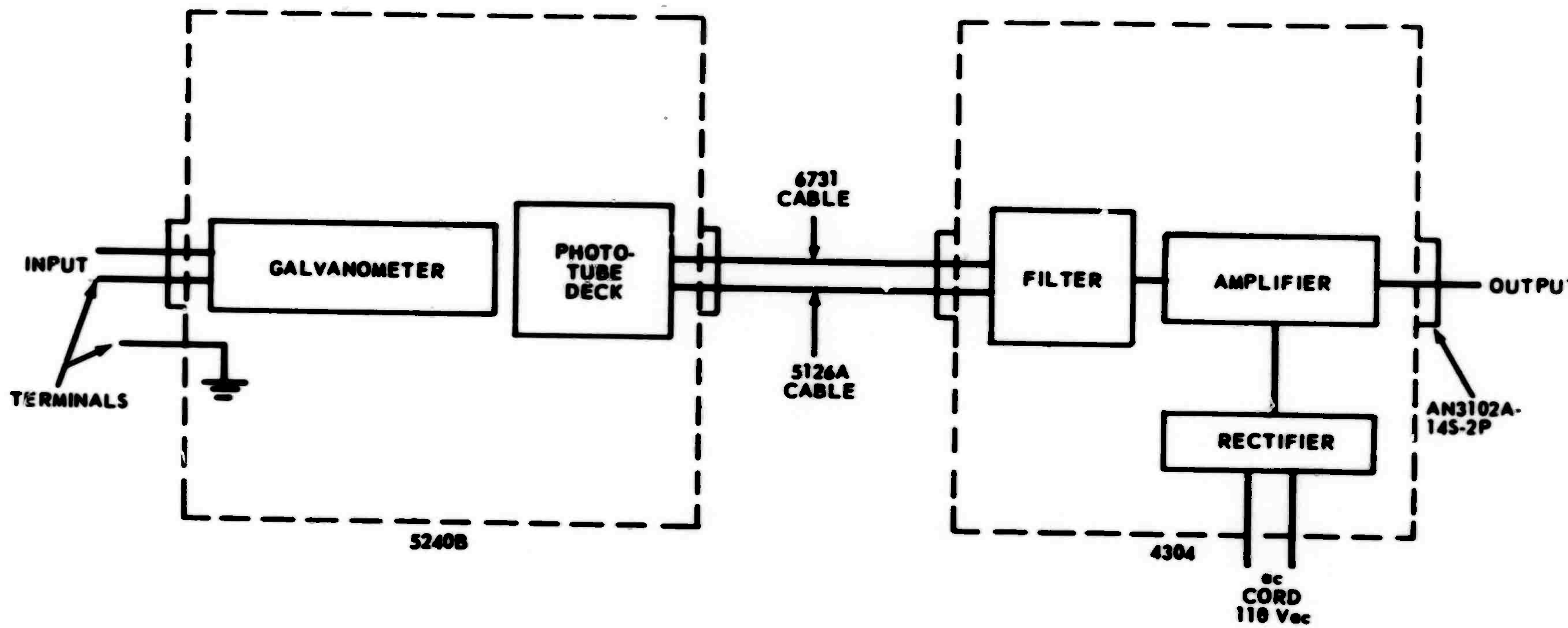


Figure 4. Phototube amplifier system, block diagram

G 2506

conductors, binding posts, and connections are free of corrosion and exhibit a clean and bright appearance. If the input cable is to be subjected to varying electrostatic fields, shielding should be used. If large ground currents exist between the locations of the amplifier and the signal source, the shield should be grounded at one end only. (Most power lines depend on ground conductance for part of their return circuit.) It may be necessary to determine by experiment where shields should be grounded.

2.5.2 Power Supply Cable

The cable (Geotech No. 5126A) which connects the amplifier to its power supply is furnished by the manufacturer. Extension of this cable is permissible, if required, but such extension should be limited to 25 feet. If an extension of more than 25 feet is required, consult Geotech. Use care in routing to avoid pickup from disturbing electrical sources.

2.5.3 A-C Cord

All models are furnished with an A-C Power Cord, Belden No. 12293, (or equivalent). Good regulation of the voltage supplied to the amplifier will insure best operating results. (See paragraph 1.3 for Specifications.)

2.5.4 Output Connections

J203 and J204 are wired in parallel inside the power-supply chassis. Either of these connectors can be used for the output. The other is used for connection to test equipment or to auxiliary recording apparatus. When it is desired to connect to the input of power amplifiers or recorders whose terminals are balanced to ground, pins A and D should be used. If an unbalanced grounded output is desired, connect pins B, C, and D, to the grounded conductor. Observe the shielding practices outlined in paragraph 2.5.1.

2.6 STORAGE

The amplifier case, when sealed, is waterproof and dustproof. During storage the amplifier case should be closed, all cable receptacles covered with dust covers, and the galvanometer terminals shorted together for protection of the galvanometer.

3. OPERATION

3.1 IDENTIFICATION OF CONTROLS AND INDICATORS

3.1.1 POWER Switch

S201 is a toggle switch located on the power-supply chassis.

3.1.2 ZERO ADJUST Control

R205 is used to zero the output voltage from cathode-to-cathode of V201 under zero-signal conditions. This control is provided with a lock.

3.1.3 Galvanometer Zero (See figure 3)

Two mechanical adjustments are provided for centering the galvanometer. An internal adjustment (B) mounted on the galvanometer top rotates the galvanometer suspension and mirror within the galvanometer case and is used for coarse adjustments. An external adjustment (A) mounted on the amplifier case rotates the galvanometer base and is used for fine adjustments after the amplifier cover has been installed.

3.2 ADJUSTMENT

After the installation has been completed and all connections have been made, adjust the amplifier as follows:

a. Terminate the galvanometer with its CDRX (external critical damping resistance) or a resistor of approximately that value.

b. Set the external galvanometer zero in the center of its adjustment range.

c. Remove the amplifier cover.

d. Turn on the power switch and watch for any indications of improper operation.

e. Adjust the internal galvanometer zero until the light beam is centered on the splitter lens. Use a small card behind the splitter lens to observe the light position.

f. Replace the cover carefully by seating it on the gasket in the same position as received.

g. Connect a VTVM to J205 and J207. Adjust the external galvanometer zero control for an output of zero volts (50 mV is normally an acceptable level to obtain with this adjustment).

h. Allow the amplifier to stabilize for about 30 minutes without any input signal, then make the following adjustment.

i. Adjust the ZERO ADJUST control mounted on the amplifier POWER SUPPLY to obtain an output of zero volts at pins A and D of J203. As a result of this adjustment, the output will take considerable time to stabilize, since the filter will charge for about 1000 seconds. If a recorder is not used, a voltmeter or milliameter can be used for this adjustment. Start with an insensitive scale (50 volts or mA) and increase sensitivity as the zero adjustment nears completion.

j. Connect a voltmeter or milliameter between J205 and J207. Readjust the galvanometer zero control for an output of zero volts.

k. Remove the top cover of the amplifier. Do this carefully to avoid disturbing the position of the case. Using a small white card, check the position of the square of light on the splitter lens. If the light square is centered within ±1/16 inch, the phototube outputs are balanced.

l. Apply a test signal to the amplifier. Use a low-frequency function generator with approximately 20 to 100 megohms series resistance to the damped galvanometer. Increase the signal until the square of light on the splitter lens is seen to deflect from its zero position. Limit deflection to ±3/8 inch. Observe the illuminated areas on the phototubes. They should not move as the square of light deflects on the splitter lens. (Nonuniform change of intensity over spot area should not be mistaken for motion.) If this test is successful, the galvanometer input circuit and optical system are in proper adjustment.

m. Replace the amplifier cover carefully; connect the desired input signal, and observe the output of a recorder or meter.

n. Allow the amplifier to operate (with or without signal) for at least 8 hours. Remove any signal and recheck the voltage at J205 and J207 and the adjustment of the external ZERO ADJUST control for zero output. The amplifier is ready for operation.

If any of the tests or adjustments described above cannot be completed successfully, refer to the MAINTENANCE section of this manual.

3.3 AMPLIFIER RESPONSE

3.3.1 General

The phototube amplifier frequency response is determined by the natural frequency of the galvanometer, the galvanometer damping, and the filter installed in the amplifier circuit. The response can be determined experimentally by applying sinusoidal signals of several frequencies to the input and measuring or recording the output signals, then calculating the ratio of output voltage to input voltage for these frequencies. The response can be predicted if the galvanometer natural frequency, galvanometer damping, and filter characteristics are known.

When a response other than the existing one is desired, changes can be made by adjusting the galvanometer natural frequency or damping, or selecting a filter having different characteristics. Any combination of the above can be used simultaneously to obtain a different response.

3.3.2 Determining Frequency Response Experimentally

a. Connect a damping resistor (R_d) across the amplifier input. The damping resistor used should have the same resistance as the circuit to which the amplifier input will be connected during operation.

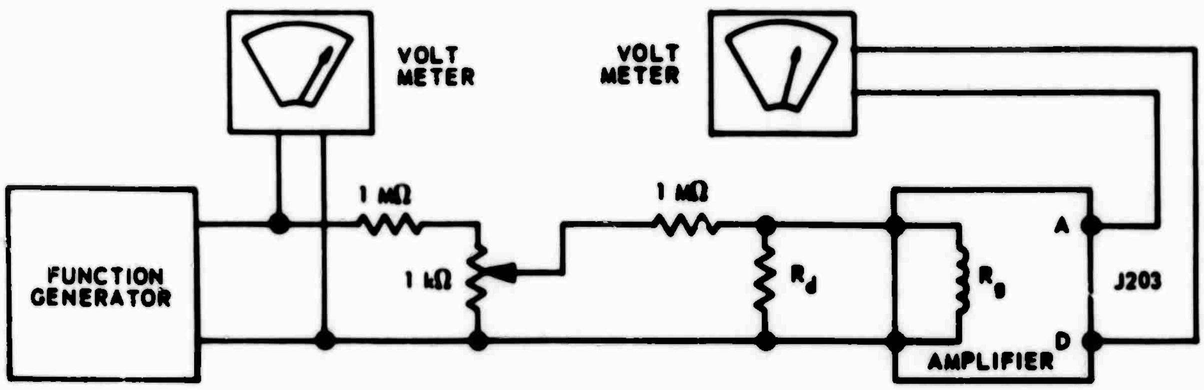


Figure 5. Test setup for determining amplifier frequency response and voltage gain

b. Connect a low frequency (0.1 to 0.01 Hz) function generator and divider network to the amplifier as shown in figure 5.

c. Connect the amplifier output (Pin A and D of J203) to a voltmeter or recorder.

d. Adjust the output of the function generator and the 1K potentiometer to obtain approximately 8 V peak-to-peak at the output of the amplifier at the lowest desired frequency (or any frequency in the center or flat portion of the amplifier bandpass).

e. Select several frequencies within the range of interest and apply signals at these frequencies to the amplifier input, measuring the function generator output voltage and amplifier output voltage at each frequency.

f. Divide the amplifier output voltage by the function generator out output voltage to obtain the frequency response characteristics of the amplifier.

<u>NOTE</u>

> To determine the voltage gain of the amplifier, calculate the ratio of the function generator output voltage and voltage across the amplifier input using the resistor values in the divider network, then multiply this ratio by the numbers obtained in step f.

3.3.3 Predicting Amplifier Response

The amplifier response can be predicted when the galvanometer natural frequency, galvanometer damping, and filter characteristics are known. When a low frequency function generator is not available, this is the most practical method of determining response. Figure 2 is a family of curves which show the response of the galvanometer as a function of frequency for several values of damping. The relative sensitivity is plotted as a function of the ratio of the actual frequency of interest and galvanometer natural frequency so the curves will apply to galvanometers having any natural frequency. To use the curves, first select several frequencies within the bandpass of the amplifier, then divide each of these by the galvanometer natural frequency to obtain the ratios f/fg. Select the curve which represents the proper damping of the galvanometer. Read the galvanometer sensitivity from the curve for each value of f/fg, then multiply these values by the corresponding value found on the curve in figure 6 representing the same frequency. When the products of these sensitivities are plotted as a function of frequency, the resulting graph will be the response of the amplifier. If the galvanometer natural frequency and damping are not known, consult the following paragraphs.

3.3.4 Measuring Galvanometer Natural Frequency

The natural frequency and critical damping resistance of the galvanometer are given on the data sheet which is sent with the instrument. If it is desired to verify these values, connect the amplifier to a recorder and run a test record as follows: Disconnect the input leads and put a 0.01 microvolt dc pulse across the coil, so that the galvanometer oscillates.

NOTE

> To obtain accurate results, it is important that no load be connected to the instrument during oscillation. Make sure that the voltage source used does not present a constant load to the coil; see the pulse generating circuit in figure 7.

Switch S_1 should be a normally-open pushbutton type, located in the circuit as shown so no load is presented to the galvanometer when it is open.

To operate, momentarily close switch S_1. This pulses the galvanometer, forcing the coil to oscillate. Do not leave switch closed when checking damping.

Note the time required for a number of cycles and divide the number of cycles by the time to get the natural frequency.

3.3.5 Measuring Galvanometer Damping (Λ_g)

The galvanometer damping (Λ_g) can be measured directly if Λ_g is to be less than 0.7. For greater damping values, the overshoot becomes extremely small and difficult to measure precisely, therefore, the damping should be calculated as described in 3.3.7.

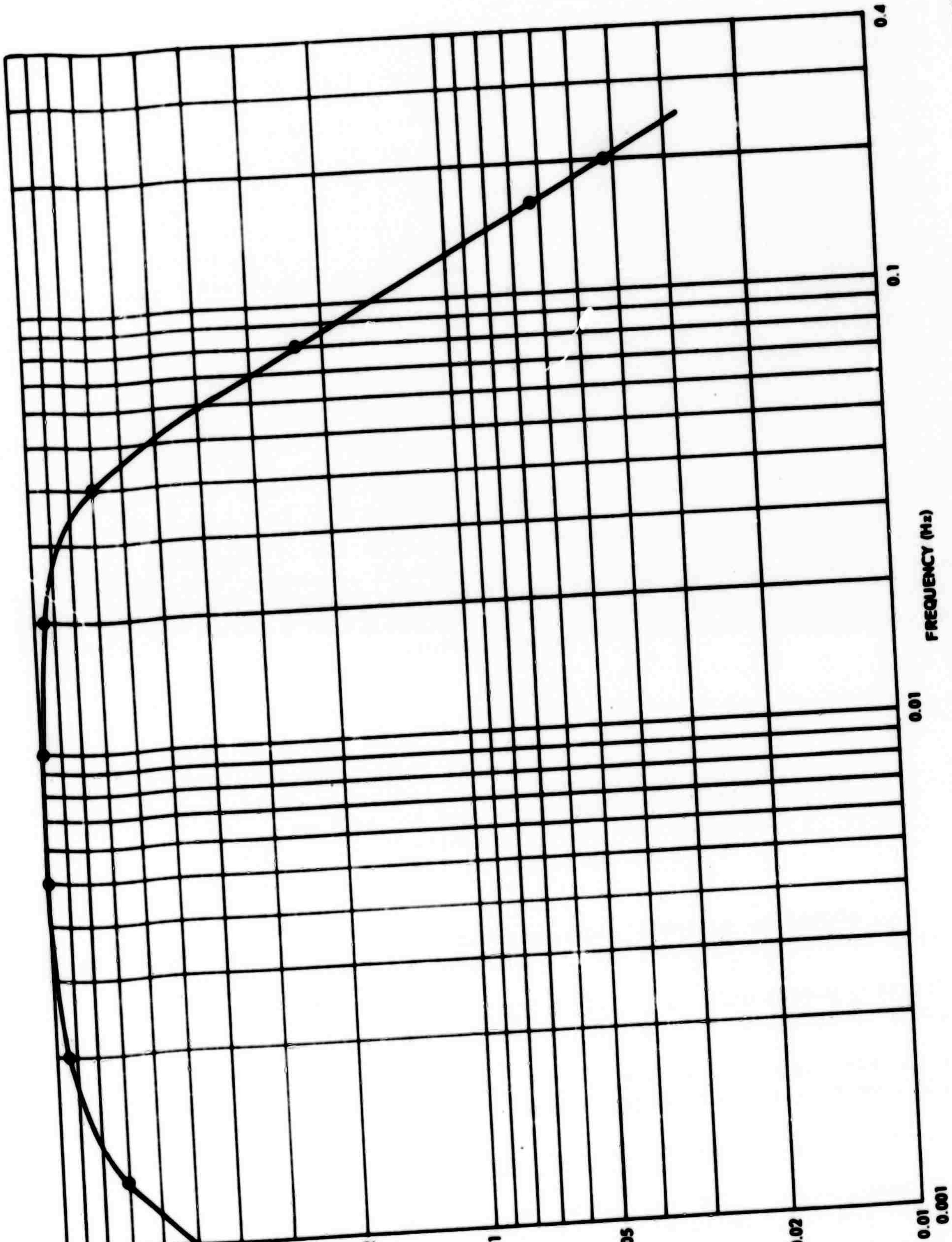
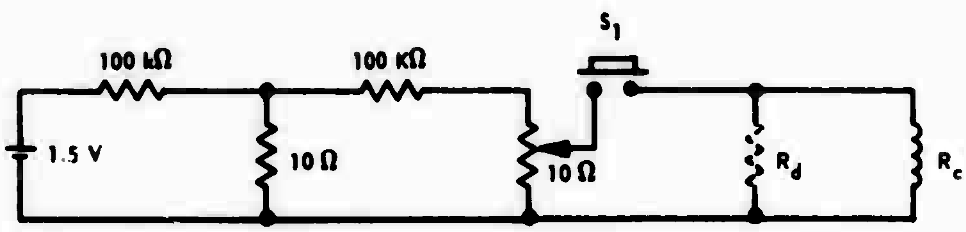


Figure 6. Frequency response of Filter, Geotech Model 6824-2



R_d = EXTERNAL DAMPING RESISTANCE AS REQUIRED (R_d IS INFINITE WHEN MEASURING OPEN CIRCUIT DAMPING)

R_c = IS THE GALVANOMETER

Figure 7. Pulse generating circuit

To measure the damping:

a. Connect a resistor (R_d) across the galvanometer terminals to simulate the circuit to which the amplifier input will be connected for routine operation.

b. Connect the pulse generating circuit shown in figure 7 to the amplifier input.

c. Connect the output signal at J205 and J207 to the input of a high impedance recorder or a VTVM.

NOTE

The filter response characteristics will alter the signal wave form to such an extent that measurements at the output J203 or J204 will not be valid for determining damping. The unfiltered signal (J205-J207) must be used.

d. Apply a sustained voltage to the galvanometer and adjust the voltage to produce an output of approximately 8 Vdc at J205-J207 after the galvanometer has stopped moving.

e. If the signal is not being recorded, read the above output voltage on the VTVM and record it for later use. Designate this voltage V_1.

f. Release the switch and allow the galvanometer to return to its center position. Note the VTVM reading at the maximum excursion of the pointer as it indicates the galvanometer overshoot. Designate this reading V_2.

g. After the galvanometer stops moving, read the voltage indicating the zero position. Designate this reading V_o.

h. Calculate the overshoot ratio as follows:

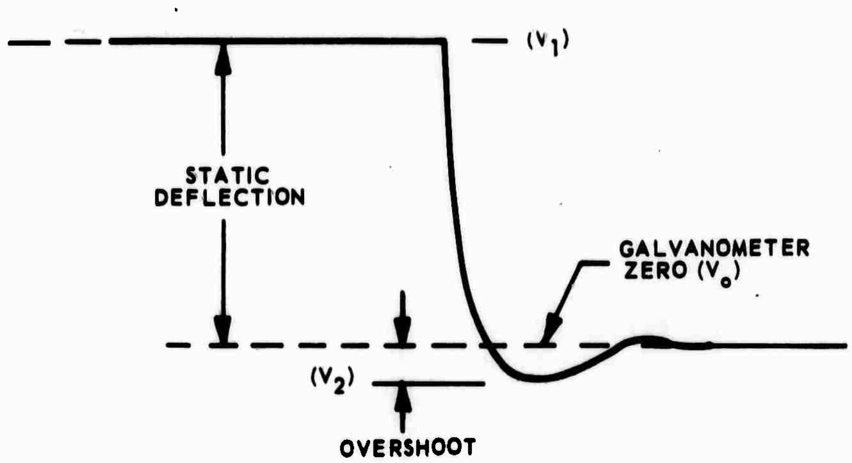
$$\text{overshoot ratio} = \frac{V_2 - V_o}{V_1 - V_o}$$

i. If recordings are made, the overshoot ratio can be determined from them as shown in figure 8.

j. After the overshoot ratio has been determined, refer to figure 9 for galvanometer damping.

3.3.6 Measuring Galvanometer Open Circuit Damping (λ_θ)

Use the setup shown in figure 7 to record a free-period signal of the galvanometer. Connect the recorder (or a VTVM) to J205 and J207. Calculate the ratio of overshoot for any two consecutive unclipped half cycles of the signal, as



$$\text{OVERSHOOT RATIO} = \frac{\text{OVERSHOOT}}{\text{STATIC DEFLECTION}}$$

Figure 8. Signal used to measure galvanometer overshoot ratio

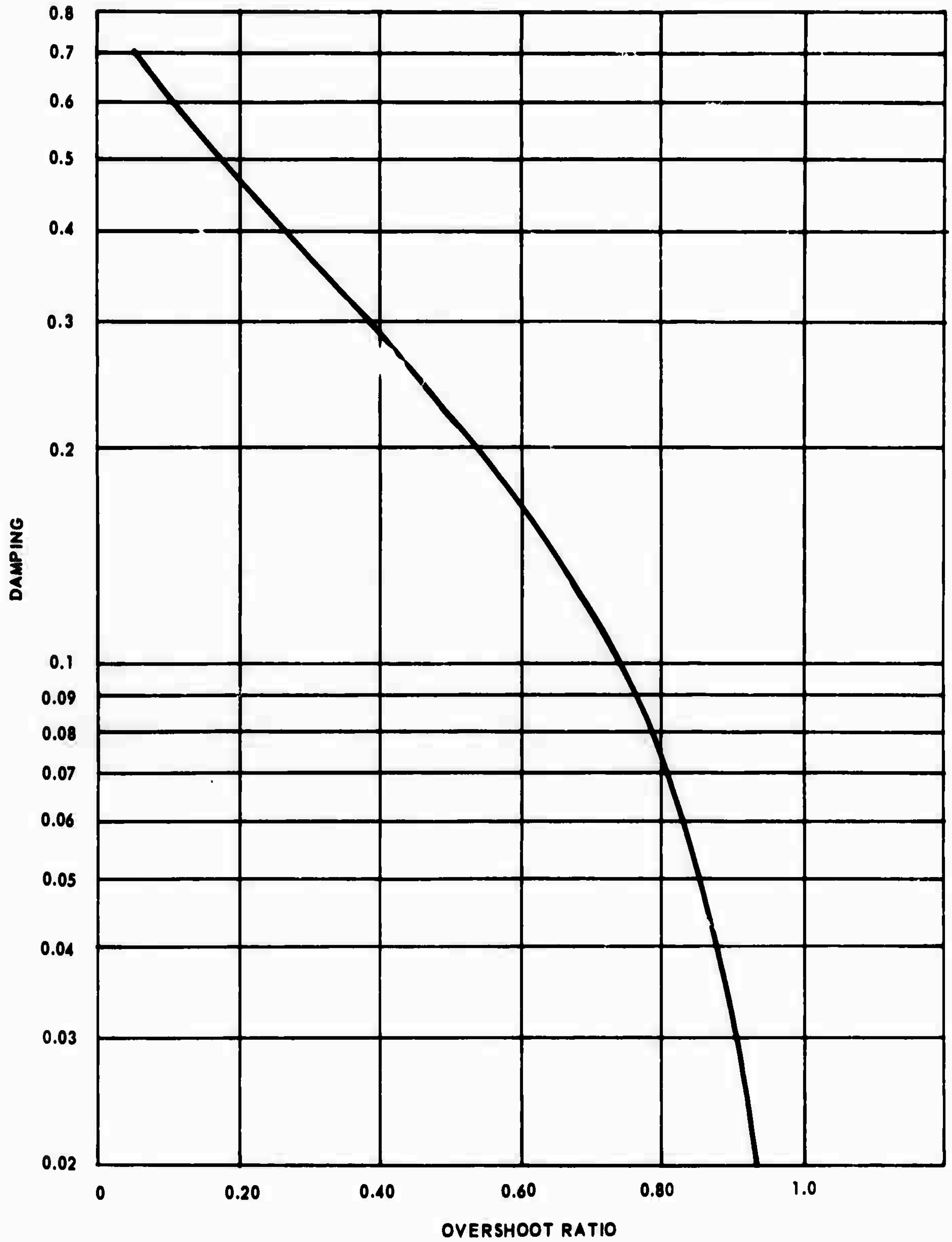


Figure 9. Graph for converting overshoot ratios to damping

G 2508

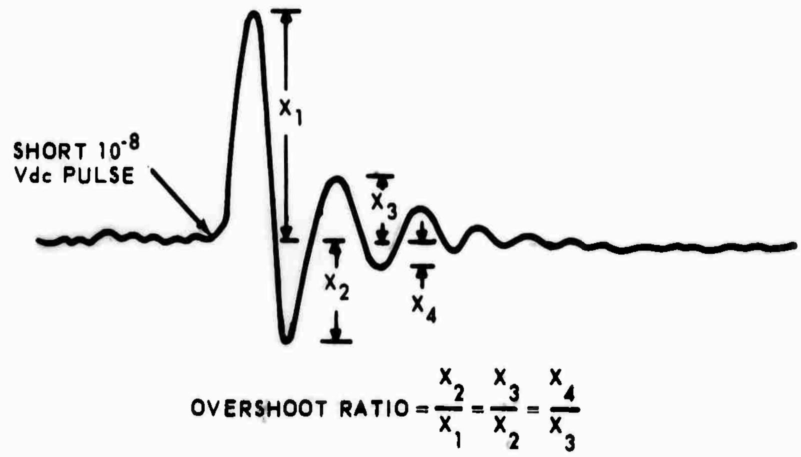


Figure 10. Illustration of method for determing overshoot ratio when checking open circuit damping

illustrated in figure 10. If a VTVM is used, the overshoot ratio will be the peak voltage (from center position) of any half cycle divided by peak voltage of the half cycle immediately preceeding. After calculating the overshoot ratio, refer to figure 9 to determine the damping. Measure the galvanometer natural frequency using the same signal recorded above. The open circuit damping value just determined, will apply for this natural frequency only. If the natural frequency is adjusted, the λ_θ must be rechecked.

3.3.7 Determining Critical Damping Resistance ($\mathcal{R}_g$)

The critical damping resistance ($\mathcal{R}_g$) of the galvanometer is the total loop resistance (coil resistance + external damping resistance) which produces a damping of 1.0 (critical damping). When the loop resistance is adjusted to this value, the galvanometer total damping (Λ_g) will be $\lambda_g + \lambda_\theta$, and $\lambda_g + \lambda_\theta$ will be 1.0. When the $\mathcal{R}_g$ is to be measured, first determine the open circuit damping (λ_θ) as described in paragraph 3.3.6.

Connect to the galvanometer terminals, a damping resistor (R_d) which will produce an overshoot ratio of approximately 0.2. Measure the total galvanometer damping (Λ_g) as described in paragraph 3.3.5. Calculate the $\mathcal{R}_g$ as follows:

$$\mathcal{R}_g = \frac{(\Lambda_g - \lambda_\theta)(R_g + R_d)}{1 - \lambda_\theta}$$

where:

$\mathcal{R}_g$ = critical damping resistance of the galvanometer

Λ_g = total galvanometer damping

λ_θ = galvanometer open circuit damping

R_g = galvanometer coil resistance (consult data sheet or measure directly)

R_d = external damping resistance

CAUTION

If R_g is measured directly, first turn the clamp screw clockwise to secure the movement so that the meter voltage cannot cause excessive deflection of the galvanometer, then be sure that the meter is set to the correct range before connecting leads to the galvanometer.

The above $\mathcal{R}_g$ will apply only for the natural frequency of the galvanometer at the time the $\mathcal{R}_g$ was determined. A typical set of numbers obtained from the above tests are:

R_g = 503Ω (measured)

R_d = 4300Ω (measured)

overshoot ratio = 0.62 (measured, open circuit)

λ_θ = 0.15 (from figure 9)

Overshoot ratio = 0.27 (measured with resistance load)

Λ_g = 0.38 (from figure 9)

$$\mathcal{R}_g = \frac{(0.38 - 0.15)\ (503 + 4300)}{1 - 0.15}$$

$$= \frac{(0.23)\ (4803)}{0.85}$$

$$= 1300\Omega$$

Having determined $\mathcal{R}_g$, an appropriate external circuit resistance to give any damping factor is easily calculated. If a damping of 0.707 is desired,

$$R_d = \frac{\mathcal{R}_g\ (1 - \lambda_\theta)}{\Lambda_g - \lambda_\theta} - R_g$$

$$= \frac{.1105}{0.707 - 0.15} - 503$$

$$= 1400\Omega$$

The damping factor for any given external circuit resistance may be calculated as follows:

$$\Lambda_g = \frac{\mathcal{R}_g (1 - \lambda_\theta}{R_d + R_g} + \lambda_\theta$$

If a 1000Ω resistor is connected across the galvanometer, then

$$\Lambda_g = \frac{1300 (1 - 0.15)}{1000 + 503} + 0.15$$

$$= 0.736 + 0.15$$

$$= 0.886$$

3.3.8 Critical Damping Resistance Adjustment

If a different critical damping resistance is desired, turn the magnetic shunt screw (directly below the galvanometer binding parts) to change the position of the magnetic shunt. Counterclockwise rotation lowers the value of $\mathcal{R}_g$; clockwise rotation raises it. In order to determine the new value of the critical damping resistance for the new position of the shunt, repeat the tests described previously in paragraph 3.3.7.

Changing the position of the magnetic shunt may have some effect on the natural period, so the period should be rechecked as outlined in paragraph 3.3.4.

3.3.9 Changing the Natural Period

Before attempting to change the natural period, care should be taken to insure that no dust or lint will enter the instrument while the cover is removed. Disconnect the input leads, turn the clamp screw clockwise to clamp the coil securely, and move the galvanometer to a dust- and lint-free room. Remove the front cover by removing the 10 screws around the edge.

Loosen the two screws in the period adjust clamp (figure 11). Being very careful that the suspension wire is traveling freely through the clamp, move the clamp toward the desired position on the period adjustment frame. Moving the clamp DOWN shortens the period, and moving it UP lengthens the period; the final position is determined by trial and error. While making this adjustment be careful not to touch the upper suspension tab.

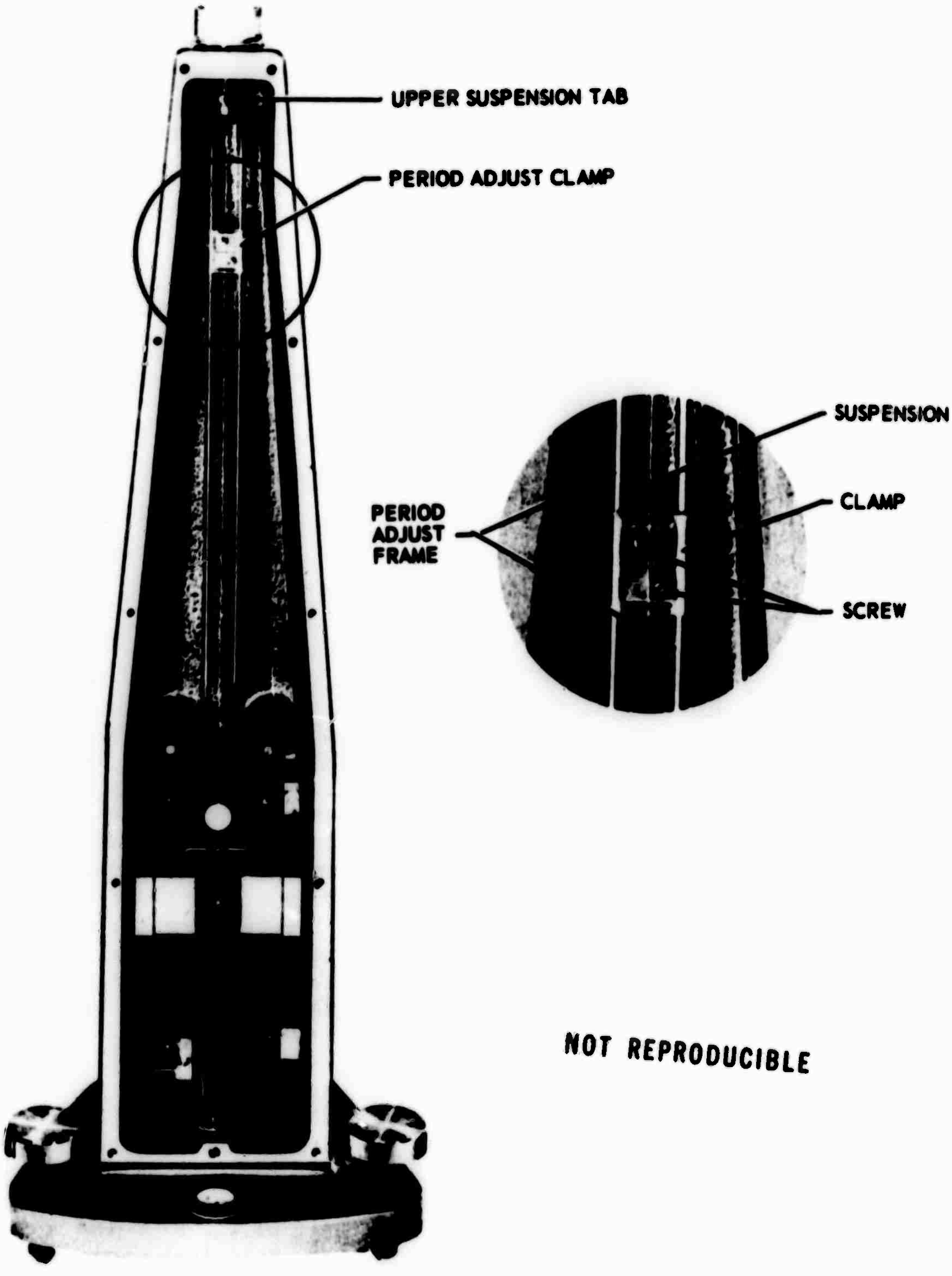


Figure 11. Galvanometer suspension assembly showing period adjust clamp

G 2509

Retighten the two clamp screws, replace front cover, and unclamp the coil. Place a small emf (not to exceed 0.01 microvolt) across the coil. Using a stopwatch, observe the time required for one oscillation of the mirror. This time is the instrument's period. Keep moving the period adjustment clamp until the desired free period is obtained. Replace the front cover. For a precise determination of period, use the method outlined in paragraph 3.3.4.

A change in period changes the value of the critical damping resistance, so it must be redetermined as outlined in paragraph 3.3.7.

4. PRINCIPLES OF OPERATION

Reference contained in the following paragraphs pertain to the schematic diagram of the phototube amplifier (figure 13) unless otherwise indicated.

4.1 INPUT CIRCUIT

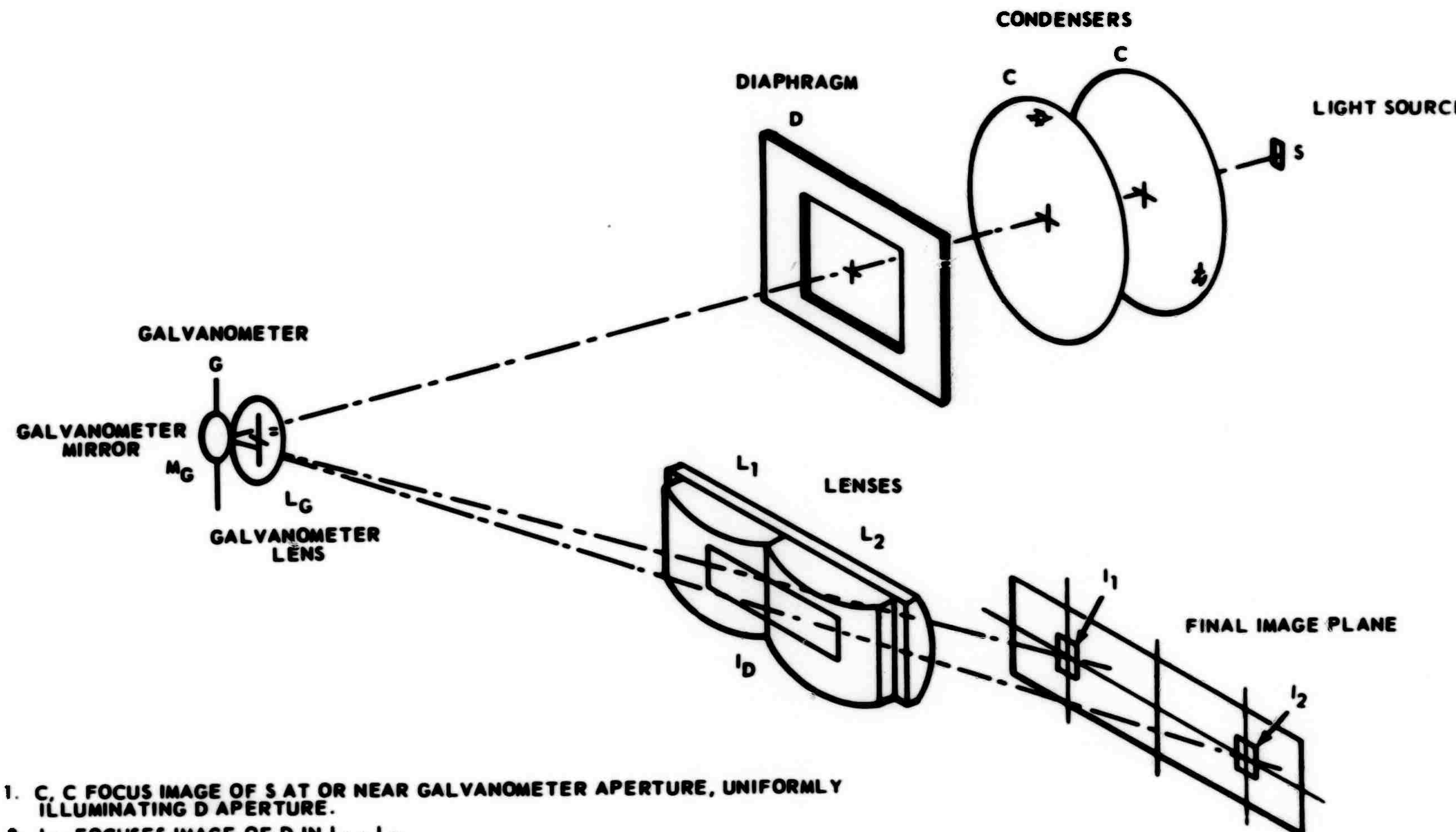
Since different galvanometers will be used in various models, no internal attenuator has been provided.

4.2 OPTICAL SYSTEM

Figure 12 is a drawing of the optical system used in the amplifier. The condensing lenses (C, C) gather light from the radiating source (S), uniformly illuminate the square diaphragm (D) opening, and focus an image of the source on the galvanometer mirror (Mg). The galvanometer lens (Lg) focuses an image of the diaphragm opening on the splitter-lens assembly (L1 and L2). This image appears as a square of light. As the galvanometer mirror rotates, the square of light moves laterally across the splitter-lens assembly. When the square of light is centered on the splitter-lens assembly, equal amounts of light are focused on the final image plane, the cathodes of the phototubes. Each spot of light on the image plane is an image of the galvanometer mirror (distorted by cylindrical shape of splitter lens), and each varies in intensity when the galvanometer is rotated. The two spots of light will remain stationary on the photocathodes when the phototubes are at the proper focal point.

4.3 PHOTOTUBE CIRCUIT

V102 and V103 are connected in series across a regulated voltage. The junction between the tubes is connected to the grid of a cathode follower, V101A, which has a very high input impedance. When equal amounts of light fall on the photocathodes, the voltage at the junction will be half of the 87 volts supplied to the phototube circuit. As the galvanometer rotates, the light division changes, causing the junction voltage to change proportionally.



1. C, C FOCUS IMAGE OF S AT OR NEAR GALVANOMETER APERTURE, UNIFORMLY ILLUMINATING D APERTURE.
2. L_G FOCUSES IMAGE OF D IN L_1 - L_2.
3. L_1 AND L_2 FOCUS IMAGES OF FALGANOMETER APERTURE AT I_1 AND I_2 RESPECTIVELY.
4. M_G ROTATION MOVES I_D PER ARROWS, MODULATING INTENSITY OF I_1 AND I_2 IN OPPOSITE SENSE. I_1 AND I_2 REMAIN STATIONARY.

Figure 12. Diagram of optical system

G 2510

4.4 INPUT CATHODE FOLLOWERS

V101 is connected in a conventional push-pull cathode-follower circuit except that the cathode resistors (R102 and R103) are quite large and the heater voltage is low. These two changes help to reduce the negative grid current of the tube. The grid of V101B, is connected to the midpoint of the phototube supply voltage. This has the effect of removing power-supply variations and the DC component from the output signal. The cathode-to-cathode voltage of V101 will be approximately zero when the light on the phototubes is equal. Signal output voltage will appear as a variation of cathode-to-cathode voltage.

4.5 FILTER

The signal voltage from V101 is connected to V201 through the filter, FL201. This filter is an active type which employs V201 in a feedback network. Typical bandpass characteristics of the standard filter are shown in figure 6. Other filters can be supplied with the cutoff frequencies moved up or down according to the application requirements, but the general circuit and principles of operation will be similar.

4.6 OUTPUT CATHODE FOLLOWERS

In addition to furnishing feedback to the active network of the filter, V201 furnishes output power. Note that the output signal is single-ended and referred to the dummy cathode. R209 and R210 are static drain resistors. C202 is used to prevent large hum voltages between the chassis and power supply. The B+ and B- voltages are above and below ground, respectively.

4.7 POWER SUPPLY

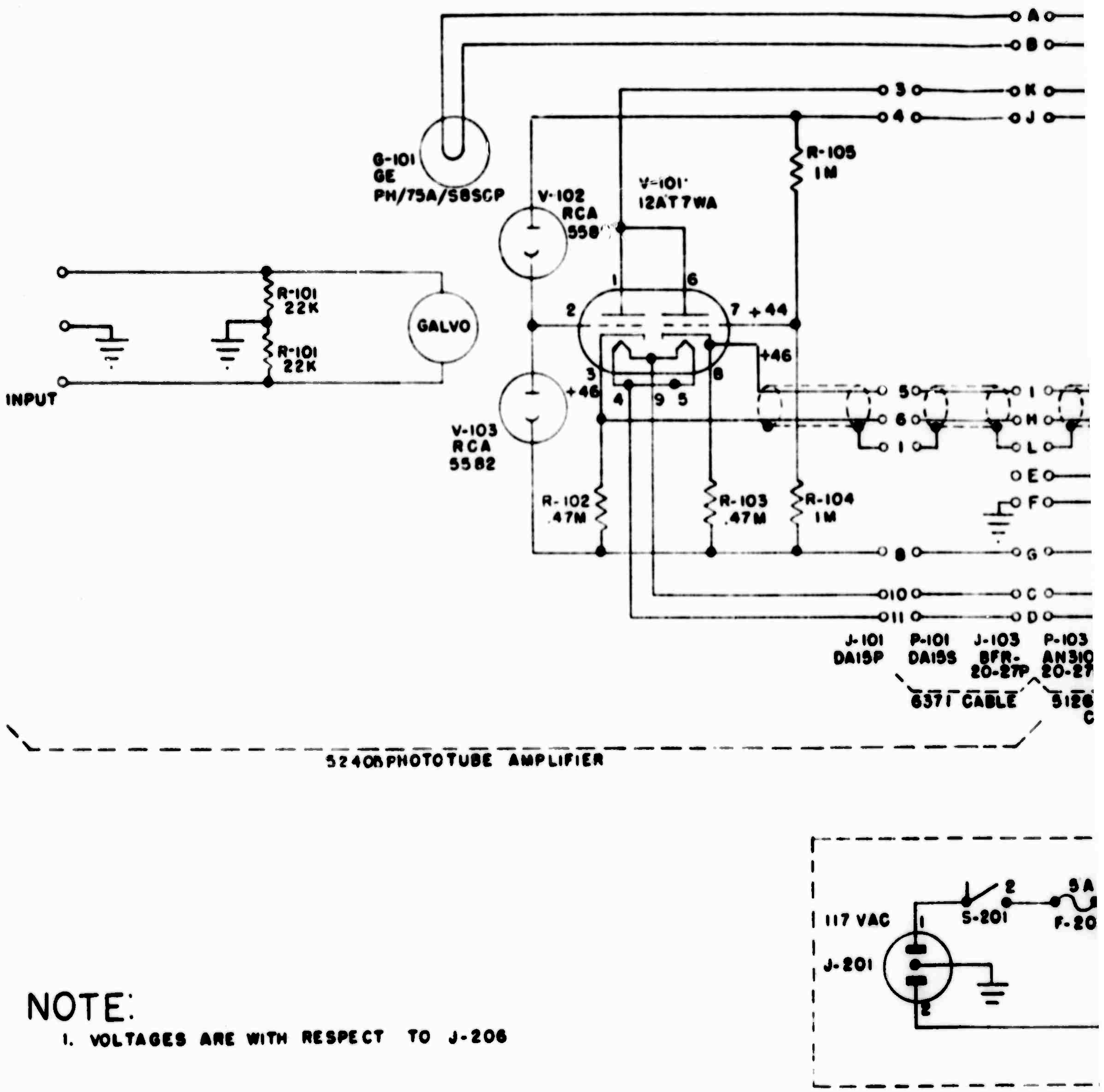
The power supply is a conventional full-wave rectifier followed by a choke input filter. Regulated voltage is supplied to the photocell bridge through R201. V202 is used as a shunt regulator for the photocell bridge. Bias voltages for V201 are developed by current through R203, R204, and R205.

5. MAINTENANCE

5.1 GENERAL

This amplifier is designed for continuous duty and may be expected to operate for long periods of time without requiring maintenance, except for centering of the galvanometer. Preventive maintenance procedures will be determined by the conditions of operation and the competence of personnel available.

BLANK PAGE



NOTE:

1. VOLTAGES ARE WITH RESPECT TO J-206

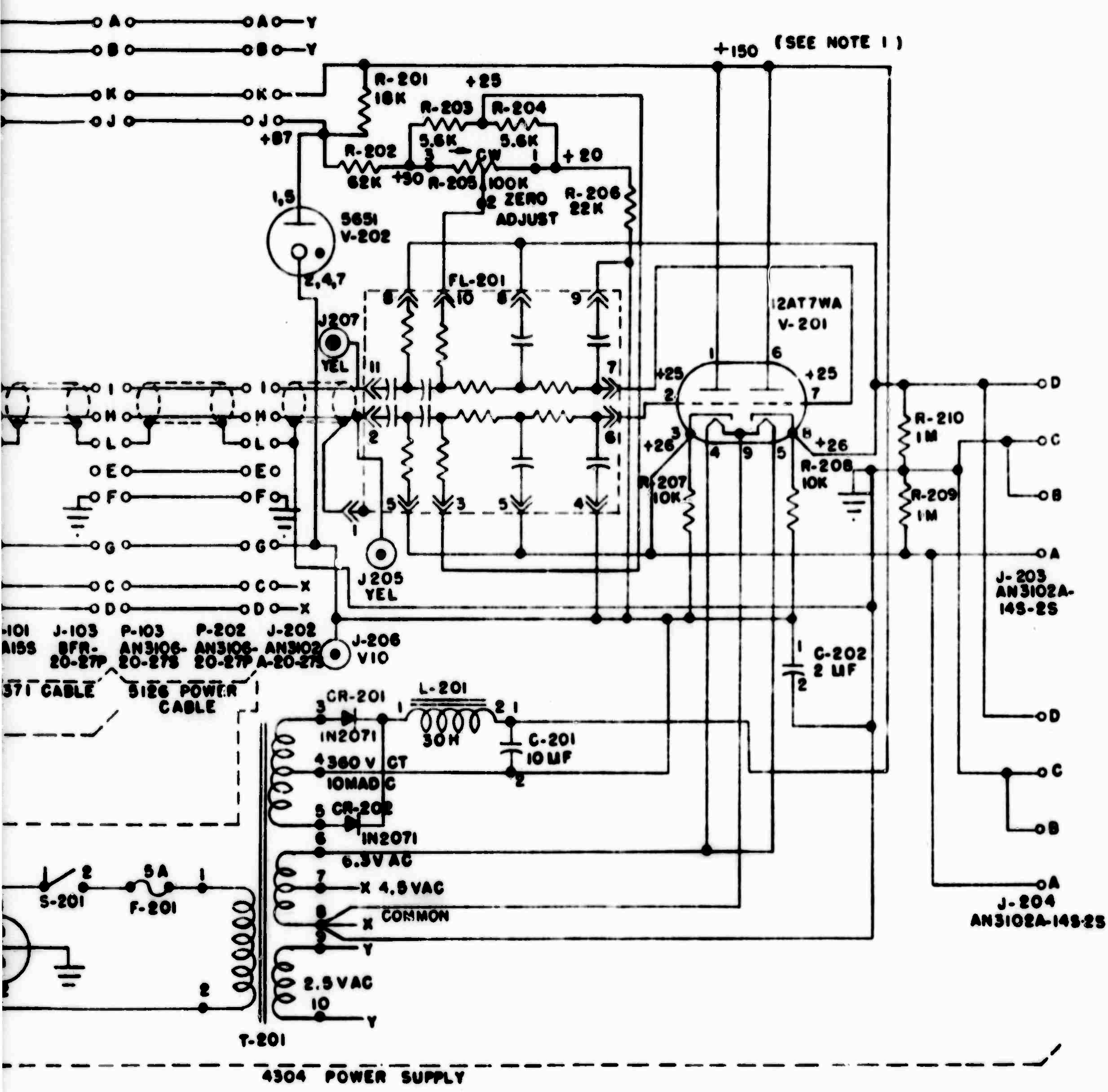


Figure 13. Phototube Amplifier, Model 5240B, schematic diagram

G 2511

235a

BLANK PAGE

5.2 CONTINUOUS OPERATION

If the amplifier is required to operate continuously and if the installation is reasonably accessible, it is recommended that no preventive maintenance be attempted. A spare amplifier should be kept in readiness if it is important to reduce the loss of operation time when a failure occurs. Some failures may be anticipated by close observation of the performance characteristics. Changes in overall gain, DC balance, or fidelity should be cause for suspicion.

5.3 REGULAR OPERATION

If the amplifier is not required to operate continuously and failure during operating hours is permissible without undue economic loss, it is recommended that no preventive maintenance be attempted until some change in operating characteristics occurs. If it is highly important that failures in operation be prevented and qualified personnel are available, it is recommended that the following preventive maintenance procedure be followed.

5.3.1 Every 500-1000 Hours of Operation

a. Check level of case.

b. Check voltage between J205 and J207 (with no input signal). If it is zero volts, make no adjustment. If the voltage is not zero, but within the range of ±5 volts DC, the external GALVANOMETER ZERO control should be adjusted to correct the error. If the voltage is outside the ±5-volt range, the power supply voltages should be checked (see schematic). If the power-supply voltages are correct, the sealed case should be opened, and the position of the light spot on the splitter lens should be checked (see paragraphs 3.2.j and 3.2.k). If the spot is in the proper position, test V101.

c. Check the ZERO ADJUST (see paragraph 3.2.i). If this adjustment is in error by more than one volt, test V201.

d. If the desiccant has been exposed to moist air for more than 4 hours, during this service procedure, it should be replaced.

5.3.2 Every 2000-5000 Hours

In addition to the procedure outlined in paragraph 5.3.1:

a. Test V201 regardless of the result of check in paragraph 5.3.1.c. If its emission or dynamic mutual conductance is low on either element by as much as 20 percent, it should be replaced.

b. Clean dust, etc., from the amplifier and power supply.

c. Remove the bottom cover from the power supply and look for oil leaks from either of the two capacitors. Replace the capacitor if the leak appears extensive.

d. Avoid opening the sealed case except when required. If the case is opened and if the amplifier has been in service for 6 months or more, replace the desiccant packages.

5.3.3 Replacement of Vacuum Tubes

Specially selected vacuum tubes are required for best operation of this amplifier. Adequate selection is provided by use of 12AT7WA premium tubes. In the extreme case where the amplifier is required to provide unattended service for periods of 6 months, it is recommended that all replacement tubes and exciter lamps be aged for a period of 100 hours before placing them in service. Most of the filament failures of new tubes and lamps will occur in the first 50 to 200 hours of operation.

5.4 PRESET ADJUSTMENTS

5.4.1 Galvanometer Replacement (Refer to figure 3)

The galvanometer can be replaced in the following manner:

a. Remove the top cover from the amplifier case. Lock the galvanometer suspension by turning the knurled coil lock in a clockwise direction.

b. Remove the three 5/16-24 bolts from the base of the galvanometer.

c. Disconnect the galvanometer by unscrewing the inside thumbscrews (J) on the binding posts and sliding out the wire conductors which go to the galvanometer terminals.

d. Lift the complete assembly straight up.

e. Put the new galvanometer assembly back into the base following in reverse the procedure outlined in a. thru d. above.

5.4.2 Galvanometer Adjustment (Refer to figure 3)

For proper alignment of the galvanometer and galvanometer base, and initial adjustment of the GALVANOMETER ZERO control, proceed as follows:

a. Turn on power to amplifier and unlock the galvanometer suspension by turning the knurled coil lock in a counterclockwise direction.

b. Adjust the external GALVANOMETER ZERO control until the control is in the middle of the rotational range. This preliminary setting is essential in minimizing ghost effects.

c. Using the zero-adjust on the galvanometer, center the square of light on the splitter lens. Observe the uniformity of illumination of a white card placed in contact with the splitter lens. If there are areas of nonuniform illumination (denoted by a change in color or shape of the normally white square), slight readjustment of the galvanometer should correct the abnormality. If the area cannot be made uniform in illumination, see paragraph 5.4.3, Lamp Adjustment.

d. If the external zero adjust does not rotate easily, the six screws in the hold-down ring (C) should be loosened. The same screws will need tightening if there is any loose play between the galvanometer base (D) and the base adaptor (E).

5.4.3 Lamp Adjustment (Refer to figure 3)

The exciter lamp is a prefocused type and can be changed without readjustment. If for any reason the optical alignment of the lamp is disturbed, adjustment is made as follows:

a. Turn on power to amplifier and unlock the galvanometer suspension by turning the knurled coil lock in a counterclockwise direction.

b. Remove the lamp and lens-tube cover (G) and loosen the hex-head screw under the lamp and lens-tube base.

c. With power on, place a small (about 1-inch diameter) white card or piece of paper in front of the galvanometer lens.

d. Move the lamp in and out (with respect to the condenser lens) until the light is focused on the extreme left side of the card (when facing galvanometer lens). Adjust the vertical position of the light spot by loosening the two 1/4-inch hex-head screws located on the lamp and lens-tube mount (H). The light spot should be centered on the horizontal centerline of the galvanometer lens on the extreme left side of the card. The position of the lamp should be adjusted so that the image of the lamp filament is focused on the mirror. This can be done by noting a focal point when the card is on the lens, and another when the card is approximately 1/2 inch in front of the lens. The change of lamp position for these two points is the distance which the lamp must be moved in the other direction to change the focal point from the lens to the mirror. After a little experience, the lamp filament can be focused on the mirror by estimation.

e. Move the lamp from side to side until the spot of light is centered on the splitter lens (F).

f. Clamp the lamp in place by tightening the hex-head screw.

g. Clean the outside of the lamp envelope thoroughly, and replace the lamp and lens-tube cover.

5.4.4 Photocell Adjustment

When all of the optical adjustments outlined above have been completed, the position of the photocells can be adjusted.

CAUTION

Do not touch any lens, exciter light, or phototube glass with the fingers. Chemical deposits on these surfaces can cause improper operation of the amplifier.

Apply power to the amplifier and observe an image of the galvanometer mirror on each of the photocathodes. Apply an input signal of sufficient amplitude to produce an output of 30 volts peak-to-peak at 0.01 Hz into an open circuit. When the position of the photocathodes is proper, there will be no relative motion of the positions of the spots and the change of shape of the spots will be minimum. Under no circumstances should the spot shine on the anode wire which is in the center of the tube. By swinging the tube and rotating its envelope, it is possible to satisfy both of these conditions. Observe the output from J205 to J207 with an oscilloscope. Apply a triangular function at 0.01 Hz to the input, and observe the output waveform. If any distortion exists, recheck the above procedure.

5.5 REPAIRS

Repairs to the amplifier should be made using the general procedures and basic techniques used with electronic devices. When the amplifier ceases to function properly, locate the cause of the malfunction following the procedures recommended under sections 4 and 5 and figure 13 (schematic diagram) and replace the defective component.

5.6 ACCESS

Vacuum tubes and all adjustment points in the amplifier are accessible when the top cover is removed. When access to other parts in the amplifier is required, the complete assembly can be removed from the case in the following manner (see figure 3):

a. The phototube deck (K) can be removed by removing the four screws holding the phenolic plate (L), the ground lead, and the power plug (M).

b. To remove the complete lamp and lens-tube assembly, unscrew the two 1/4-inch hex-head screws (N) and unsolder the lamp cable at the pins on the lamp and lens-tube base.

c. All components of the power supply are accessible by removing the top and bottom covers.

5.7 CLEANING OPTICAL SURFACES

5.7.1 Extreme care should be exercised to prevent fingerprints, dust, excessive moisture, and other foreign matter from getting on the lenses. If it should become necessary to clean any of the surfaces, it can be done as follows:

a. Mix a half-and-half solution of ethyl alcohol and acetone.

b. Apply with a soft bristle brush to the optical surface. Just enough should be applied to float away dust and particles.

c. Allow to air-dry.

5.7.2 The photocells and their teflon insulators should be cleaned by washing with a clean, soft cloth using the half-and-half solution of ethyl alcohol and acetone or ethyl alcohol only. Allow to dry. After cleaning, handle the phototubes by their end caps only. The teflon insulators should be handled with the same care after cleaning. When the photocell junction is properly insulated with clean parts, the circuit is insensitive to changes in exciter-lamp intensity over a broad range.

6. PARTS LIST

6.1 GENERAL

The nomenclature used in this section will aid in the identification of certain components of the control unit.

6.2 CODE OF MANUFACTURERS

In the component parts listing of this section, reference is made to specific manufacturers' names, given below.

01121	Allen-Bradley Company Milwaukee, Wisconsin
02660	Amphenol-Borg Electronics Corp. Chicago, Illinois
70903	Belden Manufacturing Company Chicago, Illinois
71400	Bussman Manufacturing, Division of McGraw-Edison Company St. Louis, Missouri
71468	Cannon Electric Incorporated Los Angeles, California
71279	Cambridge Thermionic Corporation Cambridge, Massachusetts
71471	Cinema Plant HI-Q Division Burbank, California
71785	Cinch Manufacturing Company and Howard B. Jones Division Chicago, Illinois
15605	Cutler-Hammer, Inc. Milwaukee, Wisconsin
76487	Millen, James Mfg. Company Malden, Massachusetts

07183	Decco, Inc. Dallas, Texas
04604	Eagle Chemical Company, Inc. Chicago, Illinois
22345	Earth Sciences Division, Teledyne Industries Pasadena, California
08807	General Electric Photo Lamp Department Cleveland, Ohio
72653	GC Electronics Manufacturing Company Rockford, Illinois
90002	Harvey Hubbell, Inc. Bridgeport, Connecticut
74970	E. F. Johnson Company Waseca, Minnesota
49956	Raytheon Microwave & Power Co. Tube Division Waltham, Massachusetts
49671	Radio Corporation of America New York, New York
99934	Renbrandt, Inc. Boston, Massachusetts
53021	Sangamo Electric Company Springfield, Illinois
99019	Geotech, A Teledyne Company Garland, Texas
01295	Texas Instruments, Inc. Semiconductor Components Division Dallas, Texas
81095	Triad Transformer Corporation Venice, California
88245	United States Engineering Company Van Nuys, California
82893	Vector Electronic Company Glendale, California
03016	Wenzel Projector Company, Inc. Chicago, Illinois

6.3 COMPONENTS

Listings in the table of replaceable parts, below, constitute a partial breakdown of the equipment. Included are all electrical parts and those operative mechanical parts which are subject to loss or failure. Omitted are the structural and minor parts such as standard bolts, nuts, and screws. Parts marked with an asterisk (*) should be kept on hand as spares to insure minimum down-time. When several amplifiers are used, a spare galvanometer is recommended.

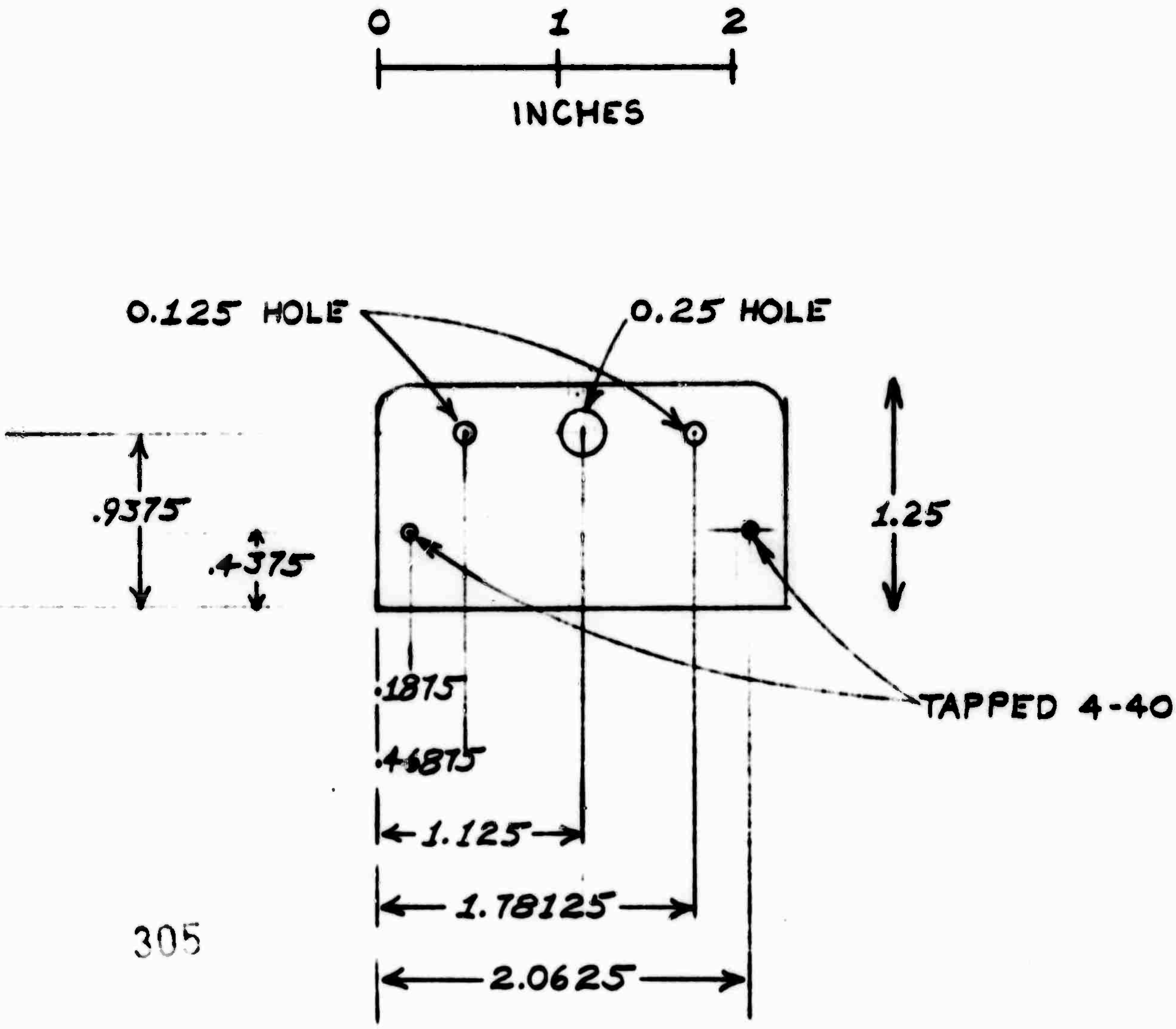
Table of replaceable parts

Item	Part number	Description	Mfgr code	Quan
*C201	7106-10	Capacitor, 10 mf, 600V, oil filled with type A brackets	53021	1
*C202	62A06-ZB	Capacitor, 2 mf, 600V, oil filled with type A brackets	53021	1
CR201	1N2071	Silicon rectifier	01295	2
CR202				
E101	952	Tube shield, for T6-1/2 bulb	71785	1
E102	1418	Insulated terminal	88245	2
*F201	MDL-1/2A	Fuse, 1/2 A, 250V, Slo-Blo	71400	1
FL201	6824-2	Filter	99019	1
*G101	PH/75A/S8SCP	Exciter lamp	08807	1
J101	DA-15P	Connector	71468	1
J103	BFR-20-27P	Connector (one only)	71468	1
	157-320-27P		02660	
J201	7486	Power connector	90002	1
J202	AN3102A-20-27S	Connector	Any	1
J203	AN3102A-14S-2S	Connector	Any	2
J204				
J205	105-607	Nylon tip jack, yellow	74970	2
J207				
J206	105-612	Nylon tip jack, violet	74970	1
L201	HSM-301	Choke, 30H, 20 mA, 1000 ohm	81095	1
P101	DA-15S	Connector	71468	1
	DA	Shell	71468	1
P103	AN3106-20-27S	Connector	Any	1
P201	7484	Power connector	90002	1
P202	AN3106-20-27P	Connector	Any	1
	AN3057-12	Cable clamp	Any	2
P203	AN3106A-14S-2P	Connector	Any	1

Item	Part number	Description	Mfgr code	Quan
R101	412	Resistor, 22K, 1/2 W, 5%	71471	2
R102| R103|	GB	Resistor, .47M, 1 W, 5%	01121	2
R104| R105|	GB	Resistor, 1 meg. 1 W, 5%	01121	2
R201	GB	Resistor, 18K, 1 W, 5%	01121	1
R202	GB	Resistor, 62K, 1 W, 5%	01121	1
R203| R204|	GB	Resistor, 5.6K, 1 W, 5%	01121	2
R205	JL	Potentiometer, 100K- 1 lockwasher M2898 1 mounting nut M2786 1 locking nut M13750	01121	1
R206	GB	Resistor, 22K, 1 W, 5%	01121	1
R207| R208|	GB	Resistor, 10K, 1 W, 5%	01121	2
R209| R210|	EB	Resistor, 1 meg, 1/2 W, 5%	01121	2
S201	8280K14	Power switch, 3 A, 250V, SPST with 29-761 locking ring	15605	1
T201	12067	Transformer, Geotech #4960	07183	1
TB101	1785	Terminal board	72653	1
TB201	32A5	Terminal strip, 1/16 x 1-3/8 x 8-1/2	82893	1
*V101	12AT7WA	Electron tube	Any	1
*V102| *V103|	5582	Photocell, gas filled	49671	2
*V201	12AT7WA	Electron tube	Any	1
*V202	5651	Electron tube	Any	1
XF201	HKP	Fuseholder	71400	1
XFL201	77-MIP-11	Socket	02660	1
XG101	PPW-13	Lamp socket	03016	1
XV101	9XM	Shield base	71785	1
XV201	21-0238-09	Tube socket, mica filled RMA saddle	Any	1
XV202	21-0238-07	Tube socket, mica filled RMA saddle	Any	1
3	9760-14	Cap and chain	02660	1
20	4495	Lock nut	99019	3
21	4494	Foot, adjustable	99019	3
22	K1-0012	Right angle drive	76487	1
26	4527	Lens, beam splitter	99019	1
30	6731	Cable assembly	99019	1

Item	Part number	Description	Mfgr code	Quan
35	5126A	Cable assembly	99019	1
36	6170	Gasket, cover	99019	1
37	GL-261	Galvanometer assembly, frequency specified	22345	1
40	A-201-45	Coupling, Tinymite	99934	1
41	28506	Right angle drive assembly	99019	1
44	125-1-2	Knob, for galvo zero	49956	1
46	211-A	Handle	71279	1
47	4495	Nut, lock	99019	3
49	6538	Sprocket	99019	2
50	26603	Galvo lens +6 Diopter	99019	1
*54	852	Desiccant, 4-unit bag	04604	2
56	5757-1	Cap, photocell, GE #49 x 622 lumiline	99019	2
57	5757-2	Cap. photocell, GE #49 x 622 lumiline	99019	2
207	12293	Power cord, 8 ft, 18-3 cond. 3-pin plug	70903	1

REVISIONS			
LETTER	DESCRIPTION	DATE	APPROVED



305

PLATE 1.25 X 2.25 X 0.125 ALUM

CONTRACT	AF44630-70-C-0035	
DRAWN BY		
CHECK. BY		
PROJ. ENGR.		

LAMONT GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY

MOTOR MOUNTING PLATE
PTA TURNTABLE

TOLERANCES:
UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES

DECIMAL		ANGLES
.X	±	±
.X X	±	
.X X X	±	

BREAK SHARP EDGES

DWG. NO. 2102		REV.	
SCALE 1/1	WEIGHT	SHEET 1 OF 1	

2103-1

K I N E M E T R I C S

INSTRUMENT MANUAL

FOR THE

MODEL LG-1

LONG-PERIOD GALVANOMETER

SERIAL NUMBER

KINEMETRICS, INC.
336 Agostino Road
San Gabriel, California 91776

BLANK PAGE

DESCRIPTION

The Model LG-1 is an extremely sensitive, long-period galvanometer designed expressly for seismological applications. It can be used with a wide variety of recorders, and provides adjustments for damping and optical focus over wide operating ranges. The galvanometer suspension is free-hanging, with the coil and mirror assembly suspended by a 24-karat gold ribbon.

The optical system has a nominal focal length of one meter, and can be adjusted to obtain precise focus over the range from 0.75 to 1.25 meters. Hence, the galvanometer-to-recorder distance is non-critical, and galvanometer placement is greatly simplified. The magnetic path assures a radial field and linearity throughout the maximum rotation. An adjustable magnetic shunt varies the flux density over a broad range for ease in matching the galvanometer to other system constants. The effect of air damping is only approximately 20 percent of critical for a 90-second period, so that operation at normal damping ratio requires no evacuation.

The 500-ohm galvanometer coil is terminated on screw-type binding posts, and is electrically isolated from the case to permit appropriate grounding at the optimum point for best system operation.

The sensitivity and critical damping resistance are dependent upon the magnetic flow strength and are adjustable over the following ranges (for 100 second period):

Characteristic	Shunted (shunt down)	Unshunted (shunt up)
Undamped sensitivity (amp/mm at 1 meter)	1.1×10^{-10}	0.58×10^{-10}
Critical Damping Resistance (CDR)	1000 ohms	3500 ohms

CONTROLS AND CONNECTIONS (Ref. Figure 1)

1. Clamp Screw. Turning this screw clockwise clamps the coil and mirror to prevent damage from excessive vibrations. Be sure to clamp the coil before moving the instrument.

2. Binding Posts. Screw-type input terminals facilitate installation and checkout of the system.

3. Provision for Grounding. Used to bleed off any electrostatic charge on the suspension material that might otherwise cause erratic behavior. In an unusually dry atmosphere, connect a 50,000-ohm resistor between the galvanometer coil ground terminal and a screw installed in this tapped hole. Scrape off black finish to bare aluminum under screw head to ensure good electrical contact.

4. Magnetic Shunt Lock Screw. Loosen this screw to change the position of the magnetic shunt to vary the damping resistance and sensitivity.

5. Precision Leveling Screws. Used in conjunction with bubble level to facilitate accurate placement.

6. Bubble Level.

7. Base. The frame assembly is easily removed from the base; this permits ready transportation and repair.

8. Zero-Adjust Knob. Used to set zero position of the spot. By rotating this knob, the optical beam may be turned through a total usable angle of approximately 50 degrees, without shadows by the optical system.

9. Adjustable Lens. Focuses light beam over range from 0.75 to 1.25 meters.

10. Base-to-Galvanometer Attachment Screws.

308

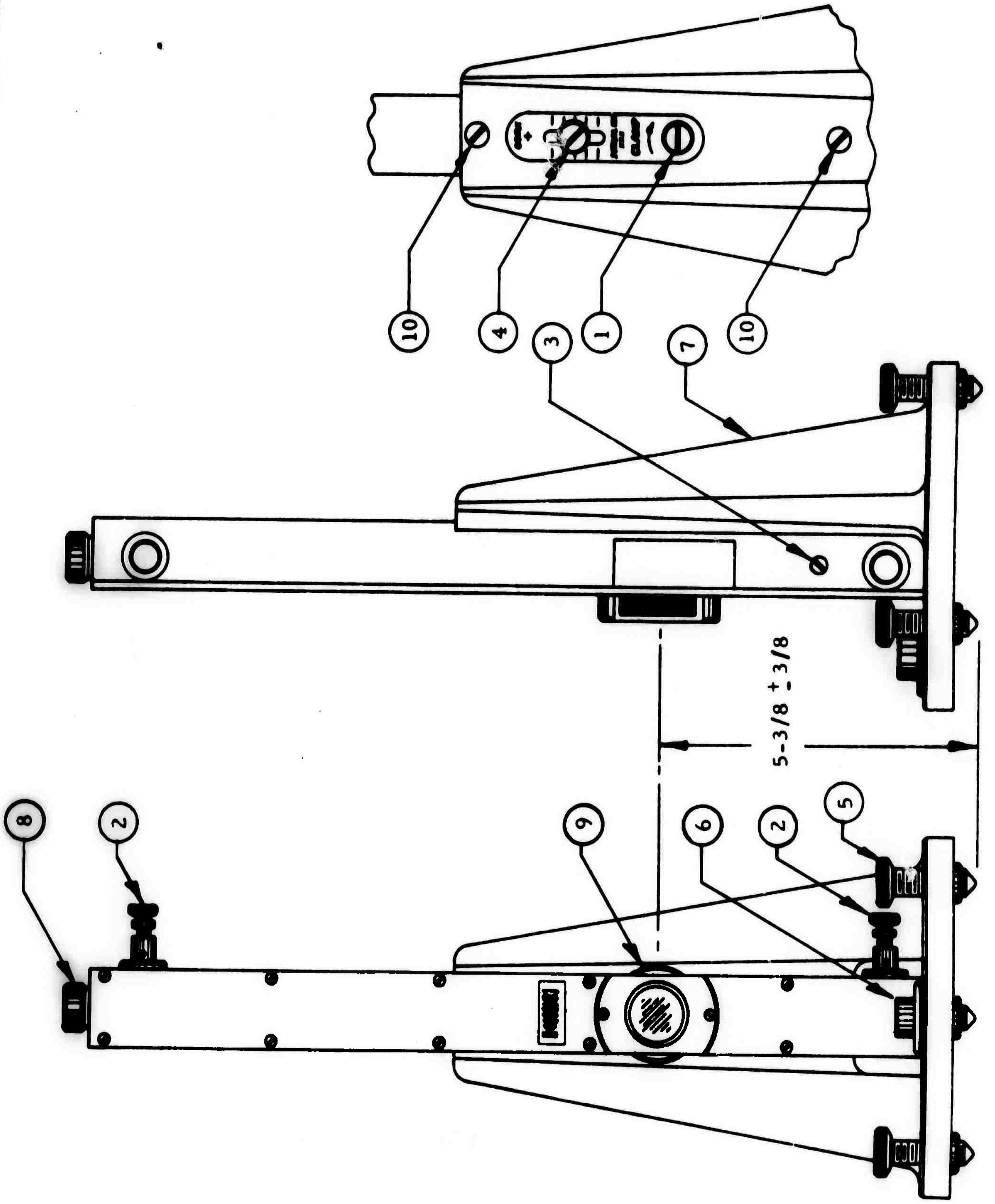


Figure 1.

INSTALLATION

Long-period instruments of all types are more susceptible to air currents and changes in temperature than are short-period instruments. In addition, dust on the coils of the LG-1 can alter the magnetic circuit of the instrument and may make it inoperable. For these reasons, care should be taken to protect the instrument from large air currents, extreme temperature variations, and dust. If it becomes necessary to work on the galvanometer at the station, a dust- and lint-free room should be used.

> CAUTION: Do not move the LG-1 without first making sure that the clamp screw is turned fully clockwise to secure the movement.

Leaving the coil clamped, place the galvanometer on a stable pier approximately one meter from the recorder (any convenient distance from 0.75 to 1.25 meters will be satisfactory). Position the instrument so that the center of the lens assembly is level with a point midway between the effective light source and the recording point. In plan view, the light beam should travel a path normal to the recorder shaft.

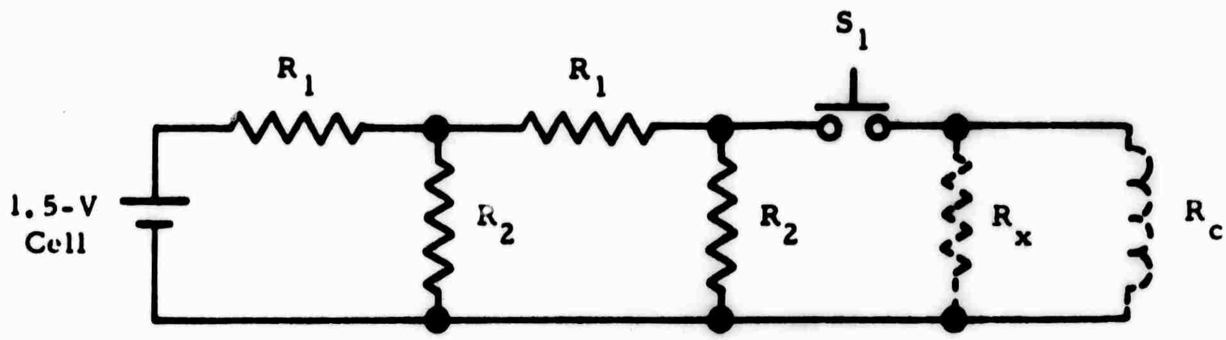
Level the galvanometer base plate using the leveling screws and the bubble level on the base. Allow a few seconds for the level indicator to stabilize between changes. This adjustment is critical, and care should be taken to be precise. If the instrument is not vertical, the suspension system may allow the coil to "drag" against the magnet.

If the frame has been removed from the base, be sure that the left-hand side (viewed from the front or lens side) of the frame is snugly against the left side of the cut-out in the base.

OPERATION

> CAUTION: When checking galvanometer movement in the following procedures, do not connect more than the recommended voltage across the terminals. Voltages in excess of 10 millivolts may produce sufficient deflection to damage the suspension. A suitable d-c pulse source that can be easily assembled for these tests is shown on page 4.

PULSE GENERATING CIRCUIT



where

R_1 = 100K ohms

R_2 = 10 ohms

R_x = external resistance as specified (R_x is infinite when measuring air damping)

R_c is the galvanometer

Switch S_1 should be a normally-open pushbutton type, located in the circuit as shown so no load is presented to the galvanometer when it is open.

To operate, momentarily close switch S_1. This pulses the galvanometer, forcing the coil to oscillate. Do not leave switch closed when checking damping.

311

CHECKING COIL MOVEMENT

CAUTION: Unclamp coil slowly.

Unclamp the galvanometer mirror by turning the screw fully counterclockwise. The coil should now swing freely. Deflection by application of emf of about 0.01 microvolt to the galvanometer terminals should cause the coil to rebound after striking the stops at either extreme of oscillation. Touching the terminals with moistened fingers will usually give sufficient amplitude for this test.

This check shows that the coil is swinging freely. If there is a tendency for the coil to stick at any point, a slight leveling adjustment may be required.

ADJUSTING THE OPTICAL PATH

Place a white card in front of the recorder drum so the light beam will be clearly visible, and turn the lamp intensity up to the maximum. Adjust the light beam from the recorder to strike the galvanometer mirror. Now, by means of the zero adjust knob on the top of the unit, adjust the rest position of the coil and mirror assembly to obtain the correct lateral position of the reflected light beam on the recorder lens. During this adjustment, it may be helpful to short the input terminals together in order to over-damp the galvanometer and prevent oscillations of the mirror.

FOCUSING

When the light spot is correctly positioned, check that it is properly focused to achieve a thin, vertical line of light striking the recording surface. To focus the spot, rotate one of the two knurled rings until the image is a thin line. Rotate both rings together until the thin line is vertical. Repeat this procedure until a fine vertical line is obtained. If it is not possible to attain a satisfactory focus, rotate the lamp assembly of the recorder to align the filament.

DETERMINING THE NATURAL PERIOD

The natural period and critical damping resistance of this galvanometer are given on the data sheet which is sent with the instrument. If it is desired to verify these values, place a strip of recording paper on the recorder drum and run a test record as follows: observing the precaution in regard to excess voltage cited above, disconnect the input leads and put a 0.01= microvolt d-c pulse across the coil, so that the galvanometer oscillates.

> NOTE: To obtain accurate results, it is important that no load be connected to the instrument during oscillation. Make sure that the voltage source used does not present a constant load to the coil; see the pulse generating circuit on page 4.

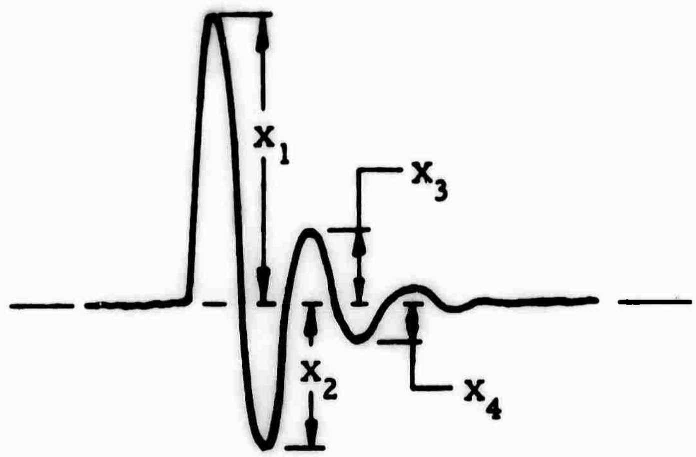
Allow the galvanometer to oscillate undisturbed for 15 or 20 minutes. Later, after developing the record, the number of oscillations per unit of time may be determined.

DETERMINING THE CRITICAL DAMPING RESISTANCE

Following the same procedure outlined in the paragraph above, disconnect all leads from the input terminals and put a small emf (0.01-microvolt) pulse across the coil. Again, be careful that the pulse generating circuit does not load the galvanometer; see pulse generating circuit on page 4 for a recommended setup. Determine the overshoot ratio by dividing the amplitude of one-half cycle by the amplitude of the previous half cycle as illustrated in Figure 2.

Using the overshoot ratio, determine the damping factor from Table I. The value thus obtained is the mechanical damping (mostly due to air resistance) of the galvanometer.

Next, loosen the shunt locking screw and push it all the way down. Then retighten this screw. This fully shunts the magnetic circuit yielding the lowest possible CDR and sensitivity. Put a 2000-ohm resistor across the terminals. Put a small voltage pulse across the coil (again being careful not to load the galvanometer with the voltage source), and determine the new overshoot ratio and damping factor.



$$E = \frac{X_2}{X_1} = \frac{X_3}{X_2} = \frac{X_4}{X_3}$$

Illustration of Method for Determining Overshoot Ratio (E) at a Specific Damping Resistance.

Figure 2.

TABLE 1

OVERSHOOT RATIO VS. DAMPING FACTOR

OVERSHOOT RATIO (E)	DAMPING FACTOR (h)	OVERSHOOT RATIO (E)	DAMPING FACTOR (h)
0.01	0.82609	0.51	0.20957
0.02	0.77970	0.52	0.20378
0.03	0.74480	0.53	0.19808
0.04	0.71565	0.54	0.19247
0.05	0.69011	0.55	0.18694
0.06	0.66713	0.56	0.18150
0.07	0.64608	0.57	0.17613
0.08	0.62658	0.58	0.17084
0.09	0.60833	0.59	0.16563
0.10	0.59116	0.60	0.16049
0.11	0.57489	0.61	0.15543
0.12	0.55942	0.62	0.15043
0.13	0.54465	0.63	0.14551
0.14	0.53051	0.64	0.14065
0.15	0.51693	0.65	0.13585
0.16	0.50387	0.66	0.13112
0.17	0.49127	0.67	0.12645
0.18	0.47911	0.68	0.12185
0.19	0.46735	0.69	0.11730
0.20	0.45595	0.70	0.11281
0.21	0.44490	0.71	0.10838
0.22	0.43417	0.72	0.10400
0.23	0.42374	0.73	0.09968
0.24	0.41359	0.74	0.09541
0.25	0.40371	0.75	0.09119
0.26	0.39409	0.76	0.08702
0.27	0.38470	0.77	0.08291
0.28	0.37554	0.78	0.07884
0.29	0.36660	0.79	0.07482
0.30	0.35786	0.80	0.07085
0.31	0.34931	0.81	0.06692
0.32	0.34096	0.82	0.06304
0.33	0.33278	0.83	0.05921
0.34	0.32478	0.84	0.05541
0.35	0.31694	0.85	0.05166
0.36	0.30926	0.86	0.04795
0.37	0.30173	0.87	0.04429
0.38	0.29435	0.88	0.04066
0.39	0.28710	0.89	0.03707
0.40	0.28000	0.90	0.03352
0.41	0.27302	0.91	0.03001
0.42	0.26617	0.92	0.02653
0.43	0.25945	0.93	0.02309
0.44	0.25284	0.94	0.01969
0.45	0.24634	0.95	0.01633
0.46	0.23996	0.96	0.01299
0.47	0.23368	0.97	0.00970
0.48	0.22750	0.98	0.00643
0.49	0.22143	0.99	0.00320
0.50	0.21545	1.00	0.00000

Having obtained these damping factors, a critical damping resistance is then computed by:

$$CDR = (h_t - h_m)(R_c + R_x)$$

where

CDR	=	critical damping resistance
h_t	=	damping factor determined with resistance across terminals
h_m	=	mechanical damping factor determined with no load
R_c	=	resistance of the coil (consult data sheet or measure directly)
R_x	=	resistance of external circuit

CAUTION: If R_c is measured directly, first turn the clamp screw clockwise to secure the movement so that the meter voltage cannot cause excessive deflection of the galvanometer. Then be sure that the meter is set to the correct range before connecting leads to the galvanometer.

Having determined the CDR when the magnet is shunted, repeat this procedure with the magnet unshunted. Loosen the shunt locking screw, push it all the way up (toward the "+") and retighten this screw. Use a 7500-ohm resistor instead of the 2000-ohm shunt across the coil.

Best response is normally obtained with critical damping (h_t = 1.0), although damping factors of 0.707 or other values are sometimes desirable. The above formula may be used to compute the value of R_x for any damping value. A typical set of calculations is shown below:

R_c = 503 ohms (measured)

R_x = 4300 ohms (measured)

E = 0.62 (measured, open circuit)

h_m = 0.15 (from Table I)

E = 0.27 (measured with resistance load)

h_t = 0.38 (from Table I)

CDR = (0.38 - 0.15) (503 + 4300)

= (0.23) (4803)

= 1105 ohms

Having determined the critical damping resistance, an appropriate external circuit resistance to give a damping factor of, say, 0.707 is easily calculated:

$$R_x = \frac{CDR}{h_t - h_m} - R_c$$

$$= \frac{1105}{0.707 - 0.15} - 503$$

$$= 1400 \text{ ohms}$$

317

CRITICAL DAMPING RESISTANCE ADJUSTMENT

If a different critical damping resistance is desired, loosen the magnet shunt screw (Figure 1, Item 4), push it up or down as needed, then retighten this screw. Pushing the screw (and shunt) upward increases CDR and sensitivity; pushing the screw (and shunt) downward decreases CDR and sensitivity. In order to determine the new value of the critical damping resistance for the new position of the shunt, repeat the tests described previously in "Determining the Critical Damping Resistance."

Changing the position of the magnetic shunt may have some effect on the natural period, so the period should be rechecked as outlined under "Determining the Natural Period."

MAINTENANCE

There should be no difficulty in obtaining perfect operation of the galvanometer, once it is properly set up. The greatest cause of galvanometer damage is failure to clamp the instrument properly prior to moving. If the galvanometer does not perform satisfactorily, Kinemetrics will be glad to render assistance and advice. Requests for assistance should include the operator's description of the trouble, a test record showing the instrument's period and overshoot ratio, and a typical recording made by the instrument during routine operation.

2200-1

OPERATION AND MAINTENANCE MANUAL

POWER SUPPLY, MODEL 14486

GEOTECH
A TELEDYNE COMPANY
3401 Shiloh Road
Garland, Texas

319

15 April 1967

BLANK PAGE

CONTENTS

320

ILLUSTRATIONS

* * * * * * * * * * *

TABLES

321

Figure 1. Power Supply, Model 14486

G 2655

322

BLANK PAGE

Impedance	Less than 1000 ohms
Dynamic range	60 dB from noise level to clipping level
Noise level	2.5 mV p-p max. within passband from 0.001 Hz to 10 Hz and 9.0 mV max. from 10.0 Hz to 450 kHz
Linearity	±2% from noise level to 80% of clipping level based on best straight line with a 0.01 Hz sine wave input
Drift	5.4×10^{-3} volts (based on an 8-hour test)
Stability	±15% change in the supply voltage will produce a maximum change in gain of 1% and a maximum change in dc offset of 2.5 mV

1.3.2 Power Requirements

Voltage	115/230 Vac ±15%, 50-60 Hz or 12.5 Vdc ±15% with a maximum ripple of 1.5 V p-p
Power	30 W at 115/230 Vac

1.3.3 Environmental Characteristics

Operating temperature	-40° to +65°C
Relative humidity	0 to 99%
Shock and vibration	Will withstand shocks and vibrations incurred during commercial shipment

1.3.4 Physical Characteristics

Height	266 mm (10.5 in.)
Width	260.3 mm (10.25 in.)
Length	304.8 mm (12 in.)
Weight	2.27 kg (5 lb)
Volume	2.26×10^{-2} m^3 (0.75 ft^3)

OPERATION AND MAINTENANCE MANUAL POWER SUPPLY, MODEL 14486

1. GENERAL INFORMATION

1.1 PURPOSE OF THE EQUIPMENT

The Power Supply, Model 14486, is used to provide power for a phototube amplifier and has two amplifier channels.

1.2 DESCRIPTION OF THE EQUIPMENT

The power supply is totally enclosed so that it will not be adversely affected by temperature changes within the temperature range. The power supply is a signal conditioner and an ac-dc power supply utilizing self-regulation and a dc to dc converter to furnish both internal and external power. The Power Supply, Model 14486, is shown in figure 1.

1.3 SPECIFICATIONS

1.3.1 Operating Characteristics

Input circuits	
Number	1
Type	Balanced
Output circuits	
Number	2
Type	Either balanced or unbalanced to ground
Amplification	1.0×10^6
Linear output	Maximum of 30 volts p-p into a 1-megohm load Minimum of 16 volts p-p into a 10K ohm load

1.3.5 Connectors

Power in	MS 3102A-16S-1P
Power out/signal in	MS 3102A-20-27S
Channel 1 outputs	MS 3102A-14S-2S
Channel 2 outputs	MS 3102A-14S-2S

2. INSTALLATION

2.1 UNPACKING

Remove the unit from its shipping container and inspect for shortages. Claims for damage should be filed promptly with the carrier.

2.2 OPTIONAL WIRING

Unless otherwise specified, Power Supply, Model 14486, is shipped wired for 115 volts, 50-60 Hz operation. For operation on 230 volts, 50-60 Hz, or on 12 volts dc, wire Terminal Board Assembly, P/N 15735, in accordance with figure 10 (optional wiring for 12 Vdc or 230 Vac operation). For dc operation change F201 fuse and fuseholder to components rated at 3 amperes and add Power Conversion Plate, P/N 16723. (Fuse, fuseholder, and plate are furnished.)

2.3 MOUNTING

Power Cord Assembly, P/N 16724, is supplied for connecting the power supply to a source of ac or dc power. Remove the cover from the power supply and inspect V201 and V202 to see that they are unbroken and properly seated in their sockets. Install filters FL201 (6824-15) and FL202 (6824-14) in channel 1 and channel 2, respectively, of the power supply chassis. Replace cover.

2.4 PREPARATION FOR RESHIPMENT

Prior to reshipment, remove the power supply cover and remove filters FL201 and FL202. Replace the cover of the power supply and pack in a suitable container.

3. OPERATION

3.1 CONTROLS AND INDICATORS

This section identifies the controls and indicators of the power supply. Table 1 lists the name, index number, reference designation, and the function of each front panel control. The index number is taken from figure 2.

Table 1. Controls and indicators

Name	Index No.	Ref des	Function
Power .5A SLO-BLO	1	XF201 F201	Fuseholder and fuse indicates whenever fuse is blown
Power 3A SLO-BLO	2	XF202 F202	Fuseholder and fuse indicates whenever fuse is blown
OFF	3	S201	Controls operating power to power supply
	4	DS201	Indicates when power is applied to the power supply
Channel 1 ZERO ADJ	5	R232	Adjusts zero signal balance of output cathode follower stage
Channel 2 ZERO ADJ	6	R223	Adjusts zero signal balance of output cathode follower stage
		R208	Adjusts regulator to determine dc output of the power supply

4. PRINCIPLES OF OPERATION

4.1 INTRODUCTION

This section discusses the principles of operation of the power supply. Figure 3 is a block diagram of the power supply that should be referred to in discussion that follows.

Figure 2. Controls and indicators G 2656

327

M-14486

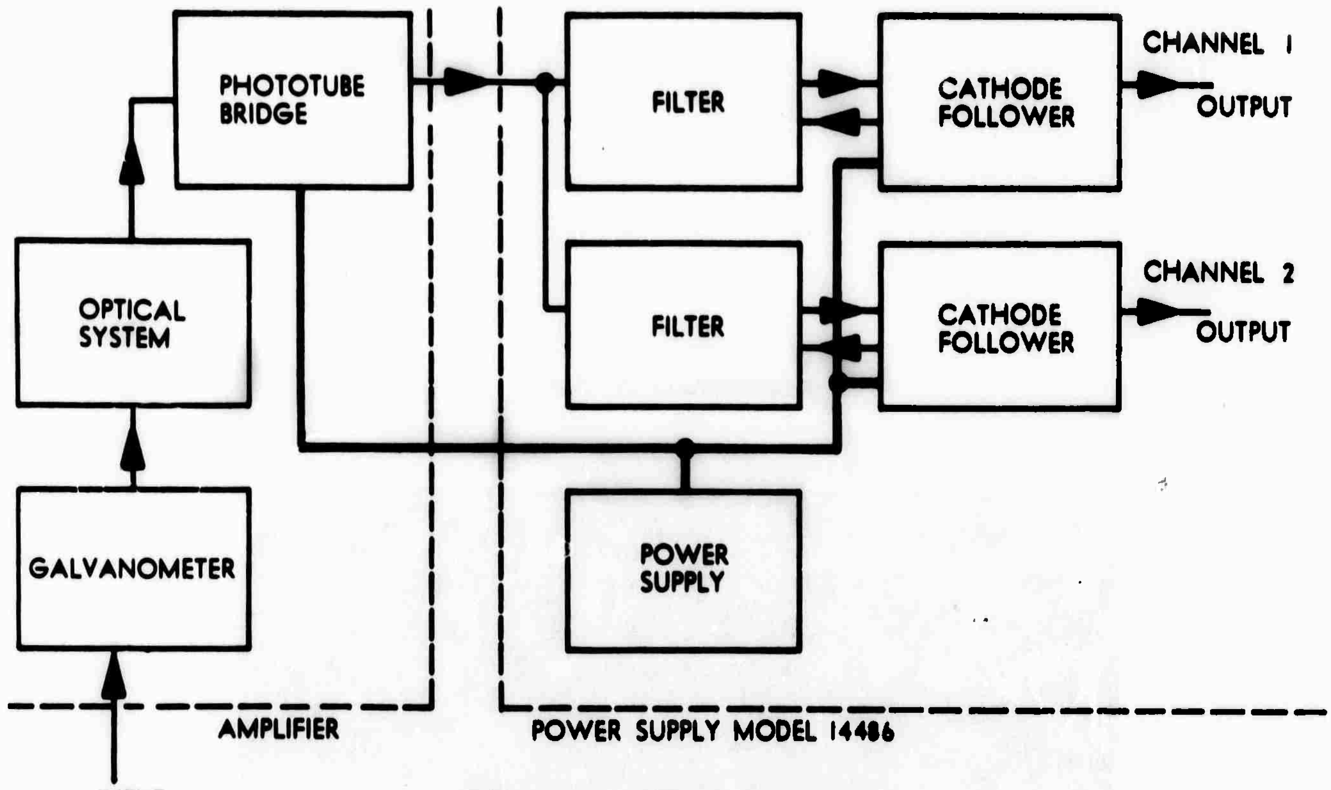


Figure 3. Block diagram

4.2 POWER SUPPLY PRINCIPLES OF OPERATION

4.2.1 The power supply is a signal conditioner and related power converter. Power connector J201 and Terminal Board Assembly, P/N 15735, may be wired for either 115 volts ac, 50-60 Hz; 230 volts ac, 50-60 Hz; or for 12 volts dc operation. Ac inputs are rectified by a bridge rectifier, consisting of silicon rectifiers CR201 through CR204, and filtered by capacitor C201 before being applied to the regulator network and the dc-to-dc converter. The regulator network, Q201 through Q205, and differential amplifier, Q206 and Q207, regulate the dc voltage applied to the converter, consisting of Q208, Q209, and toroid transformer T202, which operates at approximately 3.8 kHz. This converter output is rectified by two bridge rectifiers consisting of silicon diodes CR206 through CR213. These outputs are capacitor filtered and supply 150 volts dc to the cathode followers.

4.2.2 Filament supply voltages are taken from three separate windings on transformer T202: the exciter lamp voltage, 2.9 volts from terminals 10 and 11, for the phototube amplifier; filament voltages 6.3 volts from terminals 14 and 15, for V201 and V206; and filament voltage for V101, of the phototube amplifier, terminals 12 and 13. A 4.8-volt winding is provided to reduce noise.

5. MAINTENANCE

5.1 INTRODUCTION

This section contains information necessary to maintain the Power Supply, Model 14486.

5.2 ROUTINE ADJUSTMENT PROCEDURES

Routine adjustment procedures are necessary for proper operation of the power supply. These adjustments should be performed during initial installation and after repair or other maintenance.

NOTE

The ground connections of the scope probes should be connected to pin D on the output connectors. Under no condition shall pin A of the output connectors be grounded.

5.2.1 Noise Test

With no signal applied, connect a dual channel calibrated oscilloscope at the power supply outputs. The maximum peak-to-peak noise level in the frequency band of dc to 10 Hz should be less than 2.5 mV for each output channel. The overall maximum peak-to-peak noise level shall be less than 9 mV for each channel.

5.2.2 Output Test

Arrange equipment as shown in figure 4. Adjust the function generator for 0.01 Hz sine wave output. The peak-to-peak output of channel 1 and channel 2 of the power supply, as observed on an oscilloscope, should be at least 16 volts with a 10K ohm load on the outputs of the power supply. Adjust the input level so that the output of each channel is approximately 1 volt peak-to-peak. Load each output with a 10K ohm resistor. Each output should be decreased less than 6.5 percent.

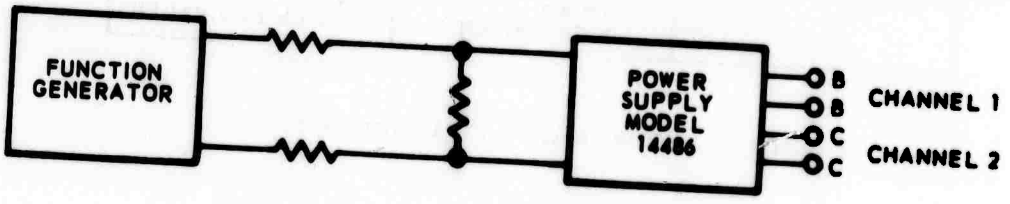


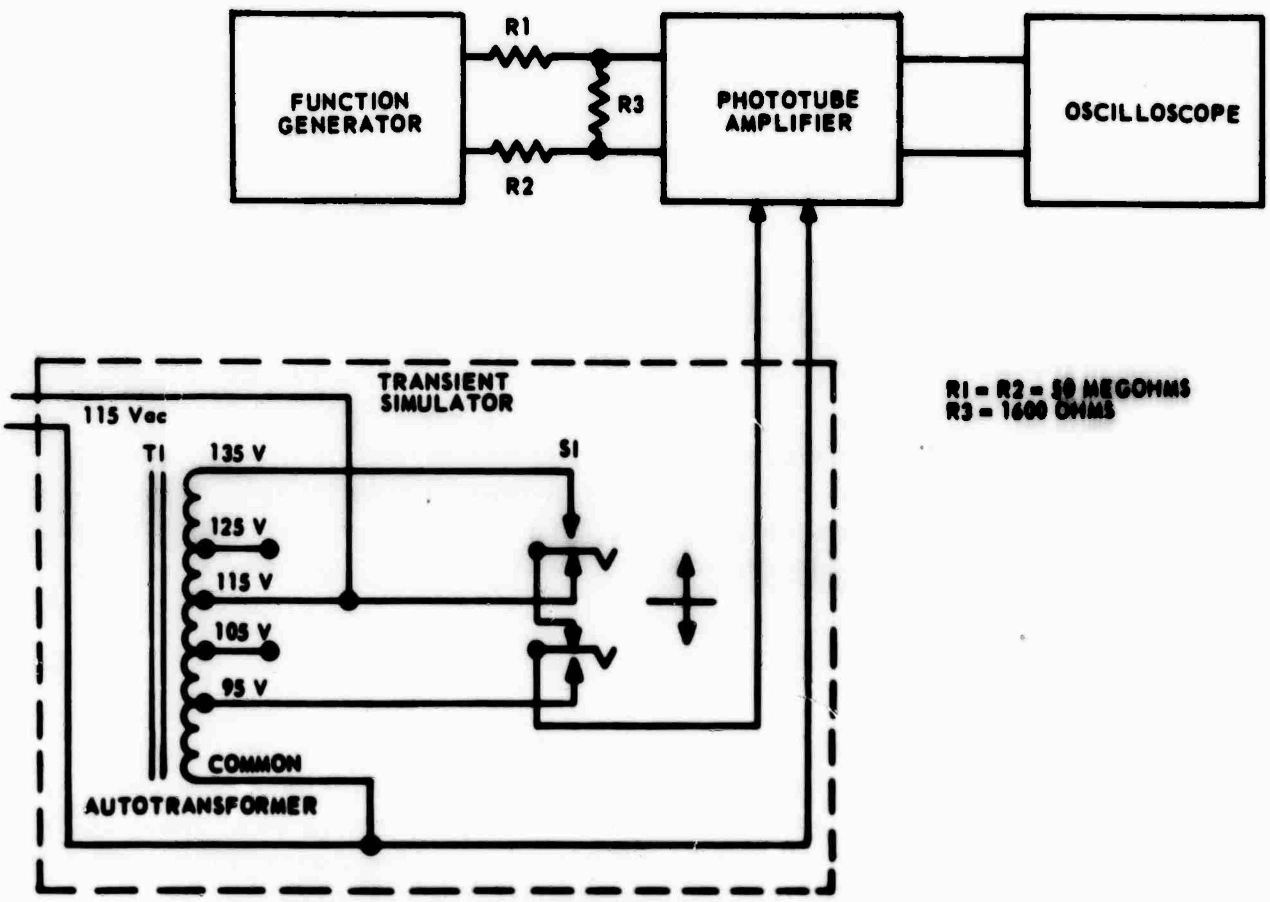
Figure 4. Test setup for output test

5.2.3 Drift Test

Load each output of the power supply with a 10K ohm resistor and ground pin D of each of the outputs. Allow the power supply to stabilize for 8 hours. Using an oscilloscope, observe the output voltage and record the voltage and time. Repeat this procedure every hour for 8 hours. The total drift should be less than 5.4 mV for each channel.

5.2.4 Power Line Variation Test

Arrange equipment as shown in figure 5. Perform test as in table 2.



DESIGNATION	MANUFACTURER	PART NO.
T1 S1	TRIAD MICROSWITCH	N-34X OR EQUIVALENT 13AT2 OR EQUIVALENT

Figure 5. Power line variation test setup G 2657

Table 2. Power line variation test

Step	Operation of test equipment	Point of test	Control settings	Performance standards
1	Adjust function generator for a convenient output below clipping level. Measure gain with SW1 in 115 volts position, 135 volts position, and 95 volts position	J210 and J211	Not applicable	Gain shall not vary more than 1% from the 115 volts standard
2	Adjust function generator output to zero. Operate SW1 to the 95 volts position while observing the output. Return SW1 to the 115 volts position while observing the output	J210 and J211	Not applicable	Observe the peak output on a dc oscilloscope, with a sweep speed of 0.2 sec/cm or less, at each switching operation. The maximum output observed must be less than 2.5 mV
3	Repeat step 2, using the 135 volts position of SW1	J210 and J211	Not applicable	As in step 2
4	Repeat steps 1, 2, and 3 for channel 2	J212 and J213		

6. REPLACEABLE PARTS

6.1 GENERAL

This section consists of a parts breakdown for the Power Supply, Model 14486. This information is presented for the identification and requisition of replacement parts or assemblies.

6.1.1 Part Numbering System

The manufacturer's (prime contractor) part number consists of a group of numbers and letters which identify the part. Vendors' part numbers and military standard numbers also appear in the listing in the part number column.

6.1.2 Vendor's Parts or Assemblies

Vendor's items are listed by the vendor's part number. The vendor's code is listed in the manufacturers' code column (Mfr code), and the vendor's name and address can be determined from the list of manufacturers.

6.2 CODE OF MANUFACTURERS

The code numbers listed in table 3 are extracted from the Federal Cataloging Handbook, H4-1.

Table 3. Code of manufacturers

Code number	Vendor's name and address
00656	Aerovox Corporation, New Bedford, Mass.
01295	Texas Instruments Inc., Semiconductor-Component Division, Dallas, Texas
02660	Amphenol Corporation, Broadview, Illinois
04713	Motorola Semiconductor Products, Inc., Phoenix, Arizona
08807	General Electric Company, Photo Lamp Department, Cleveland, Ohio

Table 3, Continued

Code number	Vendor's name and address
15605	Cutler-Hammer, Inc., Milwaukee, Wisconsin
37942	Mallory, P. R., and Co., Inc., Indianapolis, Indiana
44655	Ohmite Manufacturing Co., Skokie, Illinois
53021	Sangamo Electric Company, Springfield, Illinois
70485	Atlantic India Rubber Works, Inc., Chicago, Illinois
70903	Belden Manufacturing Co., Chicago, Illinois
71279	Cambridge Thermionic Corp., Cambridge, Mass.
71400	Bussman Manufacturing Division of McGraw-Edison Company, St. Louis, Missouri
72619	Dialight Corporation, Brooklyn, New York
72653	G. C. Electronics Company Rockford, Illinois
72825	Eby, Hugh H., Inc., Philadelphia, Pennsylvania
74970	Johnson, E. F., Company, Waseca, Minnesota
75042	I R C, Incorporated, Philadelphia, Pennsylvania
80183	Sprague Products Company, North Adams, Mass.

Table 3, Continued

Code number	Vendor's name and address
80294	Bourns, Incorporated, Riverside, California
84171	Arco Electronics, Incorporated, Great Neck, New York
88419	Cornell-Dubilier Electric Corp., Electro-Mechanical Division, Varina, North Carolina
91637	Dale Electronics, Incorporated, Columbus, Nebraska
92194	Alpha Wire Corporation, Elizabeth, New Jersey
98003	Nielson Hardware Corporation, Hartford, Connecticut
99019	Geotech, A Teledyne Company, Garland, Texas

6.3 COMPONENTS

Listings in the tables of replaceable parts and items called out on illustrations constitute a partial breakdown of the equipment. Included are all electrical parts and those operative mechanical parts that are subject to loss or failure. Omitted are the structural and minor parts, such as standard bolts, nuts, and screws.

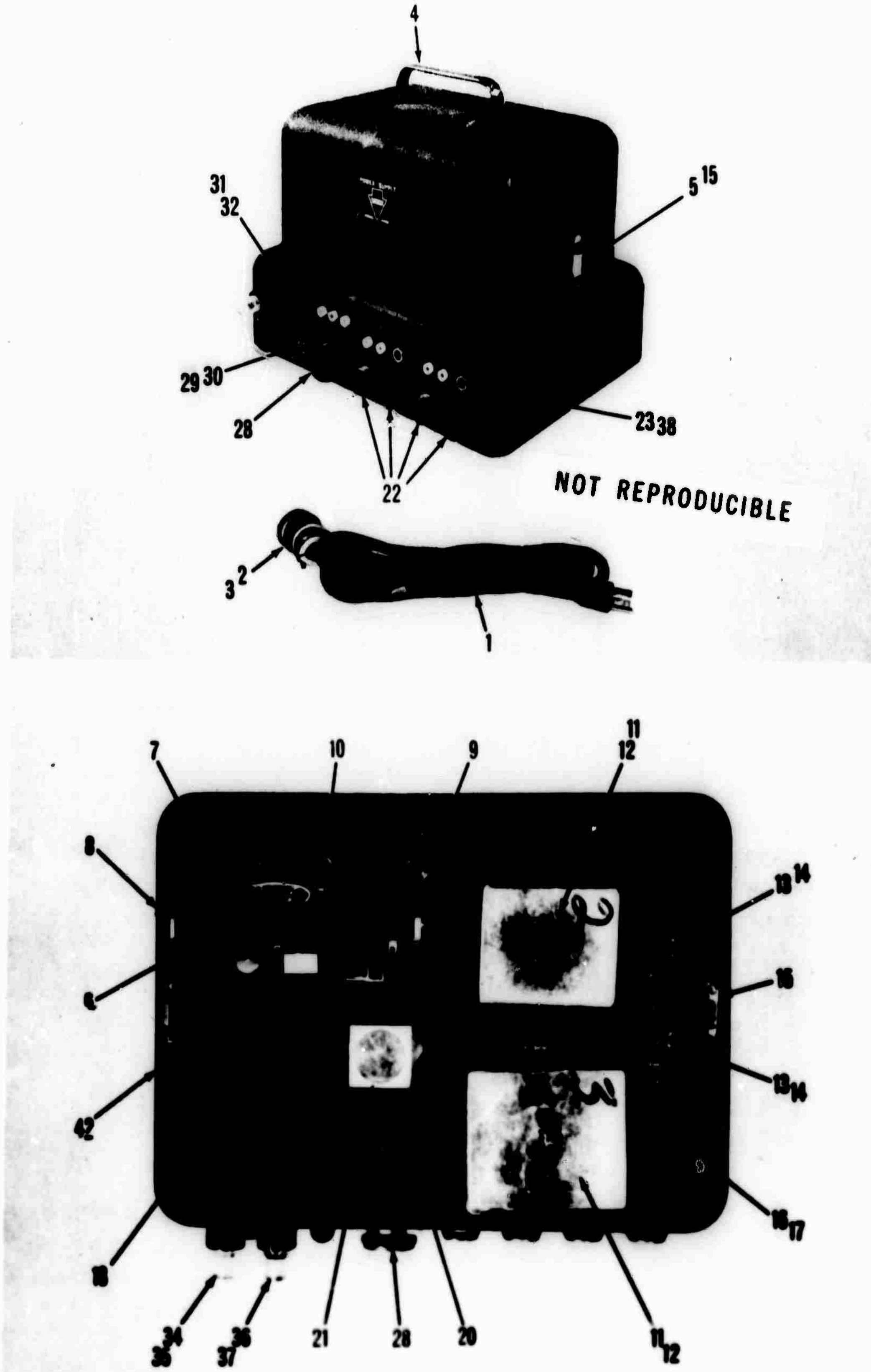


Figure 6. Power supply assembly parts identification (sheet 1 of 2) C 2638

ILLUSTRATED PARTS BREAKDOWN

Figure & index No.	Part No.	Description	Mfr code	Recommended spare parts
6-	14486	Power supply assembly		
	16724	. Power cord assembly		
-1	17408M	. . Cord, power, incl 3 pin plug	70903	
-2	MS3106A-16S1S	. . Connector, plug, electrical		
-3	MS3057-8	. . Clamp, cable		
	PVC105-10	. . Shielding	70331	
	15717	. Top chassis assembly		
-4	2111A	. . Handle	71279	
-5	HC204N	. . Catch, pull down	98003	
	X200	. . Channel, rubber	70485	
	15197	. . Chassis, top		
-6	15729	. Regulator, power supply, printed circuit board		
-7	15721	. Heat sink assembly (see figure 8 for breakdown)		
-8	16791	. Bracket, mounting		
-9	15902	. Bracket, mounting		
-10	H034F	. Grommet, rubber	72653	
-11	6824-14	. Filter assembly		
-12	77MIP11	. Socket, electron tube	02660	
-13	12AT7WA	. Tube, electron		
-14	9799-22	. Socket, tube	72825	
15	HS220-28	. Strike	98003	
-16	16087	. Dummy plug assembly		
-17	77MIP8	. Socket, tube	02660	
-18	15723	. Transformer		2
-19	15735	. Terminal board assembly, power switching		
-20	15734	. Transformer assembly, toroid		1
-21	60V06-2	. Capacitor, fixed, paper dielectric, 2 mfd, 600 Vdc, w/type A mtg bracket	53021	
	MS3106A-14S2P	. Connector, plug, electrical		
-22	MS3102A-14S2S	. Connector, receptacle, electrical		
-23	CLU1041	. Resistor, variable, 100K	44655	
	4980	. Spacer		
-24	2045F4	. Insulator, standoff	71279	

Figure & index No.	Part No.	Description	Mfr code	Recommended spare parts
-25	4DP3-503	. Capacitor, fixed, paper, dielectric, .05 mfd, 400 Vdc	84171	
-27	AS3	. Resistor, fixed, wire-wound, 0.39 ohms, 3 W, ±3%	75042	
-28	MS3102A-2027S	. Connector, receptacle, electrical		
-29	8360K6	. Switch, toggle, DPST	15605	
-30	29-761	. Ring, lock	15605	
-31	330	. Lamp	08807	3
-32	101-5030-932	. Holder, lamp	72619	
-33	MS3102A-16S1P	. Connector, receptacle, electrical		
-34	3AG1/2	. Fuse, 1/2 amp, Slo-Blo	71400	5
-35	HKL	. Holder, fuse	71400	
-36	3AG3	. Fuse, 3 amp, Slo-Blo	71400	5
-37	HKT	. Holder, fuse	71400	
	105-612	. Tip, jack, violet	74970	
	105-607	. Tip, jack, yellow	74970	
-38	4889	. Bushing, panel		
-39	HC4040A	. Capacitor, fixed, electrolytic, 4000 mfd, 40 Vdc	37942	1
	PLA6	. Cap, end	37942	
	HB8	. Bracket, mounting, capacitor	37942	
-40	HC2060A	. Capacitor, fixed, electrolytic, 6000 mfd, 20 Vdc	37942	1
	PLA6	. Cap, end	37942	
	HB8	. Bracket, mounting, capacitor	37942	
	143D18-01	. Connector	02660	
-41	15725	. Amplifier, power supply, printed circuit board		
	1075F	. Feet, rubber	72653	
	15719	. Base plate		
	2900	. Name plate (mounted on rear of chassis)		
-42	15716	. Bottom case assembly		
	PVC105-10	. Tubing, plastic, black	70331	
	PVC105-11	. Tubing, plastic, black	70331	
	PVC105-20	. Tubing, plastic, black	70331	

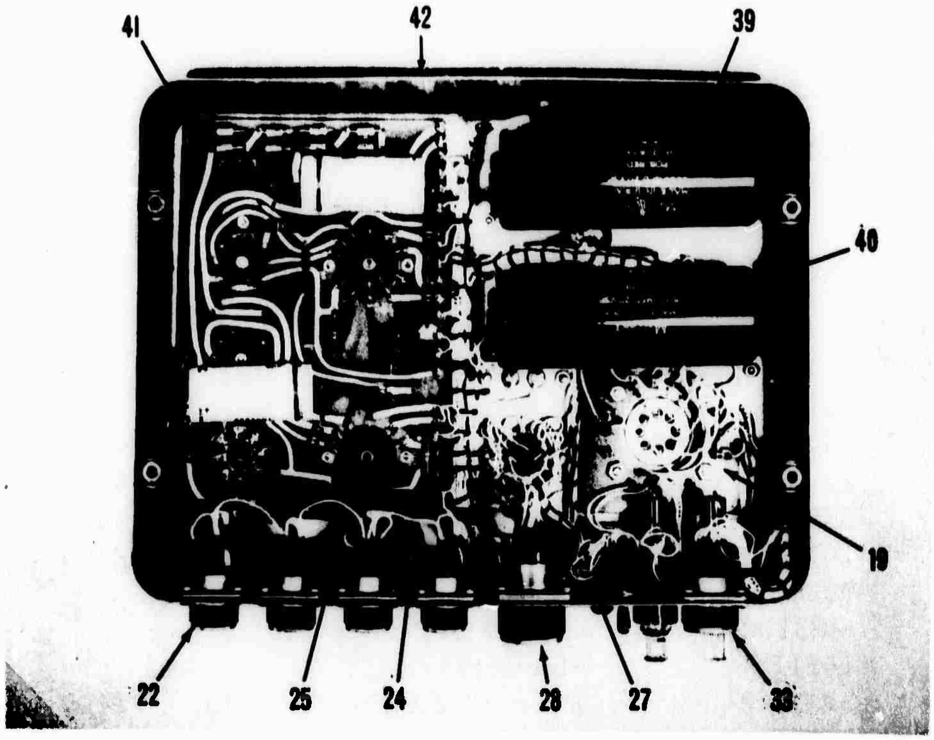


Figure 6. Power supply assembly parts identification (sheet 2 of 2) G 2659

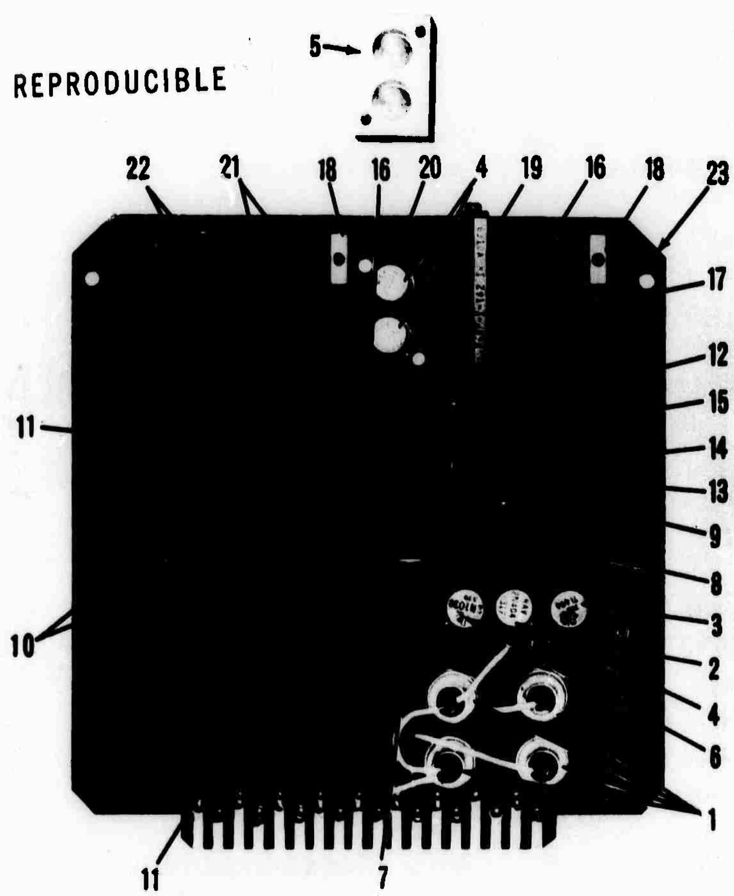


Figure 7. Power supply regulator parts identification G 2660

Figure & index No.	Part No.	Description	Mfr code	Recommended spare parts
7-	15729	Regulator, power supply, printed circuit board		2
-1	1N1538	. Semiconductor device, diode		6
-2	RC20GF473J	. Resistor, fixed, composition, 47K, 1/2 W, ±5%		
-3	TI494	. Transistor	01295	3
	Coml	. Insulator, plate, Transipad		
-4	2N404	. Transistor		5
	Coml	. Insulator, plate, Transipad		
-5	15718	. Heat sink assembly		
	Coml	. Washer, nonmetallic, fiber, No. 2		
-6	2N1038	. Transistor		
	Coml	. Insulator, plate, Transipad		
-7	RC32GF-391J	. Resistor, fixed, composition, 390 ohms, 1 W, ±5%		
-8	PWE25	. Capacitor, fixed, electrolytic, 25 mfd, 25 WVdc	00656	
-9	PWE100	. Capacitor, fixed, electrolytic, 100 mfd, 15 WVdc, type PWE	00656	
-10	MPY2W1	. Capacitor, fixed, paper dielectric, metallized, 1 mfd, 200 WVdc	88419	2
-11	242E	. Resistor, fixed, wirewound, 30 ohms, 3 W, ±5%	80183	
-12	1N751A	. Semiconductor device, diode, Zener		1
-13	RC20GF392J	. Resistor, fixed, composition, 3.9K, 1/2 W, ±5%		
-14	RC20GF752J	. Resistor, fixed, composition, 7.5K, 1/2 W, ±5%		
-15	RS220	. Resistor, fixed, wirewound, 220 ohms, 1/2 W, ±1%	91637	
-16	RS1500	. Resistor, fixed, wirewound, 1.5K, 1/2 W, ±1%	91637	

Figure & index No.	Part No.	Description	Mfr code	Recommended spare parts
-17	RC20GF-152J	. Resistor, fixed, composition, 1.5K, 1/2 W, ±5%		
-18	105-757	. Jack, tip, horizontal	74970	
-19	260P-1-102	. Resistor, variable, wirewound, 1K, 1 W, ±10%, subminiature	80294	
-20	RC20GF-222J	. Resistor, fixed, composition, 2.2K, 1/2 W, ±5%		
-21	RC20GF-122J	. Resistor, fixed, composition, 1.2K, 1/2 W, ±5%		
-22	AS	. Resistor, fixed, wirewound, 0.1 ohm, 3 W, ±3%	75042	
-23	15730	. Printed circuit board subassembly		
8-	15721	Heat sink assembly		
-1	2N1545	. Transistor		10
-2	2N1551	. Transistor		10
-3	MK15	. Holder, semiconductor device, kit, mounting	04713	6
-4	15722	. Bracket, semiconductor device set, heat sink modification		

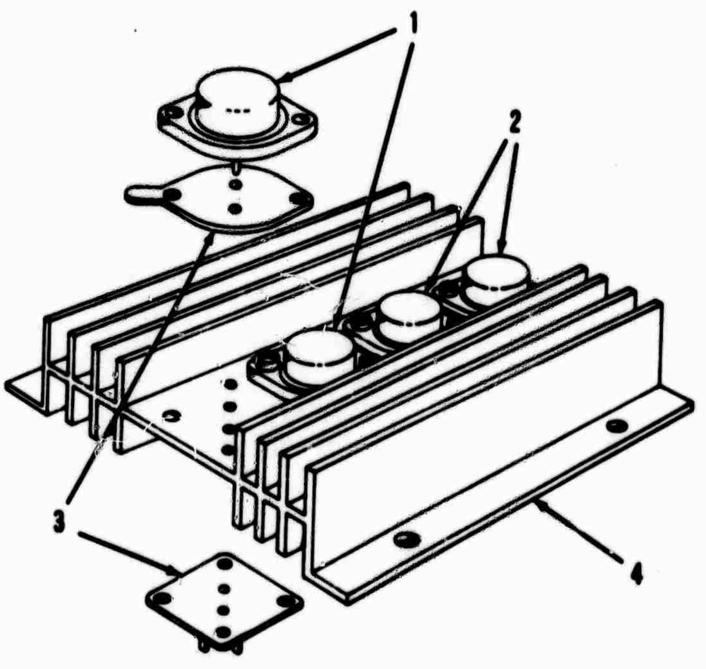


Figure 8. Heat sink assembly parts identification G 2661

NOT REPRODUCIBLE

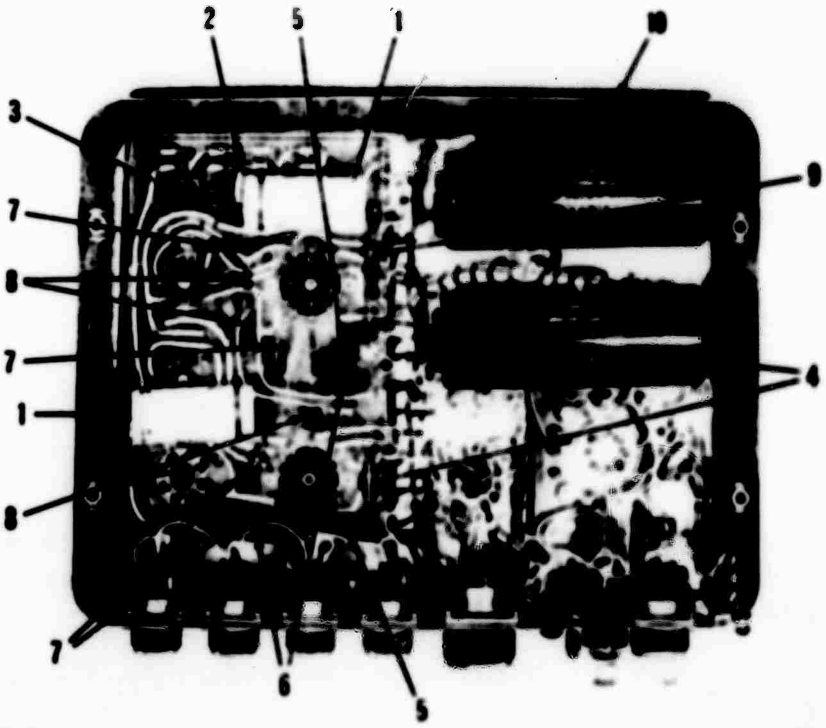


Figure 9. Power supply amplifier parts identification G 2662

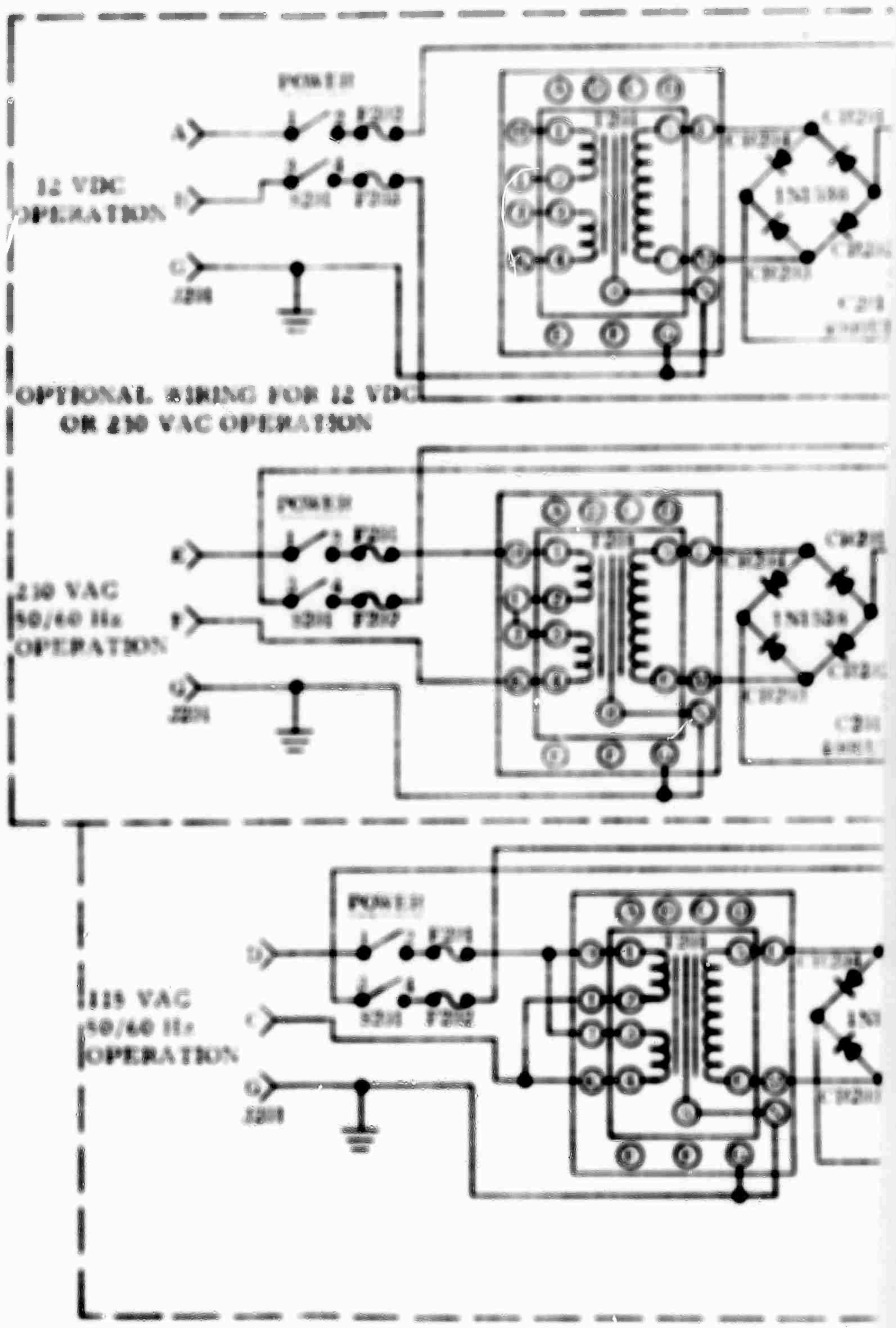
Figure & index No.	Part No.	Description	Mfr code	Recommended spare parts
9-	15725	Amplifier, power supply, printed circuit board		
-1	TVA1422	. Capacitor, fixed, electrolytic, 150 mfd, 150 WVdc	04713	2
-2	IN2613	. Semiconductor device diode		8
-3	RC20GF-124J	. Resistor, fixed, composition, 120K, 1/2 W, ±5%		
-4	RC32GF-623J	. Resistor, fixed, composition, 62K, 1 W, ±5%		
-5	RC32GF-562J	. Resistor, fixed, composition, 5.6K, 1 W, ±5%		
-6	RC32GF-223J	. Resistor, fixed, Composition, 22K, 1 W, ±5%		
-7	RC32GF-103J	. Resistor, fixed, composition, 10K, 1 W, ±5%		

Figure & index No.	Part No.	Description	Mfr code	Recommended spare parts
-8	RC20GF-105J	. Resistor, fixed, composition, 1 meg, 1/2 W, ±5%		
-9	RC32GF-363J	. Resistor, fixed, composition, 36K, 1 W, ±5%		
-10	15726	. Printed circuit board subassembly		

7. CIRCUIT DIAGRAM

The schematic diagram pertaining to the Power Supply, Model 14486, is included in this section. This diagram will assist maintenance personnel in maintaining these units.

342


POWER
12 VDC
OPERATION
OPTIONAL WIRING FOR 12 VDC
OR 230 VAC OPERATION
POWER
230 VAC
50/60 Hz
OPERATION
POWER
115 VAC
50/60 Hz
OPERATION

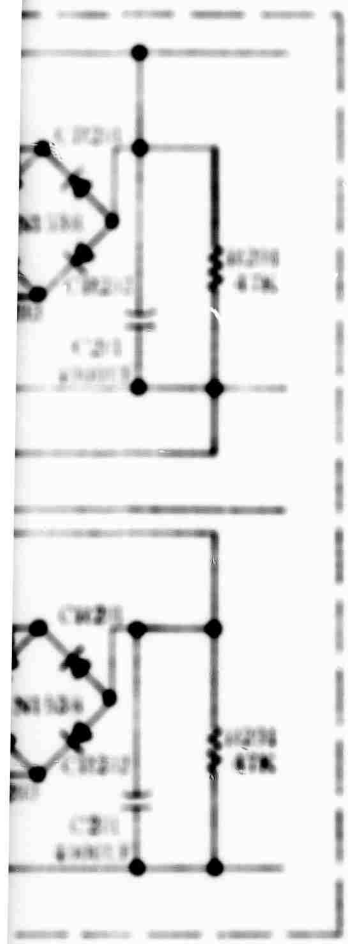
VOLTAGE AND RESISTANCE DATA

		PIN NO.								
		1	2	3	4	5	6	7	8	9
V100	E	•150VDC	•44VDC	•44VDC	0	0	•150VDC	•44VDC	•44VDC	6.4VAC
	R	APPROX. 100K•	• ••	470K	•	•	APPROX. 100K•	500K	470K	•
V200	E	150VDC•	•25VDC	•25VDC	6.3VAC	6.3VAC	•150VDC	•25VDC	•25VDC	
	R	APPROX. 100K•	6 MEG.	10K	•	•	APPROX. 100K•	6 MEG.	10K	•
V202	E	•150VDC•	•25VDC	•25VDC	6.3VAC	6.3VAC	•150VDC	•25VDC	•25VDC	
	R	APPROX. 100K•	6 MEG.	10K	•	•	APPROX. 100K•	6 MEG.	10K	•

VOLTAGES AND RESISTANCES MEASURED WITH RESPECT TO J206
VOLTAGE AND RESISTANCE MEASUREMENTS MADE WITH HP 410B
VTVM WITH NO SIGNAL INPUT.

- • OHMMETER POLARITY MUST BE TAKEN INTO ACCOUNT. TUBE PIN NEG. (−), WILL READ FORWARD RESISTANCE OF CR206, CR207, CR208, AND CR209 WHICH WILL MEASURE LESS THAN 10 OHMS
- •• MEASUREMENT MADE WITH V 102 AND V 103 IN TOTAL DARKNESS.

DO NOT CONNECT PIN A OF CONNECTORS J210 THROUGH J214 TO GROUND



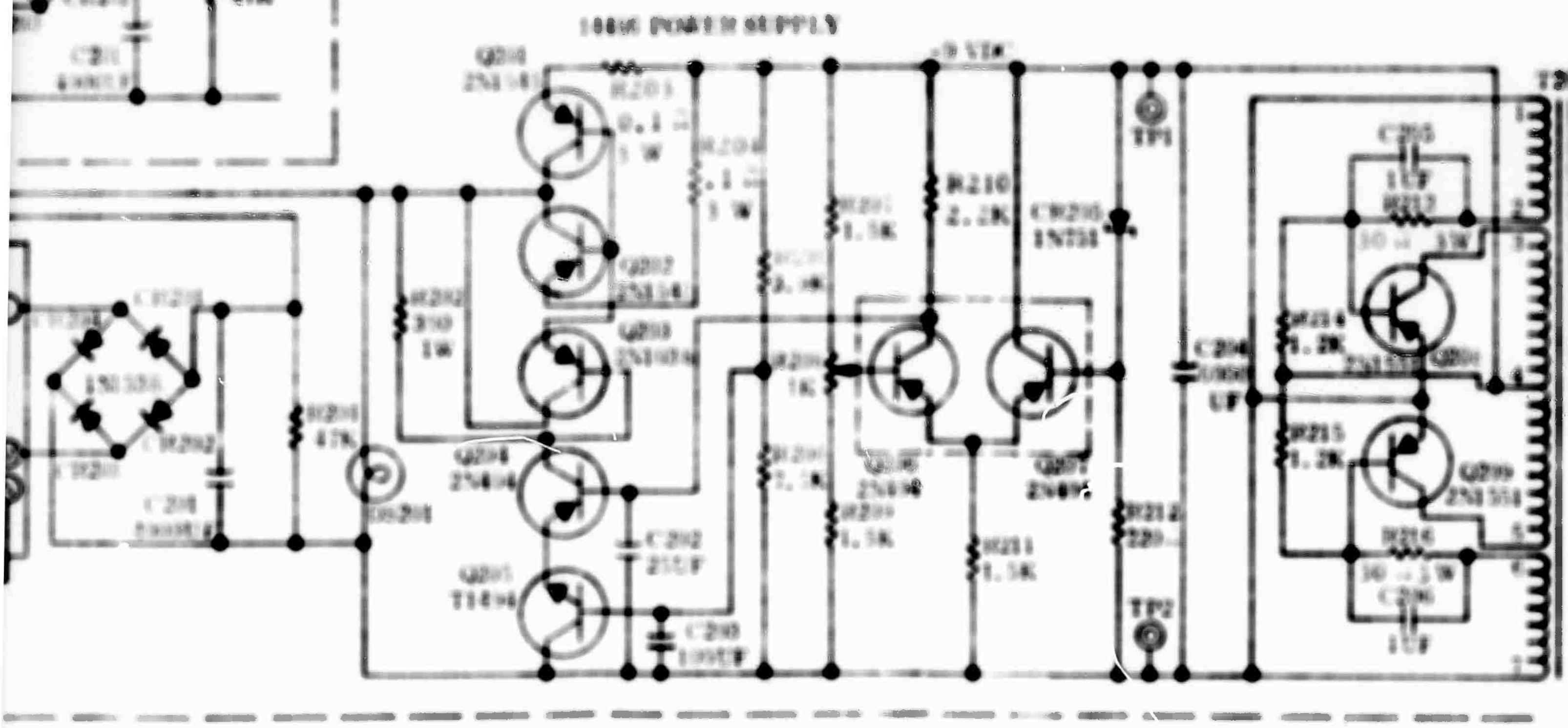
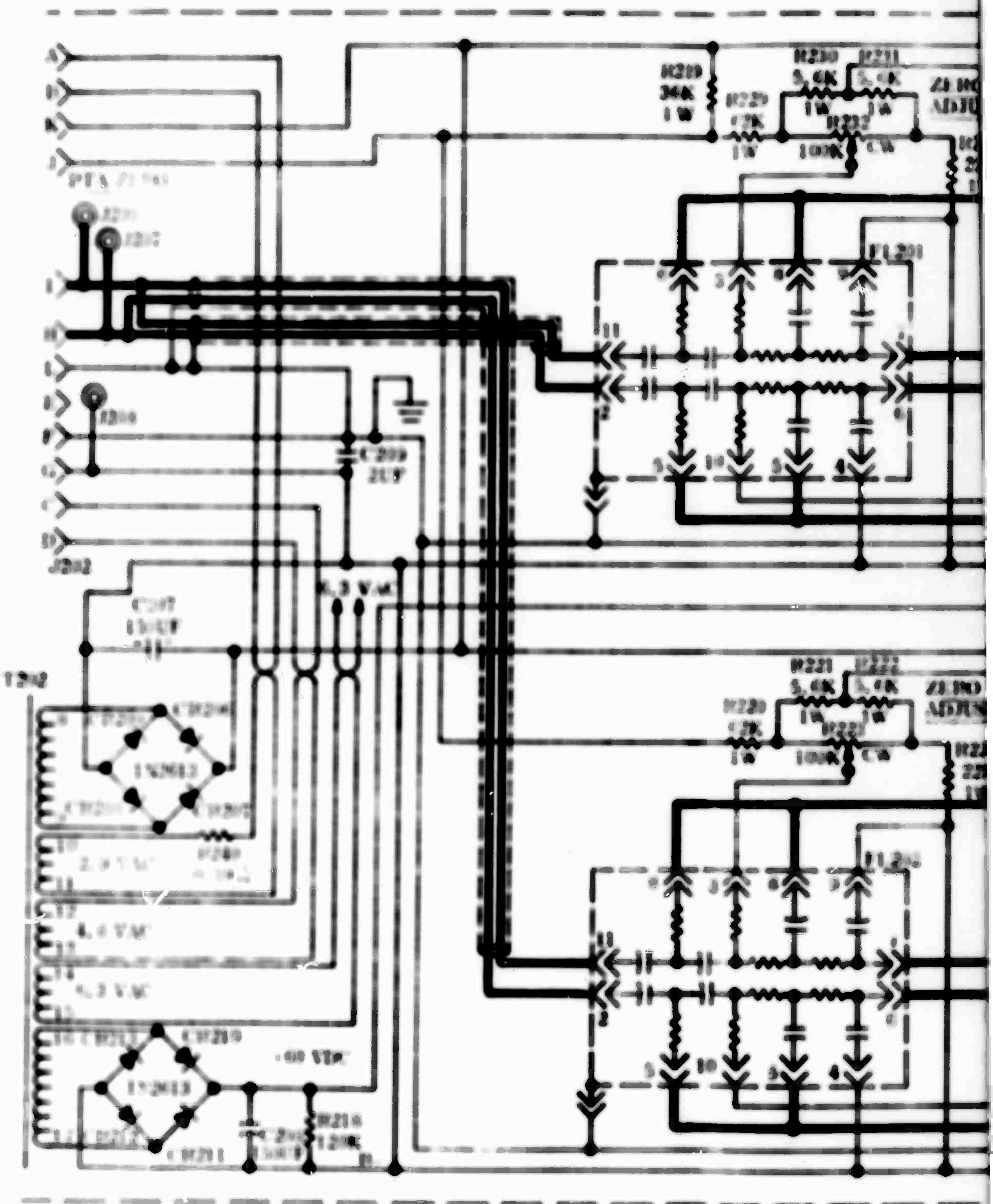


Figure 10. Schematic diagram (Sheet 1 of 2)

3434

BLANK PAGE

2200-29



R219
36K
1W
R230
5.6K
1W
R231
5.6K
1W
R232
100K
CW
ZERO ADJ
FL201
C209
2UF
J202
6.3 VAC
T202
1N2612
2.5 VAC
6.3 VAC
R221
5.6K
1W
R220
22K
1W
100K
CW
ZERO ADJ
1N2613
R216
120K

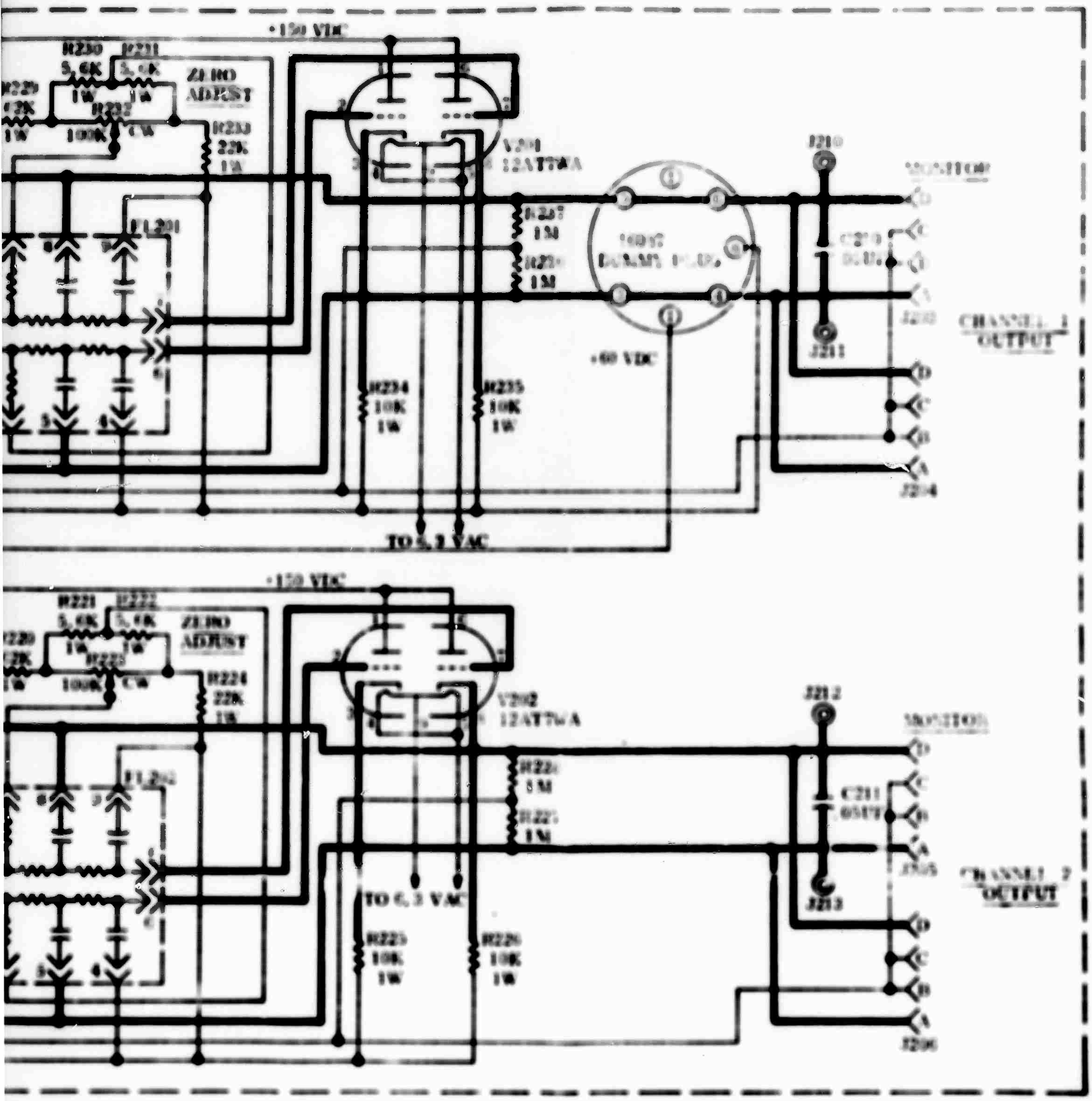
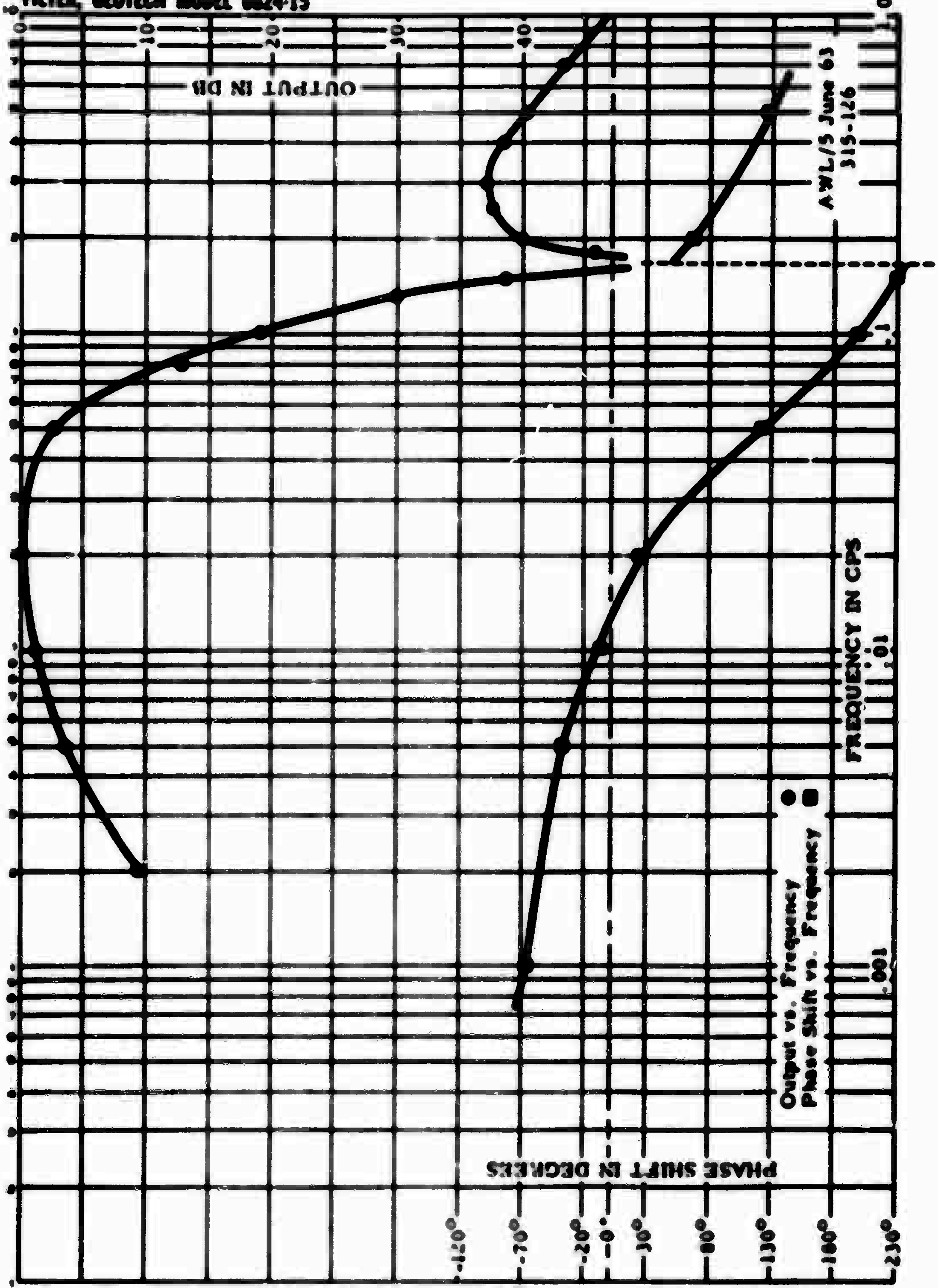


Figure 10. Schematic diagram (Sheet 2 of 2)

FILTER, GEOTECH MODEL 6824-15



Instuction Manual for Regulated Power Supply for Displacement Transducers

EXI-164

Specifications and Features

1.0 ELECTRICAL

1.1 Input----105-125 VAC, 47-420 CPS

1.2 Output Voltage-Output current

a) Slot Supply----0-25 Volts at 0.750 amperes, set in four overlapping ranges by means of internal quick disconnect transformer taps.

b) Wide Range Supply----0-25 Volts at 0.500 amperes, continuously adjustable by means of internal coarse and fine controls.

1.3 Regulation (line)----Better than ± 0.005% from 105-125 or 125-105 volts AC

1.4 Regulation (load)----Better than ± 0.005% from full load to no load or from no load to full load.

1.5 Ripple---- less than 250 microvolts rms

1.6 Response Time---- less than 20 microseconds

1.7 Temperature Coefficient---- Better than 0.01% per degree centigrade.

1.8 Long Term Stability---- Better than 0.025% for eight hours.

1.9 Output Impedance---- 0.00333 ohms or less from DC to 1KC. Above 1KC the outputimpedance increases by a factor of ten for each decade increase in frequency.

1.10 Overload and Short Circuit Protection---- Solid state short circuit and overload protected. Automatic recovery after removal of short circuit. Unit cannot be damaged by prolonged short circuits or overloads.

1.11 Polarity---- May be either positive, negative or floating up to 300 volts above chassis.

Operating temperature---- Continous duty from -20C to + 71 C ambient.

1.12 Storage Temperature---- -55C to +85C.

1.13 Output Current Vs Temperature---- Unit is rated at 0.750 amperes at 40 C ambient and is derated linearly to 0.5 amperes at 71°C. A modest amount of forced air cooling will permit full output current at 71 C.

1.14 Voltage Sensing---- Provisions are included for either Local Sensing or Remote Sensing. Refer to Figures 2,3, 4, and 5 for details.

1.15 Resistive Programming---- Provisions are included for programming the output resistively. Refer to Figure 3.

1.16 Voltage Programming---- Provisions are included for programming the output by means of an external voltage. Refer to Figure 6.

1.17 Tracking---- Tracking between output is 0.5 MV/ volt. Consult factory for connections.

1.18 Components----All components are conservatively rated and are of the highest quality. The transformer is MIL-T-27 quality, and the capacitors are 85 C types. All components are readily accessible and replacement in the field if required.

2.0 Mechanical Specifications 2300-2

2.1 Mounting:

The UNI-164 may be mounted on any one of three surfaces as shown in Fig. 1. It may also be mounted in any position desired. Mounting is accomplished by means of 10-32 screws or 10-32 studs. Both the screws and studs are supplied with each power supply.

2.1.1 Rack Mounting

The case is designed to permit mounting up to four units on a single 3½ inch rack panel. Input-output connections are made via recessed solder terminals. A screw type barrier strip adapter and a plug adapter are available as accessory items.

2.2 Weight

The net weight of the power supply is 5½ pounds. The shipping weight is 6½ pounds.

3.0 THEORY OF OPERATION

3.1 GENERAL

The UNI-164 is a dual regulated power supply composed of two identical regulator P.C. boards interconnected by a third board which houses the control potentiometers and the solder terminals. Both outputs are isolated from each other as well as from the chassis.

3.2 FUNCTIONAL DESCRIPTION (Refer to Fig. 2)
Since both regulator boards in the UNI-164 are identical, it is only necessary to describe one of them. Reference designations on both boards are identical, therefore a description of one board is directly applicable to the other one.

AC input voltage is applied to transformer T1 via terminals 5 & 6, Transformer T1 has a main secondary winding and an auxiliary winding for each regulator board. Voltage from the main secondary winding is rectified by diodes CR9, CR10, CR11, and CR12 and filtered by capacitor C3. The output from the auxiliary winding is rectified by diode CR2 and filtered by capacitor C1.

Resistor R1 and Zener Diode CR5 regulates the voltage for the constant current amplifier composed of R2, CR6, and R18 and transistor Q8. The constant current source furnishes Zener Diode CR7 and differential amplifier transistors, Q5, and Q6, with a constant current.

The voltage developed by Zener Diode CR7 is divided down via resistors R3 and R4 and applied to the base of (Q5) as a reference voltage. Resistors R9, R15, and potentiometers R16 and R17 form an error sensing network across the output terminals. Changes in output voltages, caused by fluctuations in input voltage and or load changes, and sensed by this dividing network and applied as an error voltage to the base of Q6.

The offset voltage between the bases of transistors Q5 and Q6 is amplified by transistor Q6. The amplified error voltage developed across resistor R4 is again amplified by amplifier Q7 and driver amplifiers Q2 and Q3, which in turn control the output voltage appearing at the emitter of the series regulator Q1.

Overload and short circuit protection is provided by amplifier Q4. During normal operation capacitor C6 charges through resistor R10 and diode CR13. Output current is sensed as a voltage drop across resistor R7. Transistor Q4 will begin conducting when the voltage drop across resistor R7 exceeds the sum of the voltage drop across CR13 and the emitter base junction of transistor Q4. Under this condition current which was normally flowing into the base of Q3 now begins flowing into the collector of Q4, thus turning "off" Q3 and in turn, reducing the output voltage.

As the output voltage of the power supply decreases, CR13 becomes back biased due to the charge on capacitor of C6. Capacitor C6 now discharges through resistor R12 and the emitter base junction of Q4, which in turn causes Q4 to go into further conduction and Q3 into a non-conducting state. When C6 discharges, Q4 will cease conduction, the output voltage will rise, and capacitor C6 will once again begin charging through resistor R10 and diode 13.

If at this time an overload is still present across the output terminals, the complete process will repeat itself. If the output voltage is short circuited, the average source current which flows into the load will be reduced to a small fraction of the short circuit current.

4.0 OPERATING INSTRUCTIONS

Connections to the UNI-164 are provided by ten solder terminals accessible through a slot in the front panel of the unit. AC input voltage (105-125) is applied to terminals 5-6. All sensing terminals are connected to their corresponding terminals by jumpers placed across the solder terminals. These jumpers must be removed in order to operate the unit in the remote sensing mode. All power supplies shipped from the factory are adjusted to 5.0 VDC on the lowest transformer tap.

4.1 VOLTAGE ADJUSTMENT

To obtain a desired output voltage, the cover must be removed and the correct transformer tap selected. Each of the main secondary windings has four taps. These taps are labled on the main P.C. board in terms of the D.C. output range attainable from each tap. The power supply may be damaged if it is operated outside of the prescribed limits of the transformer tap under full load conditions.

After the proper tap has been selected, coarse control R17 should be rotated fully counter-clockwise and fine control R16 fully clockwise.

Connect 115 VAC to terminals 5 and 6. Connect the negative lead of a D.C. voltmeter to terminal 2 (or 9 as applicable) and the positive lead to terminal 3 (or 8 as applicable). Adjust R17 for 1/2V above the desired output voltage. Rotate potentiometer R16 counter-clockwise to the desired output levels. Potentiometer R16 will now provide a 1/2 volt adjustment above and below the desired output voltage.

4.2 REMOTE SENSING/LOCAL ADJUST (Refer to Fig. 4)

The power supply has provisions for remote sensing at the load to compensate for the voltage drops across the leads connecting the power supply to the load. Small gauge wire such as #22 may be used for the sensing leads. Wire sizes consistant with load requirements must be used for the load connections. To connect the unit for remote sensing, remove the jumpers between terminals 1 and 2. Connect the load to terminals 4 and 1. Connect the positive sensing lead from terminal 3 to the positive side of the load and the negative sensing lead from terminal 2 to the negative side of the load.

4.3 REMOTE ADJUSTMENT- RESISTIVE

The UNI-164 has provisions for remotely adjusting the output voltage. Remote adjustment is possible with local and or remote sensing.

4.3.1 REMOTE ADJUSTMENT- LOCAL SENSING (Refer to Fig. 3)

Place a jumper across terminals 3 and 4 and remove jumper, if any, between terminals 1 and 2. Rotate potentiometer R16 and R17 fully counter-clockwise. The programming resistance is 100 ohms/Volt, therefore the value of resistance required for any output voltage is determined by multiplying the desired output voltage by 100 ohms/volt.

Connected the programming resistor or potentiometer as determined above between terminals 2 and 1. A 2.5 MFD-64 Volt capacitor must be placed across the programming resistor to avoid an increase of output ripple due to pick-up on the programming leads. The positive terminal of the capacitor is connected to terminal 2.

NOTE:

The temperature stability of the power supply when connected for remote programming, is wholly dependent on the temperature coefficient of the programming resistor. The temperature coefficient for the programming resistor should be 100 PPM in order not to degrade the temperate characteristics of the power supply.

4.3.2 REMOTE ADJUSTMENT-REMOTE SENSING (Refer to Fig. 5)

The UNI-164 has provisions for both remote adjustment and remote sensing simultaneously. To connect the power supply for this mode of operation, connect the positive output terminal and the positive sensing terminal as described in paragraph 3.2. Connect the negative terminal #1 to the negative side of the load.

Remove jumper if any between terminals 1 and 2. Connect the programming resistor (bypass with capacitor as described in paragraph 3.3.1) between terminal #2 and the negative side of the load.

4.3.3 VOLTAGE PROGRAMMING

The UNI-164 output can be programmed with an externally connected programming power supply. Two methods of operation are available:

1. Both controls (R16 and R17) are set fully counterclockwise. In this case the output voltage will equal the programming voltage "E" on a one to one basis, except for a fixed 800 MV offset.
2. Controls R16 and R17 are set to give the minimum output voltage required. Voltage from the programming supply "E" will then increase the output above the minimum set voltage on a one to one basis. In both cases the programming supply "E" must have a reverse current capability of 11 ma.

Alternately, when supplies with less than 11 ma. reverse current capability are used, a resistor capable of drawing 11 ma. at the minimum programming voltage must be connected across the output terminals of the supply. This programming supply must be rated to handle all excess resistor current at the maximum programming voltage.

Note: That if a voltage range exceeding five volts is required, the maximum current drawn from the UNI-164 must be derated linearly to 500 ma. when a 0-25 voltage range is required. The transformer tap must not be set higher than the highest voltage desired.

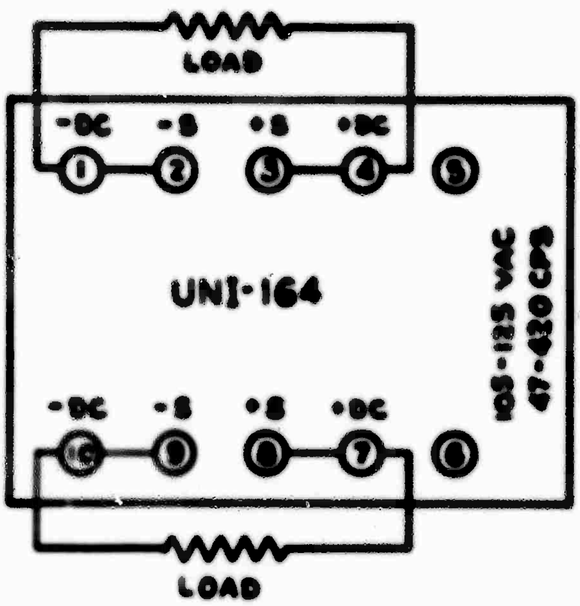


Fig. 2
LOCAL ADJ. - LOCAL SENSING

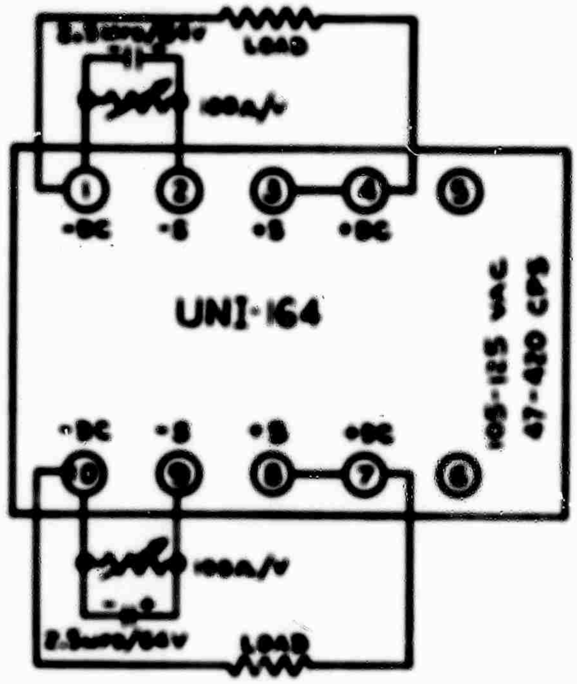


Fig. 3
REMOTE ADJ. - LOCAL SENSING

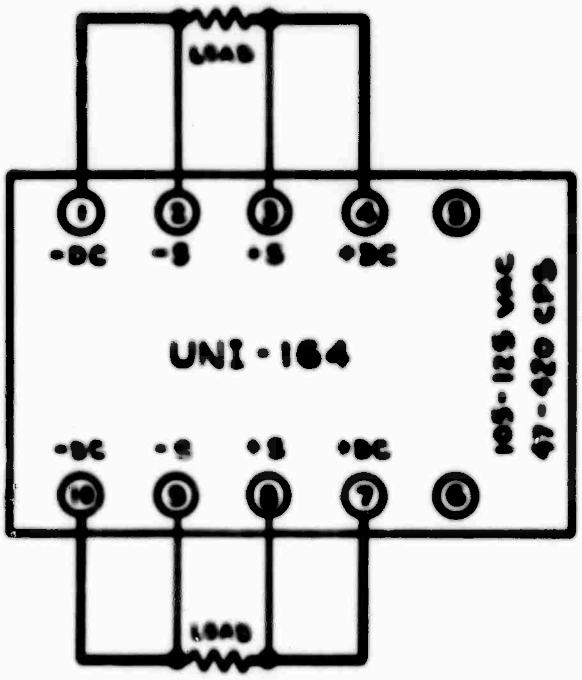


Fig. 4
LOCAL ADJ. - REMOTE SENSING

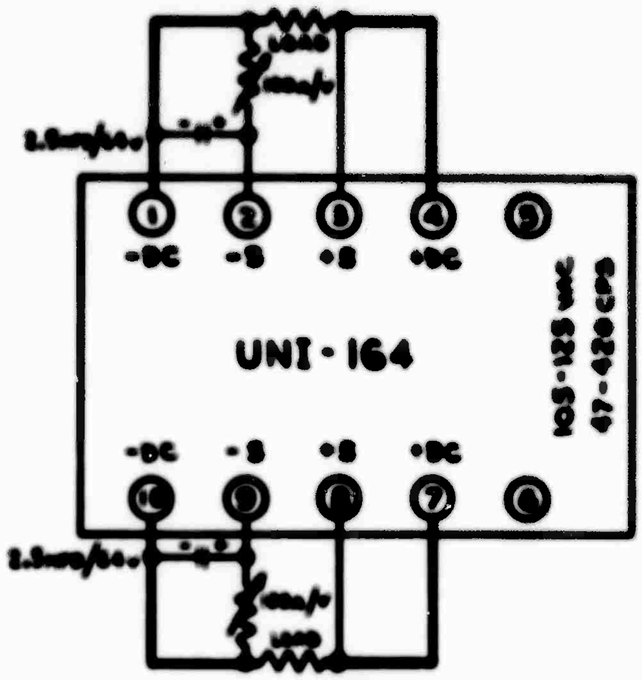
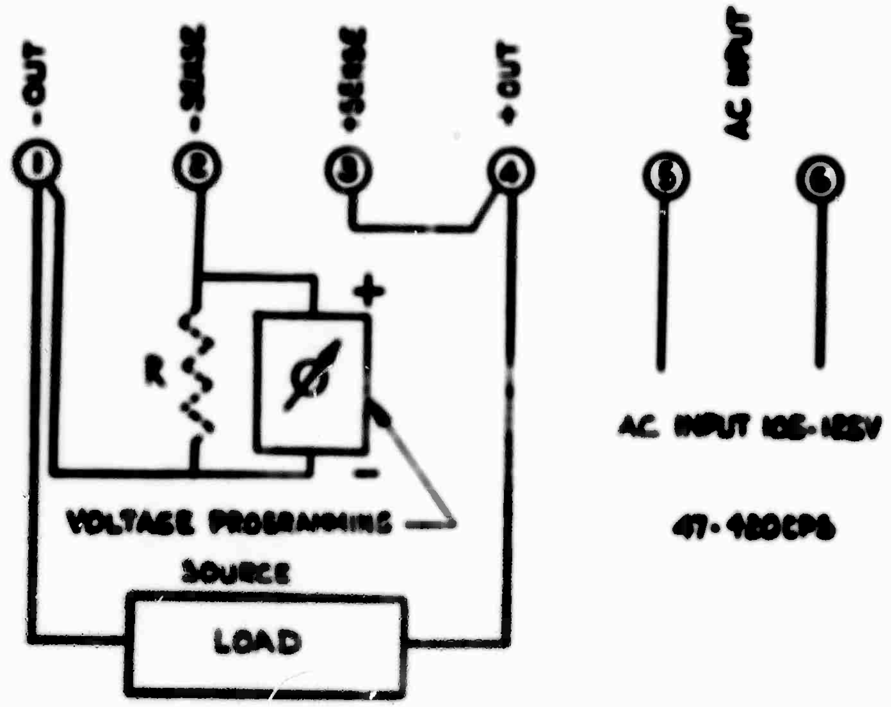


Fig. 5
REMOTE ADJ. - REMOTE SENSING



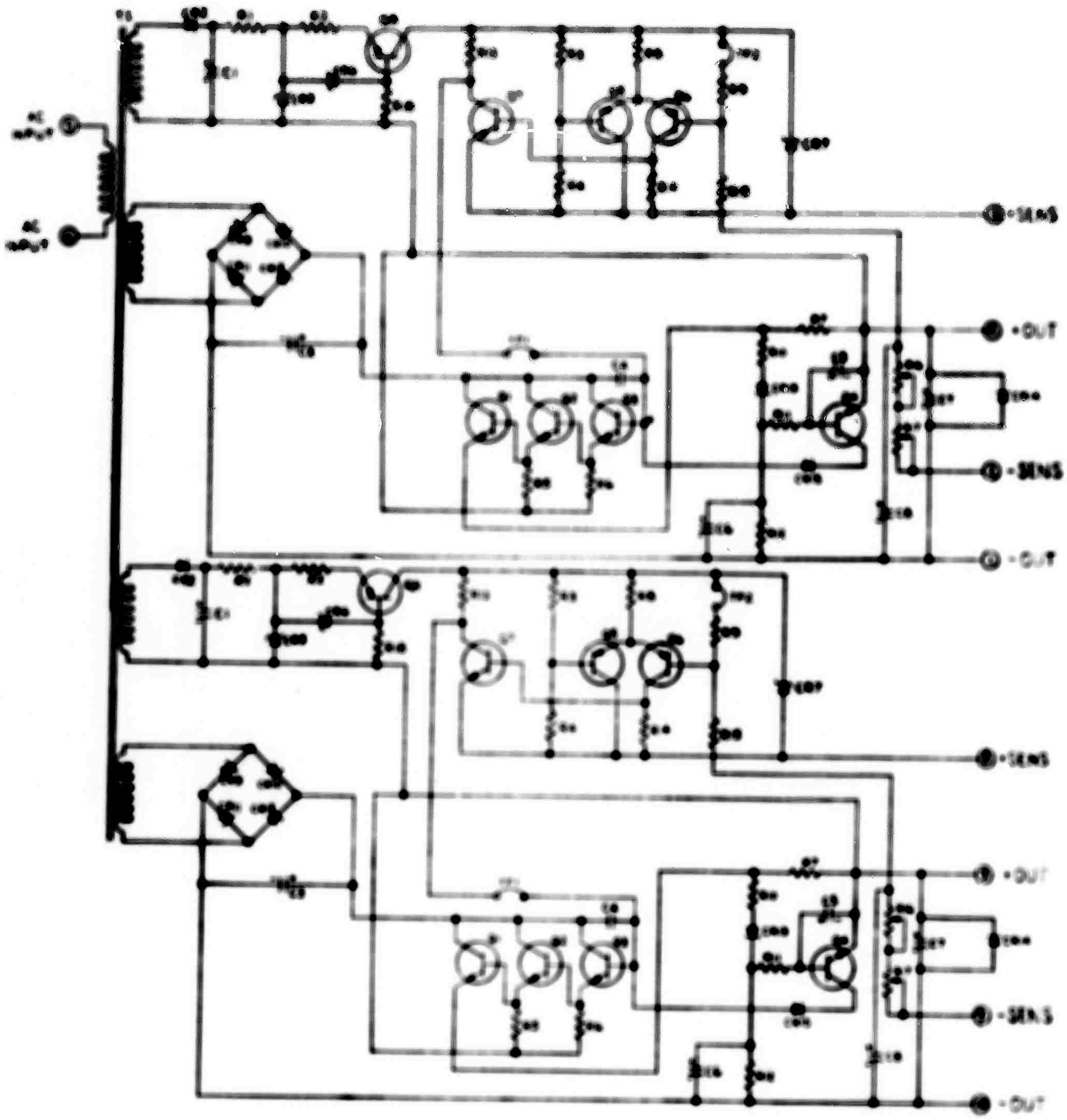
CONNECTIONS FOR VOLTAGE PROGRAMMING

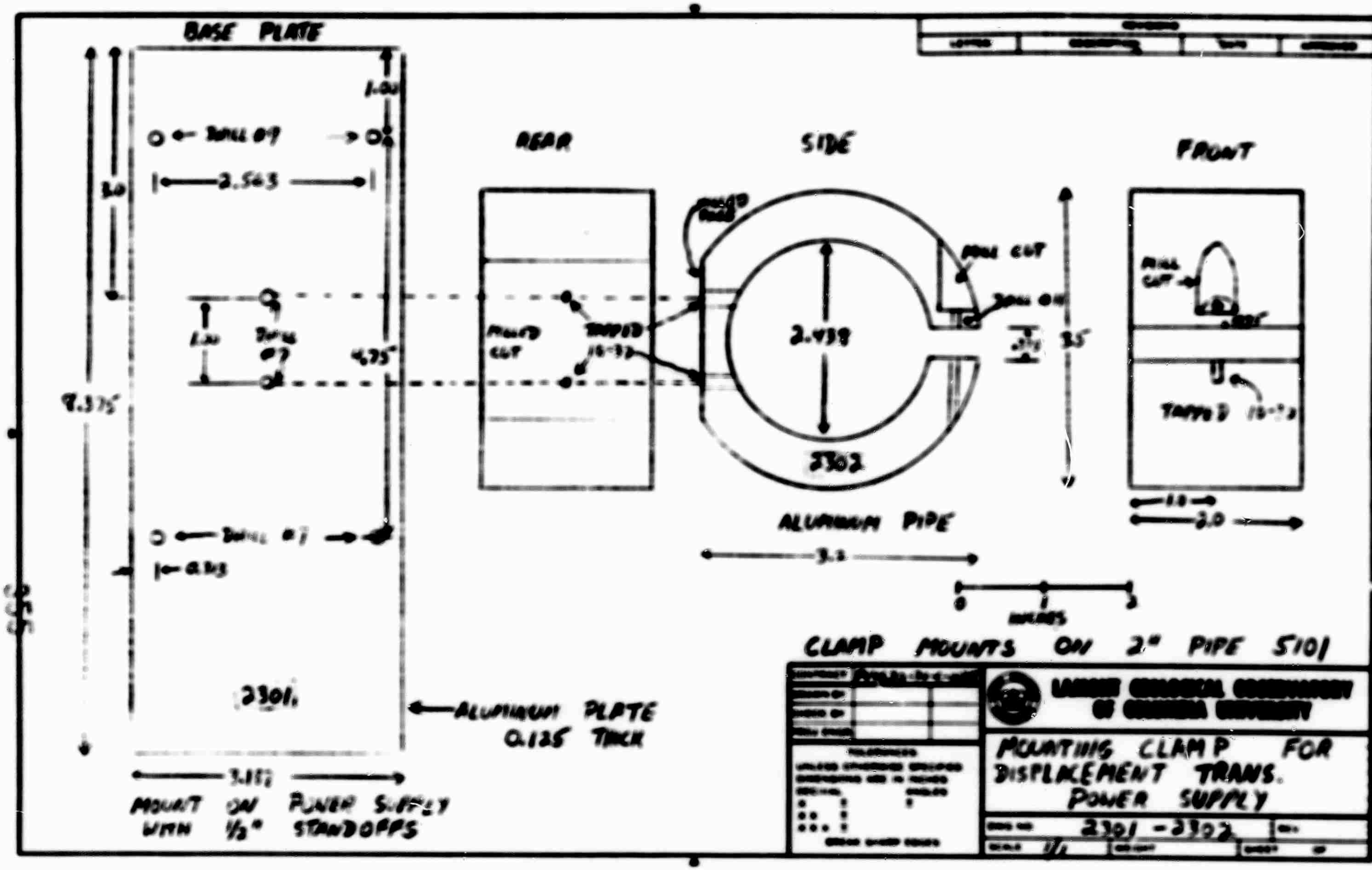
FIG. 6

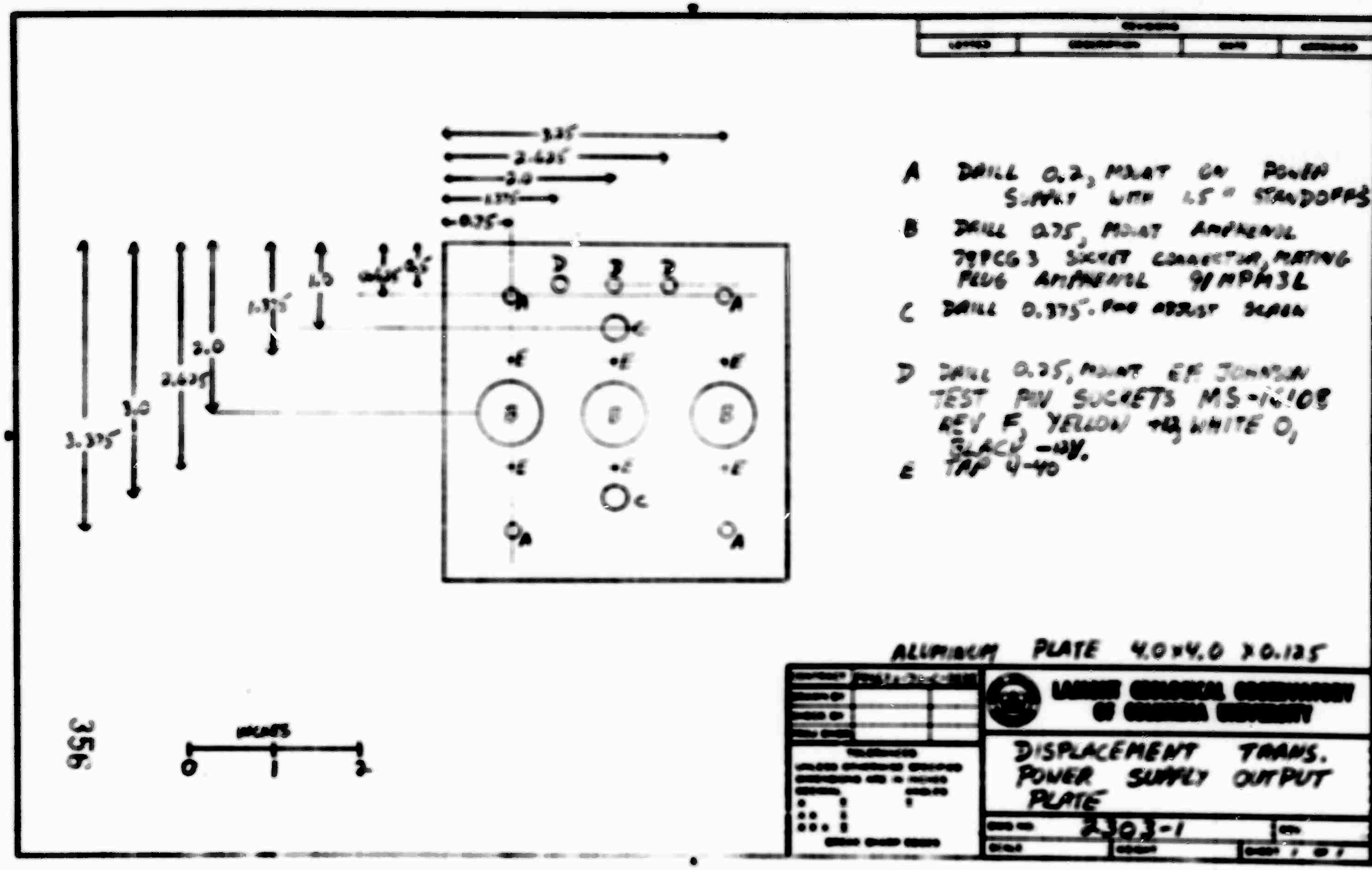
[illegible]	[illegible]	[illegible]	[illegible]
C1	[illegible]	CAPACITOR, [illegible]	[illegible]
C2	NOT USED		
C3	[illegible]	CAPACITOR, [illegible]	[illegible]
C4	[illegible]	CAPACITOR, [illegible]	[illegible]
C5	[illegible]	CAPACITOR, [illegible]	[illegible]
C6	[illegible]	CAPACITOR, [illegible]	[illegible]
C7	[illegible]	CAPACITOR, [illegible]	[illegible]
C8	[illegible]	CAPACITOR, [illegible]	[illegible]
CR1	NOT USED		
CR2	[illegible]	RECTIFIER, [illegible]	[illegible]
CR3	NOT USED		
CR4	NOT USED		
CR5	[illegible]	ZENER DIODE, [illegible]	[illegible]
CR6	[illegible]	ZENER DIODE, [illegible]	[illegible]
CR7	[illegible]	ZENER DIODE, [illegible]	[illegible]
CR8	NOT USED		
CR9	[illegible]	RECTIFIER, [illegible]	[illegible]
CR10	[illegible]	RECTIFIER, [illegible]	[illegible]
CR11	[illegible]	RECTIFIER, [illegible]	[illegible]
CR12	[illegible]	RECTIFIER, [illegible]	[illegible]
CR13	[illegible]	RECTIFIER, [illegible]	[illegible]
CR14	[illegible]	RECTIFIER, [illegible]	[illegible]
CR15	[illegible]	RECTIFIER, [illegible]	[illegible]

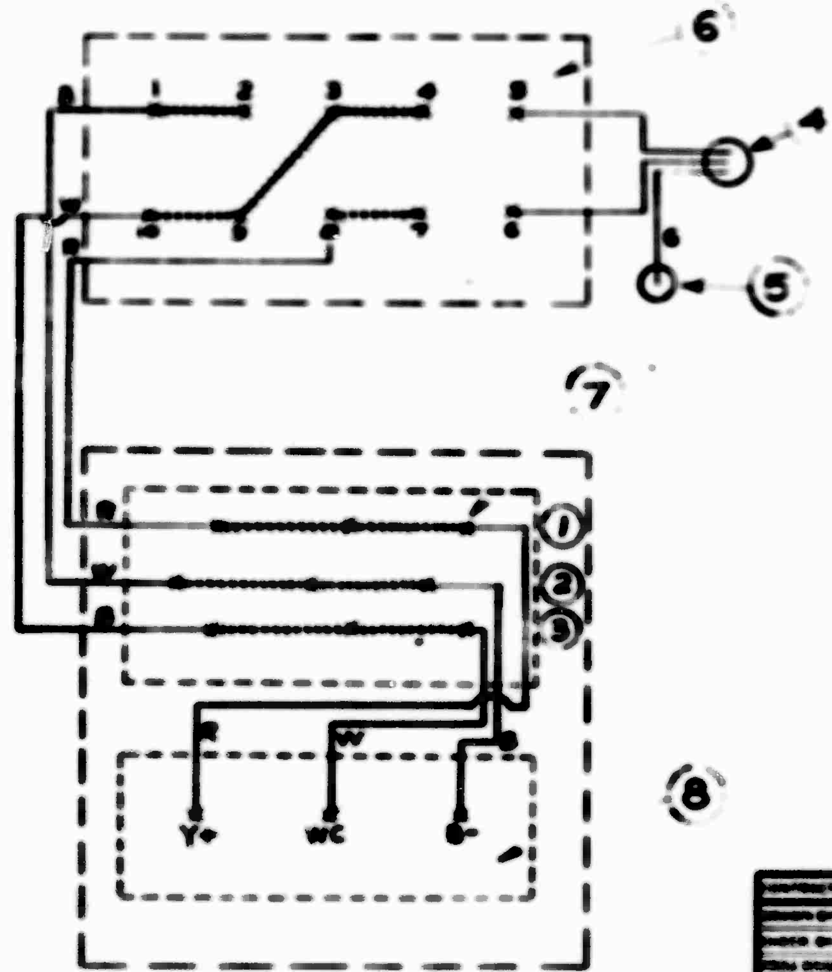
N O T E: [illegible]

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
T1		[illegible] TRANSFORMER	[illegible]
[illegible]	[illegible]	[illegible] TRANSISTOR	[illegible]


AC INPUT
AC INPUT
+SENS
+OUT
-SENS
-OUT
+SENS
+OUT
-SENS
-OUT


BASE PLATE
DRILL #7
2.563
3.0
1.00
DRILL #7
4.75"
9.375"
DRILL #7
0.313
2301
ALUMINUM PLATE
0.125 THICK
3.157
MOUNT ON POWER SUPPLY
WITH 1/2" STANDOFFS
REAR
MILLED CUT
TAPPED 10-32
SIDE
2.438
2302
MILL CUT
ALUMINUM PIPE
3.2
3.5"
FRONT
MILL CUT
TAPPED 10-32
1.0
2.0
INCHES
CLAMP MOUNTS ON 2" PIPE 5101
MOUNTING CLAMP FOR
DISPLACEMENT TRANS.
POWER SUPPLY
2301 - 2302

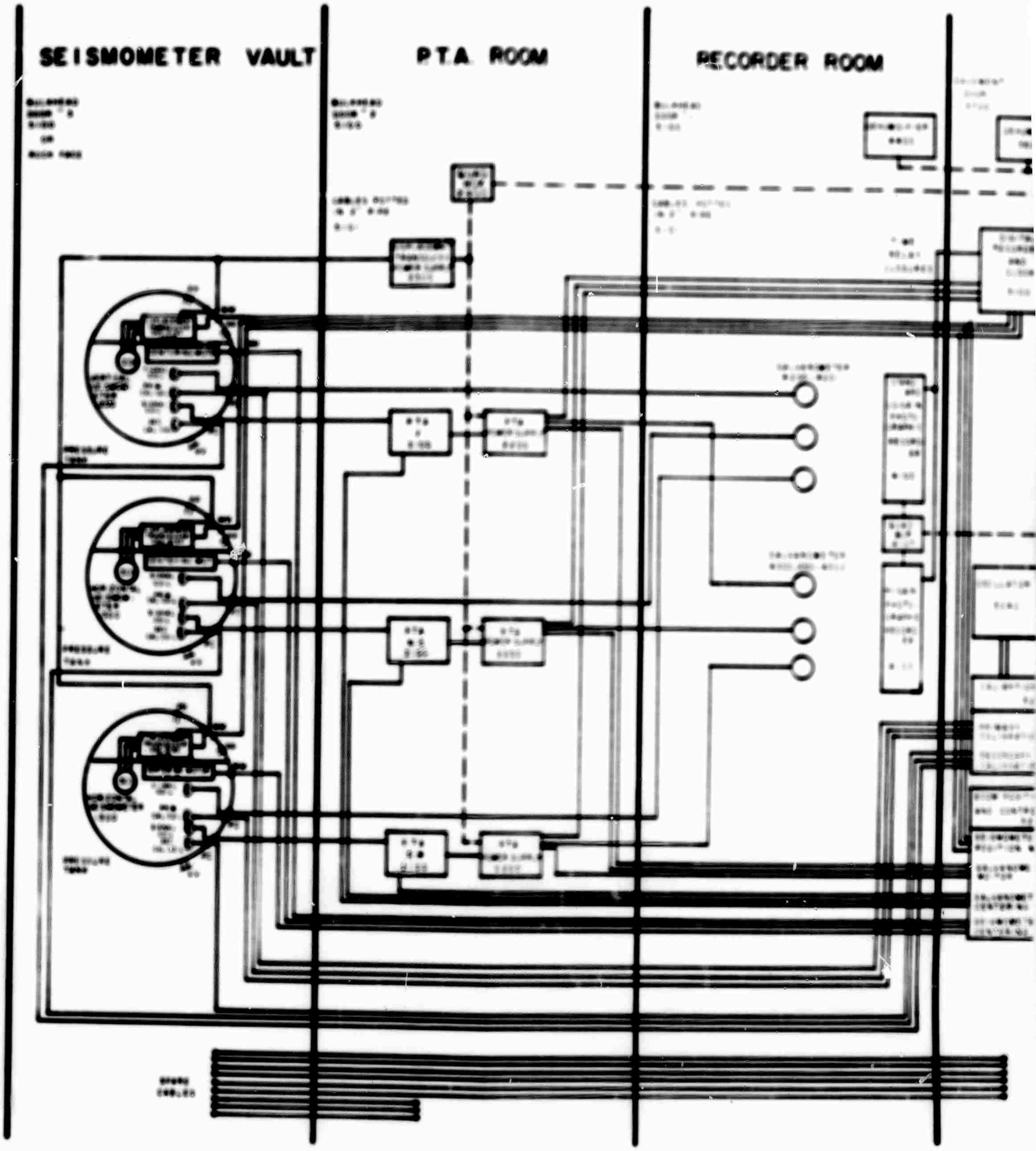

3.25
2.625
2.0
1.375
0.75
1.375
1.5
2.0
2.625
3.0
3.375
INCHES
0
1
2
A DRILL 0.2, MOUNT ON POWER SUPPLY WITH 1.5" STANDOFFS
B DRILL 0.75, MOUNT AMPHENOL 79PCG3 SOCKET CONNECTOR, MATING PLUG AMPHENOL 91MPM3L
C DRILL 0.375". FOR ADJUST SCREW
D DRILL 0.25, MOUNT EF JOHNSON TEST PIN SOCKETS MS-16108 REV F, YELLOW +12, WHITE 0, BLACK -12V.
E TAP 4-40
ALUMINUM PLATE 4.0 x 4.0 x 0.125
DISPLACEMENT TRANS. POWER SUPPLY OUTPUT PLATE
2303-1

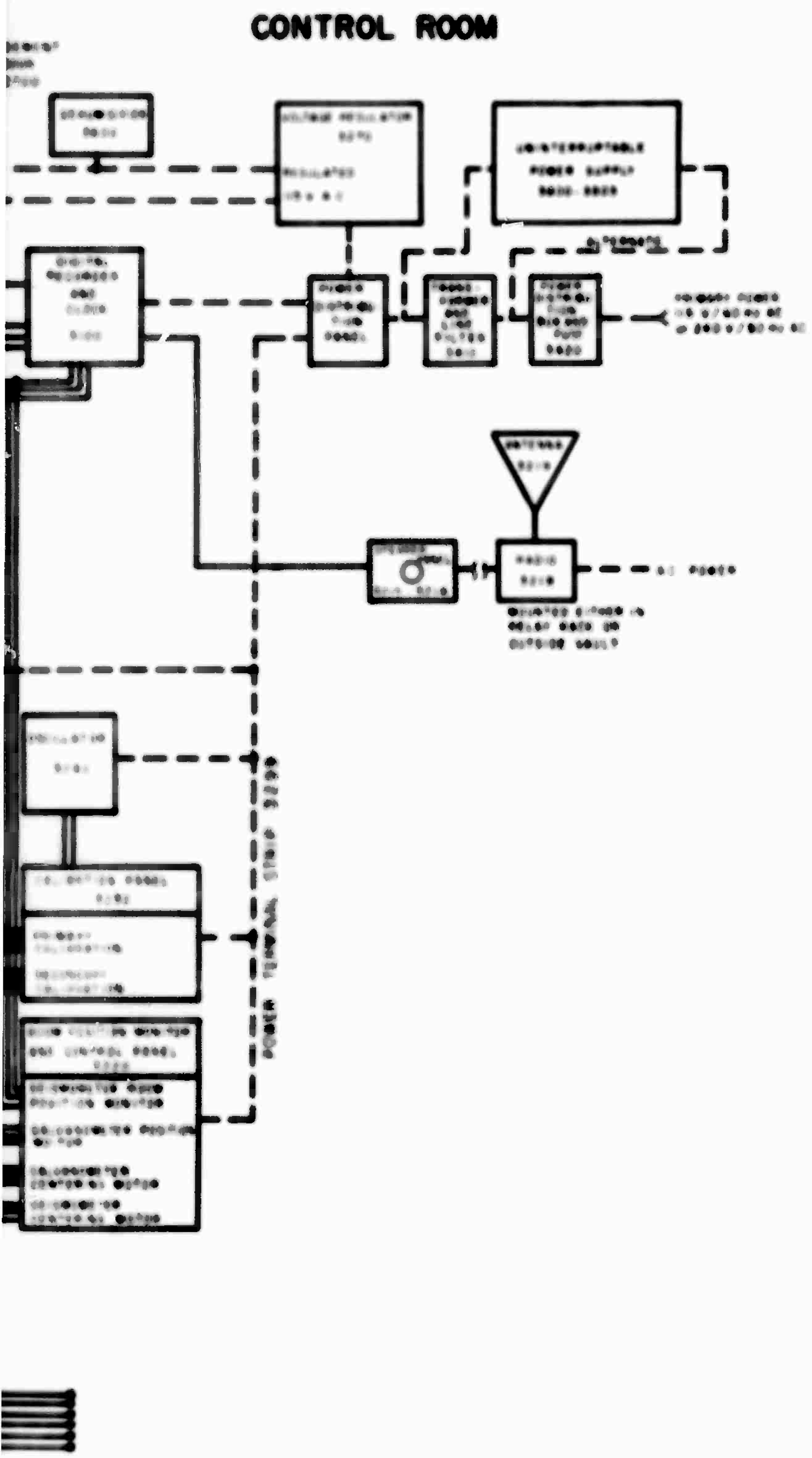


NOTES:
- ① - PIN # 1 +12V DC
- ② - PIN # 2 -12V DC
- ③ - PIN # 3 COMMON
- ④ - 110 VOLTS
- ⑤ - GROUND CONNECTED TO CASE OF POWER SUPPLY
- ⑥ - P.C. BOARD
- ⑦ - 3 AMPHENOL 3-PIN CONNECTORS
- ⑧ - TEST POINTS
- Y+ YELLOW +12 V DC
- WC WHITE COMMON
- B- BLACK -12V DC
- ▬ DENOTES JUMPER LEADS
- G GREEN
- R RED
- B BLACK
- W WHITE

WIRING DIAGRAM FOR 2303

2303 - 2


SEISMOMETER VAULT
P.T.A. ROOM
RECORDER ROOM



SYMBOLS USED ON PRESSURE TANK		
VV	PRESSURE TANK VENT VALVE	1102
PC	POTTED CABLES	8208
MM	MARSH - MARINE CONNECTORS	1101 1103
PP	PIPE PLUG	1104

LAMONT - DOHERTY GEOLOGICAL OBSERVATORY OF COLUMBIA UNIVERSITY

HIGH - GAIN BROAD - BAND LONG - PERIOD SEISMIC SYSTEM

358a