TM 11-6625-2507-14

TECHNICAL MANUAL

OPERATOR'S, ORGANIZATIONAL, DIRECT SUPPORT, AND GENERAL SUPPORT

MAINTENANCE MANUAL

RECORDER, THERMAL OSCILLOGRAPH AN/USM-365(V)1

(FSN 6625-230-3835)

HEADQUARTERS, DEPARTMENT OF THE ARMY
JUNE 1973

WARNING

Be careful when working with the 115-volt power connections. SERIOUS INJURY or DEATH may result from contact with these terminals.

CAUTION

The equipment contains highly complicated circuitry. Maintenance personnel should not attempt any maintenance without reading and fully understanding the applicable section relating to that maintenance.

THIS MANUAL IS AN AUTHENTICATION OF THE MANUFACTURER'S COMMERCIAL LITERATURE WHICH, THROUGH USAGE, HAS BEEN FOUND TO COVER THE DATA REQUIRED TO OPERATE AND MAINTAIN THIS EQUIPMENT. SINCE THE MANUAL WAS NOT PREPARED IN ACCORDANCE WITH MILITARY SPECIFICATION, THE FORMAT HAS NOT BEEN STRUCTURED TO CONSIDER LEVEL OF MAINTENANCE NOR TO INCLUDE A FORMAL SECTION ON DEPOT MAINTENANCE STANDARDS.

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HEADQUARTERS

DEPARTMENT OF THE ARMY

WASHINGTON, D.C., 29 June 1973

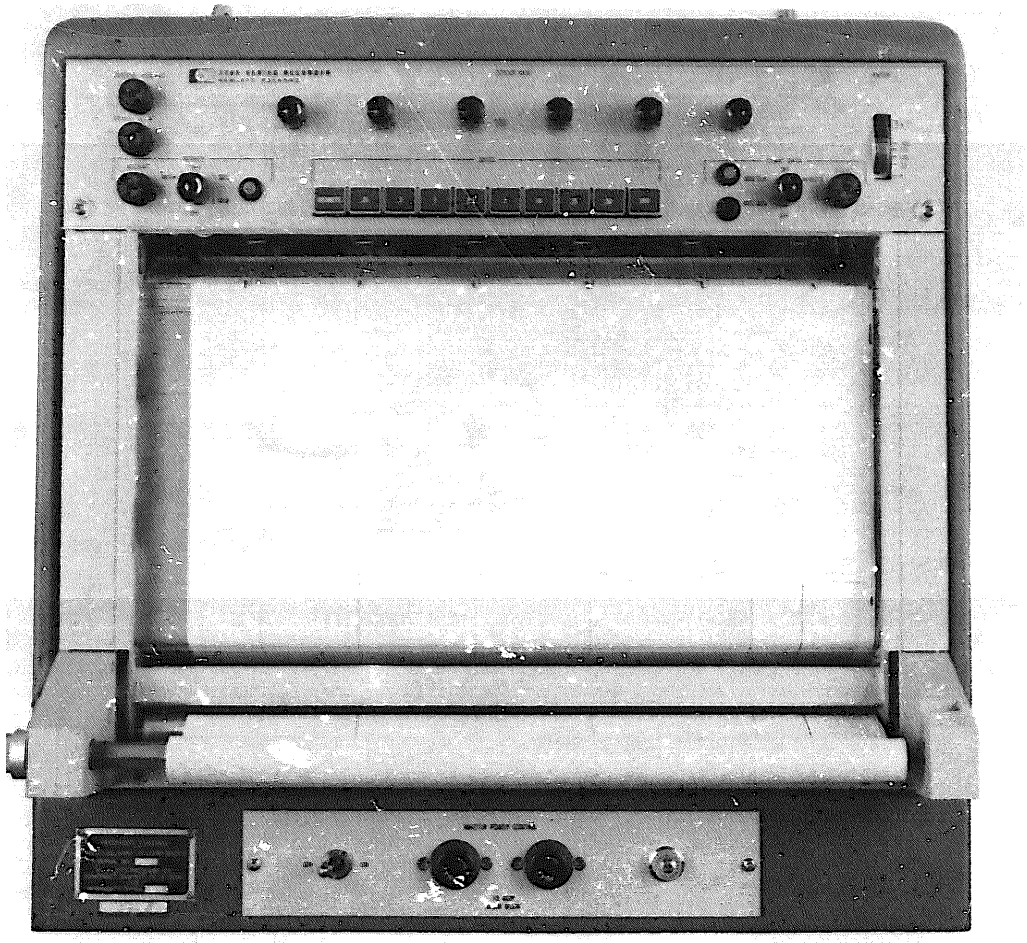
Operator's, Organizational, Direct Support, and General Support Maintenance Manual

RECORDER, THERMAL OSCILLOGRAPH AN/USM-365(V)1 (FSN 6625-230-3835)

Current as of 15 November 1972

LIST OF ILLUSTRATIONS

LIST OF TABLES



EL 6625-2507-14-TM-1 ①

Figure 1-1①. Recorder, Thermal Oscillograph AN/USM-365(V)1 (sheet 1 of 2)

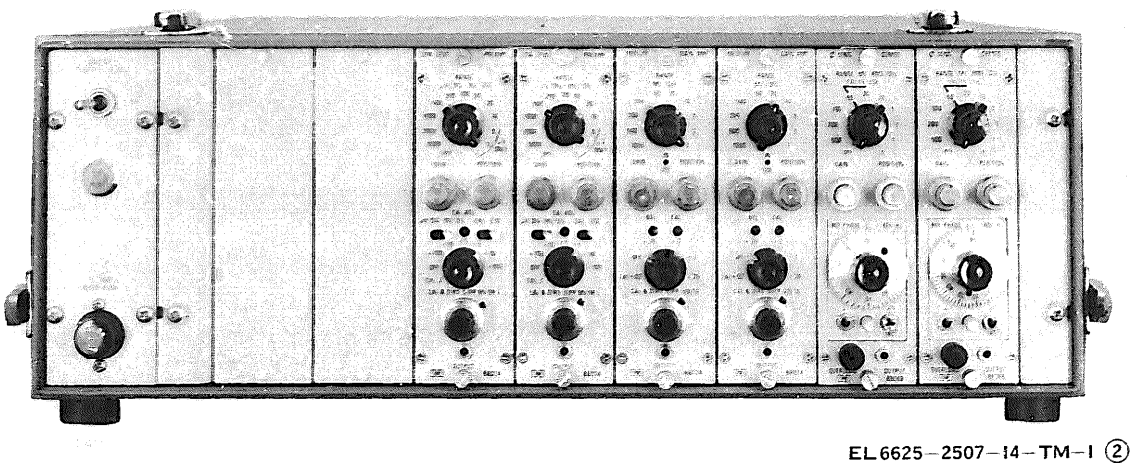


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Figure 1-1②. Recorder, Thermal OscillographAN/USM-35-65(V)1 (sheet 2 of 2)

SECTION I

GENERAL INFORMATION

1-1. Scope

a. This manual provides operating and maintenance instructions for Recorder, Oscillograph Thermal AN/USM-365(V)1 (fig. 1-1). Also included in the manual is coverage of similar commercial components (table 1-1) and various system options (table 1-1). Throughout the manual, the AN/USM-365(V)1 components are referred to by their commercial part number designations. Paragraph 1-4 lists the Army nomenclatured components that comprise an operable system together with the corresponding part number designations.

b. A maintenance allocation chart appears in appendix B.

c. Plug-In Units, Electronic Test Equipment PL-1305/U, PL-1306/U, and PL-1307 are covered in appendixes C, D, and E, respectively.

d. The repair parts and special tools lists appear in TM 11-6625-2507-20P TM 11-6625-2507-40P

1-2. Indexes of Publications

a. DA Pam 310-4. Refer to DA Pam 310-4 to determine whether there are new editions, changes, or additional publications pertaining to the equipment.

b. DA Pam 310-7. Refer to DA Pam 310-7 to determine whether there are modification work orders (mwo's) pertaining to the equipment.

1-3. Forms and Records

a. Reports of Maintenance and Unsatisfactory Equipment. Use equipment forms and records in accordance with instructions in TM 38-750.

b. Report of Packaging and Handling Deficiencies. Fill out and forward DD Form 6 (Report of Packaging and Handling Deficiencies) as prescribed in AR 700-58 (Army)/NAVSUP PUB 378 (Navy)/AFR 71-4 (Air Force)/and MCO P4030.29 (Marine Corps).

c. Discrepancy in Shipment Report (DISREP) (SF 361). Fill out and forward Discrepancy in Shipment Report (DISREP) (SF 361) as prescribed in AR 55-38 (Army)/NAVSUP PUB 459 (Navy)/AFM 75-34 (Air Force)/ and MCO P4610.19 (Marine Corps).

d. Reporting of Equipment Publication Improvements. Report of errors, omissions, and recommendations for improving this publication by the individual user is encouraged. Reports should be submitted on DA Form 2028 (Recommended Changes to Publications) and forwarded direct to Commander, US Army Electronics Command, ATTN: AMSEL-MA-AN, Fort Monmouth, NJ 07703.

e. Administrative storage. For procedures, forms and records, and inspections requared during administrative storage of this equipment, refer to TM 740-90-1

1-4. Items Comprising an Operable AN/USM-365(V)1.

(fig. 1-1)

Federal Stock No.	Hewlett-packard part number	Item	Qty	Dimensions (in.)			
				Height	Depth	Width	Weight (lb)
6625-230-3835	7706B OP14	Recorder, Thermal Oscillograph AN/USM-365(V)1 consisting of:					
6625-230-3834	7706B (with options 02 and 11	Recorder, Thermal Oscillograph RD-347/U.	1	19.75	21.5	21.0	100 (approx)
6625-263-6041	8802A	Plug-In Unit. Electronic Test Equipment Pl-1305/U.	2	7.0	20.0	2.06	5 (approx)
6625-905-1296	8803A	Plug-In Unit, Electronic Test Equipment PL-1306/U.	2	7.0	20.0	2.06	5 (approx)
6625-231-0402	8806B	Plug-In Unit, Electronic Test Equipment PL-1307/U.	2	7.0	20.0	2.06	5 (approx)
	858-1400	Case, preamplifier power supply	1				
	358-1400	Case, Recorder, Thermal Oscillograph.	1				

Table 1-2. System Options

Option No.	Description	Hewlett-Packard Part No.
Option 01	Omits System Cabinet Adds Master Power Panel Replaces Power Supply std. 3 foot cord (8120-1008) with 10 foot cord Replaces Preamplifier Power Supply std. 3 foot cord (8120-1008) with 10 foot cord	1061A - Option 05 1069-03A 8120-1007 8120-1007
Option 02	Omits System Cabinet Omits Power cord for Driver Amplifier Power Supply Omits Power cord for Preamplifier Power Supply Omits Slide assembly for Preamplifier Power Supply (01) Adds Recorder and Driver Amplifier Portable Case Adds Preamplifier Power Supply Portable Case	1061A- Option 05 8120-1008 8120-1008 01060-60310 358-1400 858-1400
Option 08	Specifies 50 Hz System	
Option 09	Specifies system voltage of 230V	9100-2029 Transformer
Option 11	Adds mm/min speeds to Recorder (normally mm/sec only). Changes Second time marker to Minute time marker.	358-100D (8 channel) 356-100DW (6 channel)
Option 12	Omits one or more Driver Amplifiers If two are omitted from 7708B system, recorder is:	7700-02B 356-100N
Option 15	Adds extra event marker between two channels (normally between channels 1 and 2)	608-100C11

1-10. Additional characteristics can be given to the system by including auxiliary equipment such as the Model 358-800-1 paper takeup with horizontal paper table for easy access to the chart for making notes (see paragraph 1-30). The 7706B and 7708B systems can also be connected to a Monitor Scope or Numerical Display by means of the signal cable Monitor connector.

1-11. System Specifications

1-12. Specifications which are applicable to each channel of the system, including driver amplifiers and galvanometers, are listed in Table 1-3 For system characteristics which include the preamplifier (refer to applicable appendix)

1-13. Component Description

1-14. Thermal Recorder 356-100CW and 358-100C.

1-15. The recorder displays the system read-out data on a six-channel chart for the Model 356-100CW and DW and an eight-channel chart for the Model 358-100C and D. The recording is visible as soon as it is made, with the most recent several inches remaining in view at all times. The recording is made by a light-weight writing arm driven by the galvanometer. The stylus at the tip of the writing arm, under controlled heat, traces the variable on heat-sensitive, plastic-coated Permapaper ®. Recorder specifications are listed in Table 1-4 The Model 358-100C Recorder is shown in Figure 1-2

Table 1-3. System Specifications

Power Requirements:		115 volts ac (± 10%), 60 Hz, 550 watts. 230 volts ac optional. 50 Hz optional. Power Cord (accessory 8120-0960) is 10 feet long (3,28 meters).
Size:	System Cabinet	72-5/8 in. (1844 mm) high, 24 in. (609 mm) wide, 25-1/2 in. (648 mm) front to back on rack, 35 3/4 in. (908 mm) front to back on base.
	Portable Cases:	Recorder Case 19-3/4 in. (502 mm) high, 21 in. (533 mm) wide, 21-1/2 in. (546 mm) front to back. Amplifier Case 7-9/16 in. (199,5 mm) high, 22 in. (570 mm) wide, 21-1/2 (546 mm) front to back.

Weight:

Configuration	7706B	7708B
With preamps: In cabinet (typical)	512 lbs (232 kg)	547 lbs (248 kg)
Without preamps: In cabinet	480 lbs (214 kg)	515 lbs (233 kg)
Less cabinet (Option 01)	257 lbs (116 kg)	289 lbs (131 kg)
Portable (Option 02) Recorder	200 lbs (91 kg)1	232 lbs (105 kg)
Signal Conditioners	103 lbs (46 kg)	103 lbs (46 kg)
Recorder alone	160 lbs (73 kg)	175 lbs (79 kg)

NOTE

The following specifications are for the sub-system of Recorder and Driver Amplifier only. Full specifications depend upon selection of preamplifier for a particular channel.

Frequency Response:	7706B Sub-system:	DC to 3 dB down at 125 Hz, at 10 divisions peak-to-peak amplitude.
	7708B Sub-system:	DC to 3 dB down at 150 Hz, at 10 divisions peak-to-peak amplitude.
Transient Response:	7706B Sub-system:	5. 0 milliseconds for a 10 division displacement (10% to 90% with 4% or less overshoot).
	7708B Sub-system:	4. 0 milliseconds for a 10 division displacement (10% to 90% with 4% or less overshoot).
Interchannel Cross Talk:		At least 66 dB below input signals or sum of input signals.
Linearity:	Method 1:	After setting mechanical zero of stylus within ±1 division of chart center and calibrating for zero error at center scale and +20 divisions, error is less than ±0. 25 division at any point on printed coordinates.
	Method 2:	After setting mechanical zero of stylus within ±1 division of chart center and calibrating for zero error at lower and upper ends of printed coordinates, error is less than ±0. 5 division at any point on scale.
Noise:		No noise is visible on recording with zero signal input.

Table 1-4. Recorder Specifications

Frequency Response:
Model 356-100CW (or DW) has galvanometers with 45 Hz natural resonance; provide recordings from dc to 3dB down at 125 Hz (with drive circuit), at 10 div. peak-to-peak recording.

Model 358-100C (or D) has galvanometers with 55 Hz natural resonance; provide recording from dc to 3dB down at 150 Hz (with drive circuit), at 10 div. peak-to-peak recording.

Transient Response:
Model 356-100CW (or DW) with drive circuit, provides recordings having 5 millisecond rise from 10% to 90% of final deflection (pulse input).

Model 358-100C (or D) with drive circuit, provides recordings having 4 millisecond rise from 10% to 90% of final deflection (pulse input).

Damping:
Galvanometer with velocity-voltage feedback, in combination with drive circuit, provides the same response as a 71% damped galvanometer.

Linearity:
Within ±0.25 divisions, including drive circuit. Linearity is measured and defined as follows:

a. Set stylus to mid-scale, then apply dc voltage for an exact 20 divisions upscale deflection.

b. Apply, in sequence, 0%, 25%, 50%, 75% 100%, and 125% of voltage applied in step a. Repeat with opposite polarity. Run paper to avoid hysteresis.

c. Stylus deflections must coincide exactly at +20 division line. The linearity error is the difference between the recorded deflection and the chart division with which it should coincide.

Hysteresis:
Previous signals do not affect recorded data by more than ±0.15 divisions.

Galvanometers:
One in each recording channel, high-torque, D'Arsonval movement. Each has single-ended drive coil plus a velocity-voltage pickup winding; each winding has approximately 16.5 ohms at room temperature.

Galvanometer Sensitivity:
Approximately 16 milliamperes per division.

Gain Stability:
Including drive circuit, not more than 0.1% change in gain per 10°C within the temperature range of 0°C to 50°C. Not more than 0.15% change in gain for line voltages 103V to 127V.

Drift:
Including drive circuit, after 30-minute warm-up, drift is less than 0.1 division for 20°C temperature variation within the range of 0°C to 50°C. Short term drift from the line voltage changes in the range 103V to 127V is less than 0.05 div.

Limiting:
Galvanometer mechanical limiting just beyond full-scale by spring bumpers. Electrical limiting in drive circuit is fully adjustable for + or − limit.

Noise:
Not visible on recording, including drive circuit, with zero signal input.

Chart Speeds:
100, 50, 25, 10, 5, 2.5, 1, .5, and .25 mm/sec on 358-100C models, or mm/sec and mm/min on 358-100D models. Standard speeds can be changed on special order.

Chart Drive:
One synchronous motor for mm/sec speeds plus a second synchronous motor (358-100D only) for mm/min speeds.

Power:
115 volts, 60 cycles, 930 watts, including Driver Amplifier and Driver Amplifier Power Supply. Changes in line frequency will cause time-axis errors in the recording.

Size:
17-1/2 in. (444,5 mm) high x 19 in (482 mm) wide. Front to back 20-3/4 in. (527, 15 mm) including standard paper take-up at front.

Weight:
About 160 lbs. (72, 5 kg) for 356-100CW. About 192 lbs. (87 kg) for 358-100C.

Mounting:
On latch slide and frame assembly; locks in normal and in extended positions.

Writing Arms:
Hot wire stylus for recording on heat-sensitive, plastic-coated Permapaper®. Length 4.2 in. (10,67 mm) for Model 356-100CW (or DW) and 3.4 in. (8,65 mm) for Model 358-100C (or D).

Timer Marker:
Single trace, at right hand edge of the chart, to record one-second (C, CW models) or one-minute (D, DW models) timing pulses, or to mark events.

Local/Remote Operation:
Provided for turning chart drive ON or OFF selection of chart speeds; operation of standard marker; operation of one auxiliary marker, if used.

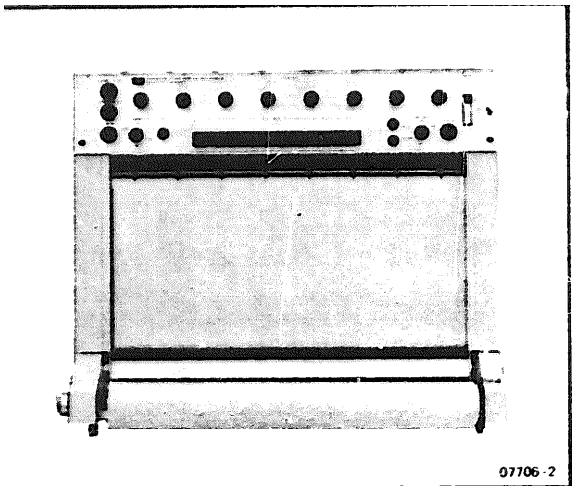

Figure 1-2. Model 358-100C Recorder

1-16. Preamplifiers, Series 8800

1-17. The preamplifiers in this series are plug-in units which are inserted into the system from the front. The preamplifiers condition the input signals for the amplifiers which drive the recorder galvanometers and associated circuits. Input and output connections are made at rear connectors through the preamplifier power supply. Preamplifier specifications in the system are given in the appropriate appendix.

1-18. Preamplifier Power Supply 8848A

1-19. The 8848A Power Supply (figure 1-3) provides operating power for up to eight 8800-series preamplifiers, serves as a transfer chassis for signal input and output circuits, and contains the preamplifiers. The preamplifiers, which are interchangeable, make all connections needed for operation when they are slid into the preamplifier power supply rack. They are held in place by two screws.

1-20. The power supply normally ordered contains 440 Hz and 2400 Hz transducer excitation printed circuit cards that provide oscillator signals for use by carrier preamplifiers. The requirement for either card can be deleted by specifying an option:

Option 01	Less 2400 Hz card.
Option 02	Less 440 Hz card.

1-21. Driver Amplifier Power Supply, 356-400BW and 358-400B

1-22. One Driver Amplifier Power Supply is included in each system. The power supply chassis contains a separate supply for each pair of the six or eight driver amplifiers. It also serves as a transfer chassis for the driver amplifiers. The power supply is fastened to the recorder rear. Input, monitoring, and remote control connectors are located along the lower edge of the supply, facing the rear. The supply may be tipped outward for servicing and for access to the three heavy-duty connectors which connect the driver amplifiers to the galvanometers.

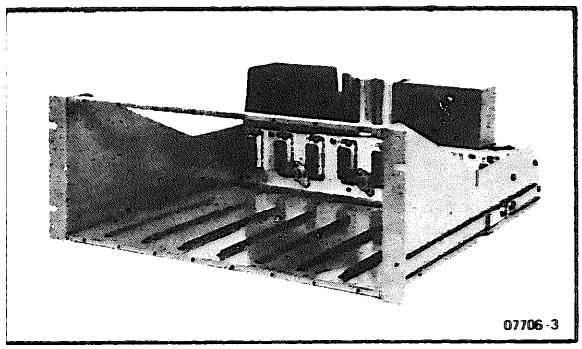

Figure 1-3. Model 8848A Preamplifier Power Supply

Figure 1-4 illustrates the Model 358-400B Driver Amplifier Power Supply with driver amplifiers installed. Table 1-6 lists the driver amplifier power supply specifications.

Table 1-5. 8848A Preamplifier Power Supply Specifications

Regulated Outputs:
+12V dc at 800 mA maximum.
-12V dc at 800 mA maximum.
Ripple not more than 5 mV under full load.

Unregulated Outputs:
+18V dc at 600 mA maximum.
-18V dc at 600 mA maximum.
(Current capacity is 1.4 amperes less current supplied by regulated output circuits.)

Power Requirements:
115 or 230 volts (switch provided), 50 to 400 Hz, 120 watts full load.

Oscillator Outputs:
440 Hz ±2% floating, 14V ac peak-to-peak, 4 watts maximum. Amplitude stability ±5%.

2400 Hz ±2% floating, 10V ac rms, 50 mW maximum. Amplitude stability ±5%.

Weight:
About 26 lbs (11,8 Kg), less preamplifiers.

Dimensions:
7 in. (178 mm) high, x 19 in. (482 mm) wide, x 20-7/8 in. (531 mm) front to back.

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Table 1-6. 358-400B Driver Amplifier Power Supply Specifications

Regulated Outputs:
+12 volts, ±0.6 volts, 0.5 mA maximum.
-12 volts, ±0.6 volts, 0.5 mA maximum.
Regulated lines show not more than 100 mV voltage changes for line voltages 103 to 115 and 115 to 127 volts. Maximum ripple is 100 mV peak-to-peak.

Unregulated Outputs:
+17.5 volts, ±1.7 volts, 300 mA maximum.
-17.5 volts, ±1.7 volts, 300 mA maximum.

Power:
115 volts, ±10%, 50-400 Hz, approximately 12.5 watts for each Driver Amplifier.

Weight:
Approximately 14 lbs (6,3 kg).

Fuses:
Four 0.5 ampere fuses, one for each pair of Driver Amplifiers.

Dimensions (inches and millimeters):
15-1/8 in. (384 mm) high x 16-7/8 in. (429 mm) wide x 5 in. (127 mm) front to back.

1-23. Driver Amplifier 7700-02B

1-24 **One Driver Amplifier** (Figure 1-5) **is provided for each channel. The combination of driver amplifier and galvanometer simulates the characteristics of a simple galvanometer at 71% of critical damping, by negative velocity-voltage feedback from the galvanometer in conjunction with a compensation circuit in the driver amplifier. Driver amplifier specifications are listed in** Table 1-7

1-25. System Cabinet 1061A (Cabinet Option 05).

1-26. **The cabinet mounts and encloses all components of the recording system. The power panel above the preamplifiers and the blower system are considered part of the cabinet.**

1-27. Master Power Panel 1069-03A.

1-28. **The Hewlett-Packard Master Power Panel 1069-03A provides primary ac power switching and distribution for systems that are furnished less cases or cabinet. The panel, which matches the front panel appearance of system components, is used in custom installations of Hewlett-Packard recording systems. See** Figure 2-8A **for wiring of the panel.**

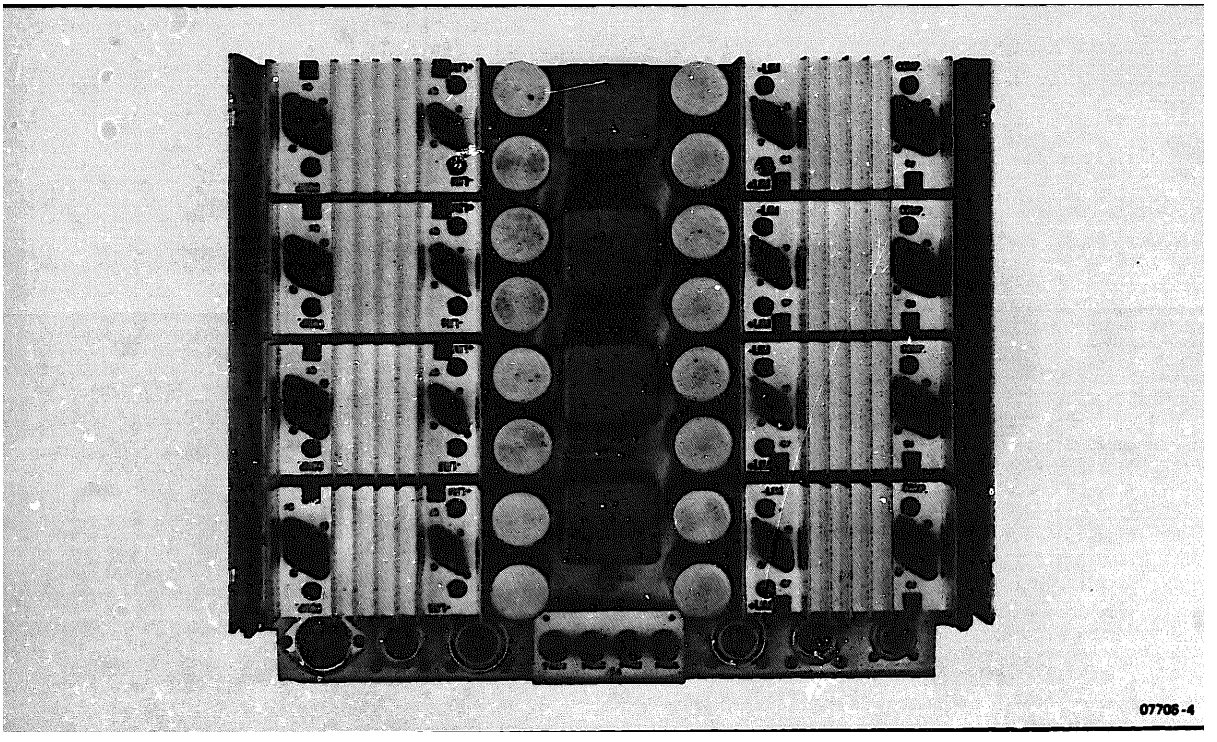


Figure 1-4. Model 356-400B Driver Amplifier Power Supply (With Driver Amplifiers)

Table 1-7. Driver Amplifier Specifications

Input Sensitivity:
100 millivolts per division (± 2.5 volts full scale) nominal.

Input Resistance:
100K ohms, single-ended.

Gain Stability:
Less than 0.15% change in gain for line voltage change from 103 to 127 volts. Less than 0.1% for 10°C change in amplifier ambient temperature from 0°C to 75°C.

Drift:
Less than 0.05 div on recording chart for change in line voltage from 103 to 127 volts after 30 min. warmup. Less than 0.1 div on recording chart for 20°C change in amplifier ambient temperature within the range 0°C to 75°C.

Frequency Response:
Internally adjusted for operating with recording galvanometer; provides frequency boost of from +7 dB to +17 dB at 150 Hz.

Weight:
About 1.3 lbs. (0.59 kg).

Noise:
Not visible on recording. Electrical amplitude depends upon frequency compensation, and is typically less than 0.75 mA rms.

Linearity:
Not greater than 0.1% non-linearity over entire ± 400 mA output range.

Output:
Full-scale output equals ± 400 mA through an ungrounded 17-1/2-ohm load. Output source resistance above 2000 ohms, typical value.

Limiting:
Fully adjustable for each polarity.

Cross Talk:
With common power supply, interchannel cross talk is less than -66 dB.

Signal Monitoring:
From connector on Driver Amplifier Power Supply rear panel. Output level ± 2.5 volts for full-scale on the recording (approximately). This connector is in parallel with preamplifier output.

Table 1-8. System Accessories

PREAMPLIFIER POWER SUPPLY ACCESSORIES

(8) Connector 5 pin F (Input)	1251-1895
(8) Connector 10 pin M (Aux. Input)	1251-1944
(1) Connector 9 pin M (J33 Remote)	1251-1708
(1) Signal Cable	07727-60010
(8) Grommet	0340-0404

RECORDER ACCESSORIES

(1) Fuse, 0.6 A Slow Blow	2110-0016
(1) Fuse, 3.2 A Slow Blow	2110-0013
(1) Screwdriver (stylus pressure)	8710-0875
(1) 1-oz tube lubricant	6040-0222
(1) 3/4-oz bottle motor oil	6040-0220
(1) Spline wrench	8710-0876
(1) Lamp bulb	2140-0002
(1) Stylus pressure tester	14015A

For 8-Ch Recorders (4-cm channels):

(2) Record cores (hex)	1490-0773
(1) Writing arm	399
(1) Marker arm	411-3
(1) Roll Permapaper (green, industrial)	651-58
(or black, medical)	651-48

For 6-Ch Recorders (5-cm channels):

(2) Recorder cores (hex)	1490-0774
(1) Writing arm	398
(1) Roll Permapaper (green)	651-57
(1) Marker arm	411-10

DRIVER AMPLIFIER POWER SUPPLY (356-400BW, 358-400B) ACCESSORIES

(1) 9-contact male conn.	1251-1707
(1) 19-contact male conn.	1251-1717

MASTER POWER PANEL ACCESSORIES (OPTION 01)

(1) Pilot lamp	2140-0228
(1) Power cord	358-1400-C4

1-29. SYSTEM ACCESSORIES

1-30. **System accessories provided with the individual system components are listed in** Table 1-8

1-31. **In addition to these accessories supplied, a horizontal writing table with concealed paper takeup** Figure 1-6 **is available on special order. The Model 358-800-1 Paper Take-up can be operated with its horizontal writing table extended, or retracted to provide a flush-front system. In the extended position, the hinged top surface of the paper takeup functions as a horizontal writing surface. This paper take-up accommodates up to 200 feet of recorded Permapaper, and is illustrated in** Figure 1-6

1-92 **Also optional is the DC Marker Driver Amplifier Model 14040A. This accessory permits either + or - dc marker traces to be generated instead of the standard trace, which is applied at line frequency.**

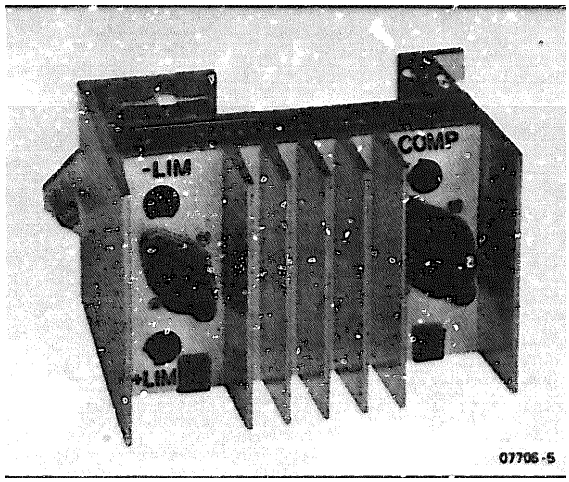


Figure 1-5. model 7700-02B Driver Amplifier

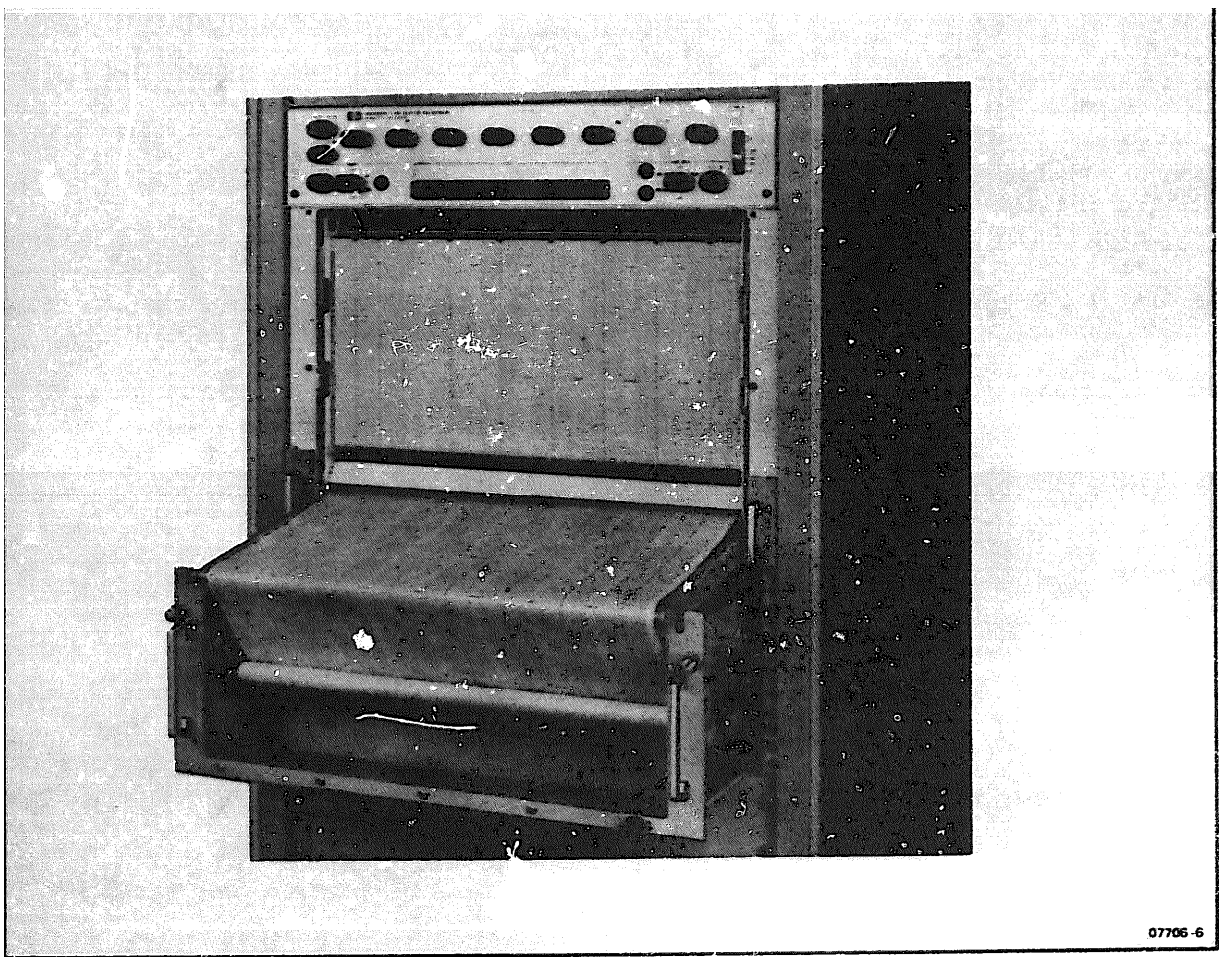
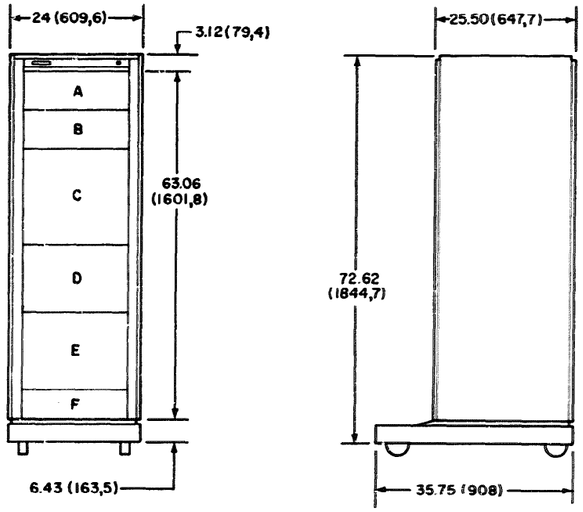


Figure 1-6. Optional 356-800-1 Paper Take-up In Extended Position

SYSTEM INSTALLATION DIMENSIONS



UNIT	DESCRIPTION	DIMENSIONS	
		INCHES	MM
A	BLANK PANEL, 00511-00062	7	177,8
B	POWER SUPPLY, 8848A	7	177,8
C	RECORDER, 356-100CW OR 358-100C	17.5	444,5
D	BLANK PANEL, 00511-00064	12.25	312
E	DOOR, 01060-60280	14	355,6
F	AIR GRILL, 01060-00360	5.25	133,4

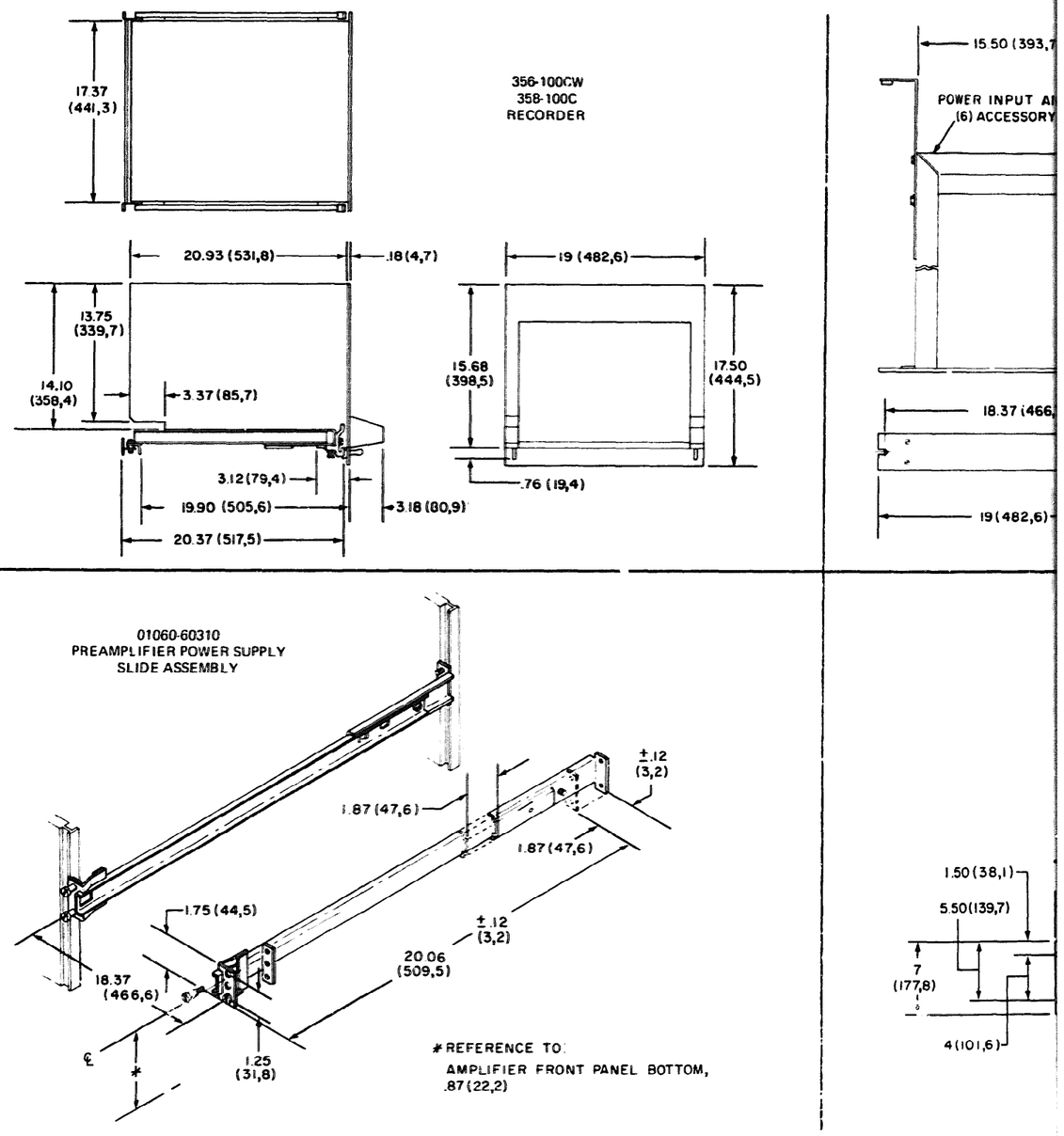
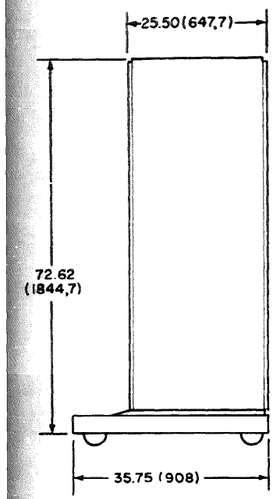
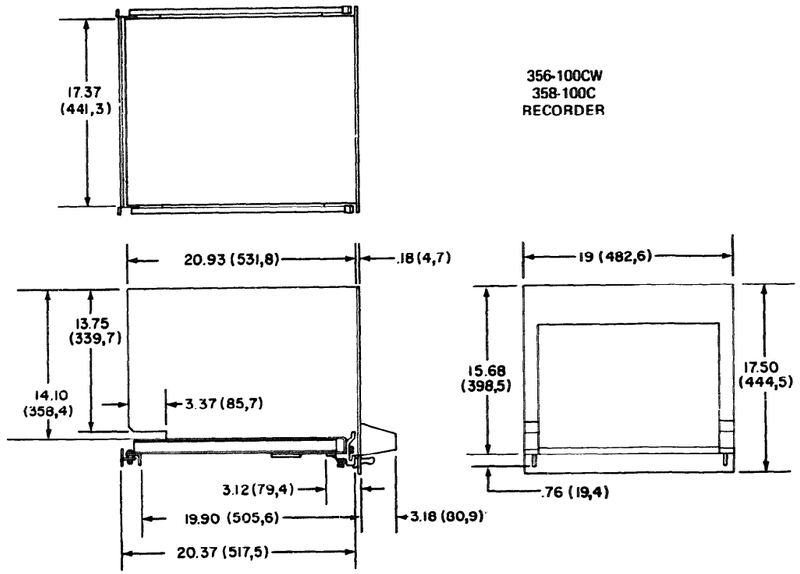
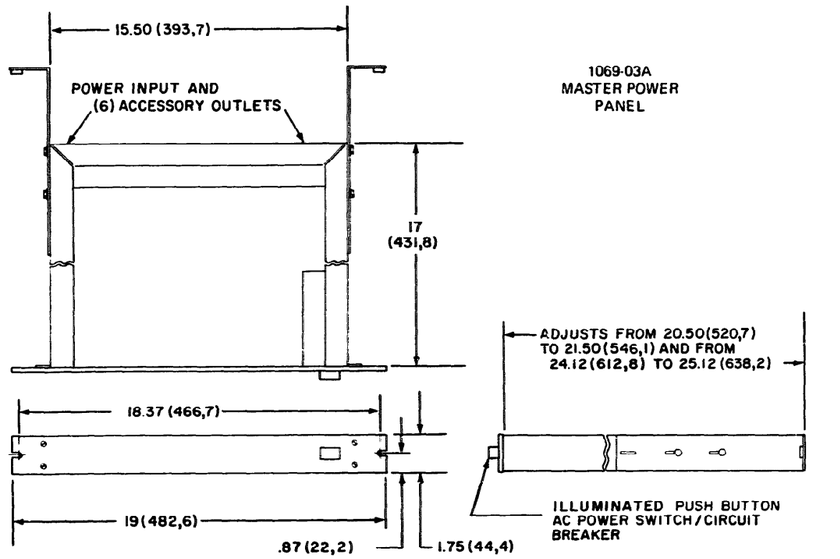


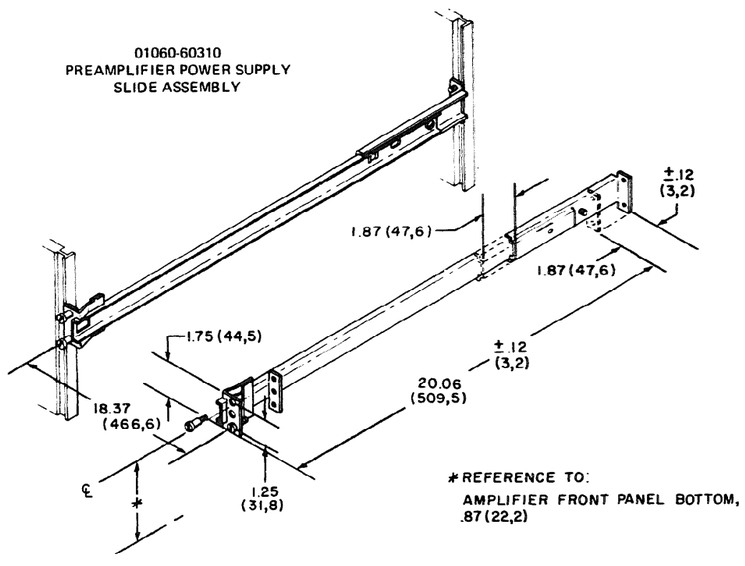
Figure 2-1. System



	DIMENSIONS	
	INCHES	MM
062	7	177,8
	7	177,8
R 358-100C	17.5	444,5
0064	12.25	312
	14	355,6
	5.25	133,4







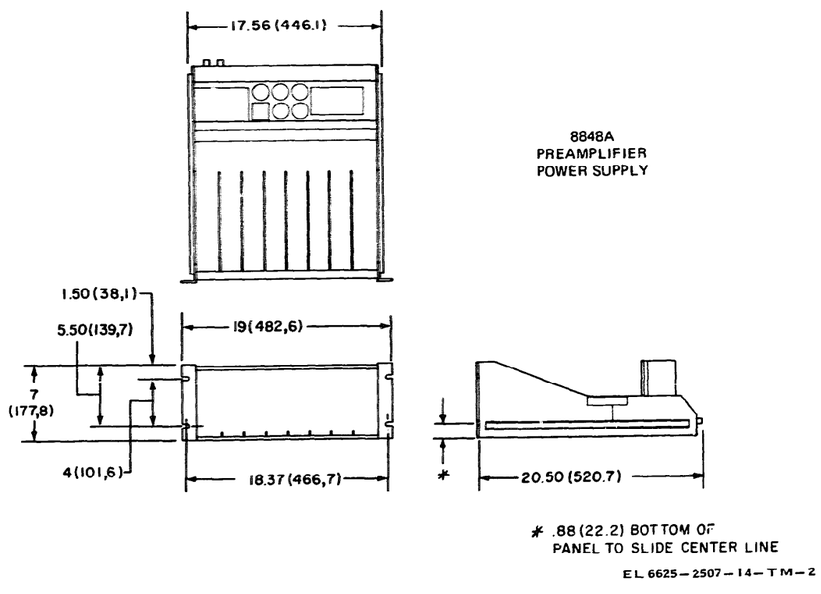


Figure 2-1. System and component installation Dimensions.

SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section contains information on initial inspection of the system, and system installation. Installation information includes system and component dimensions (Figure 2-1), environmental factors essential to efficient system operation, removing shipping retainers, preparing cables, and interconnecting the system components. In addition, information is provided to install system components (Option 01 System) in a custom cabinet and to provide remote control circuits for the recorder.

2-3. INITIAL INSPECTION

2-4. Mechanical Inspection.

2-5. Cheek the System for external damage, such as broken controls or connectors, and dents or scratches on the panel surface. If damage is found, refer to paragraph 1-3 for instructions on filling out the necessary forms. If the shipping carton is not damaged, check the cushioning material and note any signs of severe stress as an indication of rough handling in transit. Retain the packaging material for possible future use.

2-6. Electrical Inspection.

2-7. Check the electrical performance of the System as soon as possible after receipt; see Section V for the recommended performance checks. The checks will verify that the System is operating within the specifications listed in Table 1-3. This check is a good test procedure for incoming quality control inspection and for an operational check after repairs or adjustments have been made.

2-43 through 2-12 Deleted.

2-13. INSTALLATION.

2-14. Environment.

2-15. System location should be reasonably free from vibration, dust, corrosive or explosive vapors or gases, extremes of temperature, humidity, etc. The floor should be level and must supply support for all four wheels of the System. Allow sufficient room at the front for operation with any part of the System extended forward, and at the rear for servicing with the access door open.

2-16. System installation must allow adequate clearance for exhaust of cooling air from the cabinet, or maximum ambient temperature must be derated.

2-17. Check that the power line voltage, voltage regulation, power capacity, frequency, and frequency stability are suitable for the requirements of the System. The time-axis accuracy of the recording will be directly dependent upon the frequency stability of the power line. Frequency rating of recorder is shown on nameplate (Figure 2-4, 11).

2-18. Preparation for Use.

2-19. SYSTEM WITH CABINET. The Recorder is firmly held in the cabinet with shipping screws. These and other retainers must be released before use. Prepare the Recorder for operation using the following procedures, referring to Figures 2-2, 2-3 and 2-4 for location of the shipping retainers:

a. Open cabinet rear access door, locate and remove four shipping screws which hold Recorder to cabinet shipping brackets (Figure 2-2, 1, 2, 3, 4).

b. At the front of cabinet, remove two copper shipping screws which hold Recorder to cabinet (Figure 2-3, 5, 6).

c. Pull up two lock levers (below Recorder panel) and pull out Recorder until it locks in place, Remove four shipping screws, two each side, which hold writing platen during shipment (Figure 2-3, 7). After removal, push Recorder back into place.

d. Open viewing window and remove tape which holds stylus guard retainer down on platen table (Figure 2-2, 8). Leave window open.

Pull out on stylus lifting lever (left side of platen table, center), hold platen table with one hand, lift up and out on table locking table. Take out spool of Permapaper and look in through paper compartment to identify two chrome plug buttons (Figure 2-2, 9). Pry out right-hand button to release motor chain, and interchange with left-hand button. Replace Permapaper or install new roll (see paper loading instructions Figure 3-4).

f. Remove the protective gummed paper from the viewing window and close the window.

g. Use the reverse of this procedure to prepare the Recorder for re-shipment or storage.

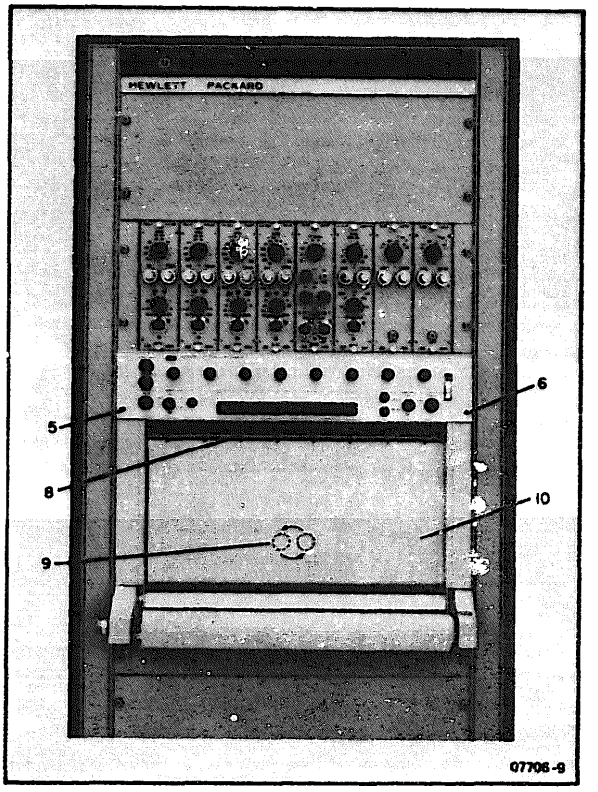


Figure 2-3. Shipping Retainer Locations, Front

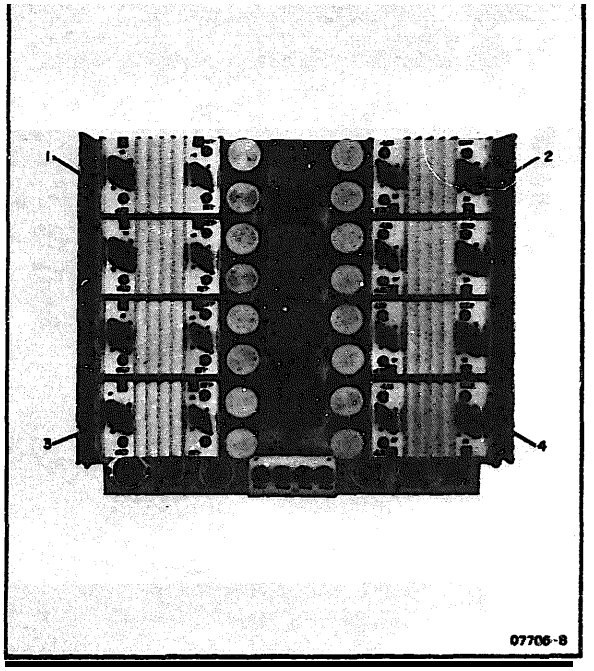


Figure 2-2. Shipping Retainer Locations, Rear

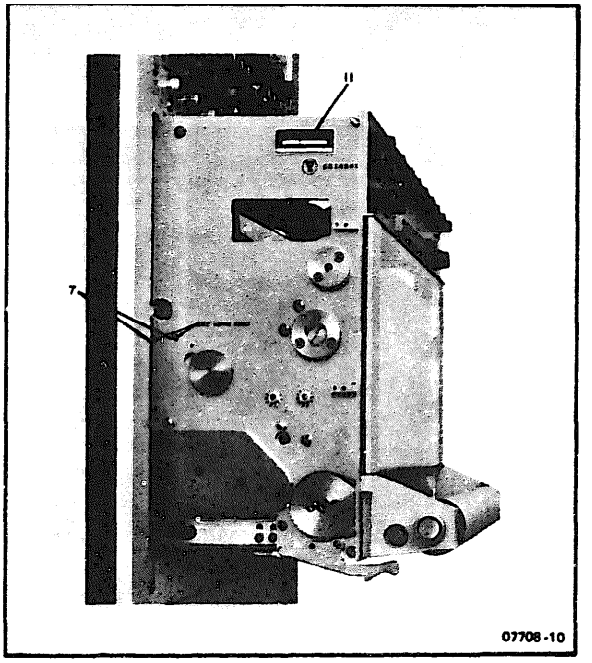


Figure 2-4. Shipping Retainer Locations, Both Sides

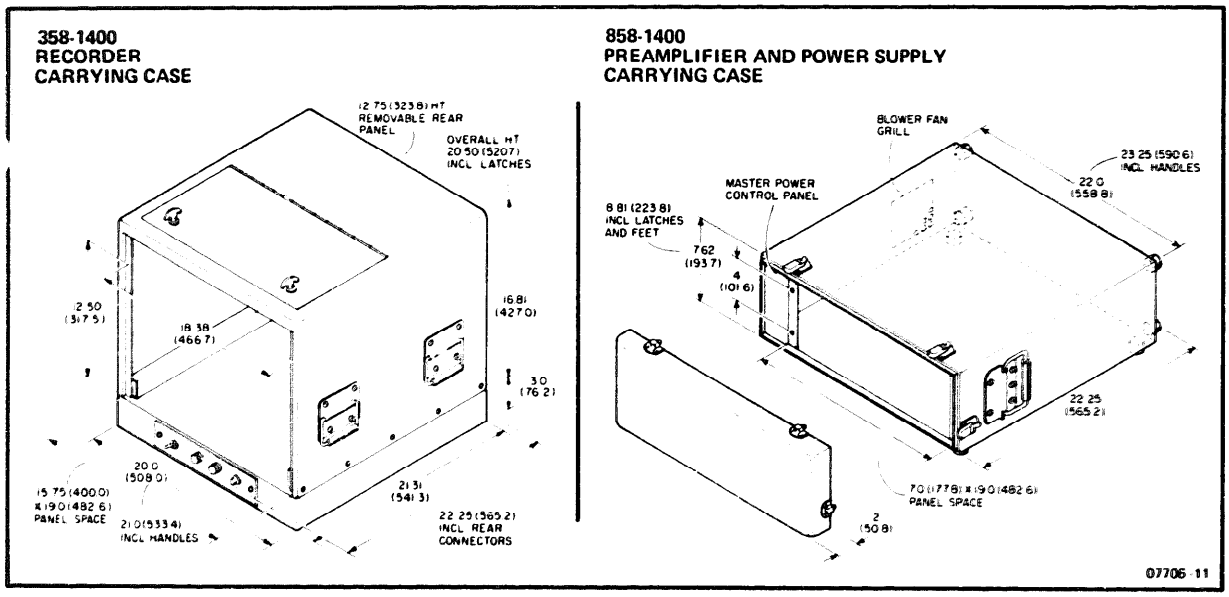


Figure 2-5. Portable Cases (System Option 02)

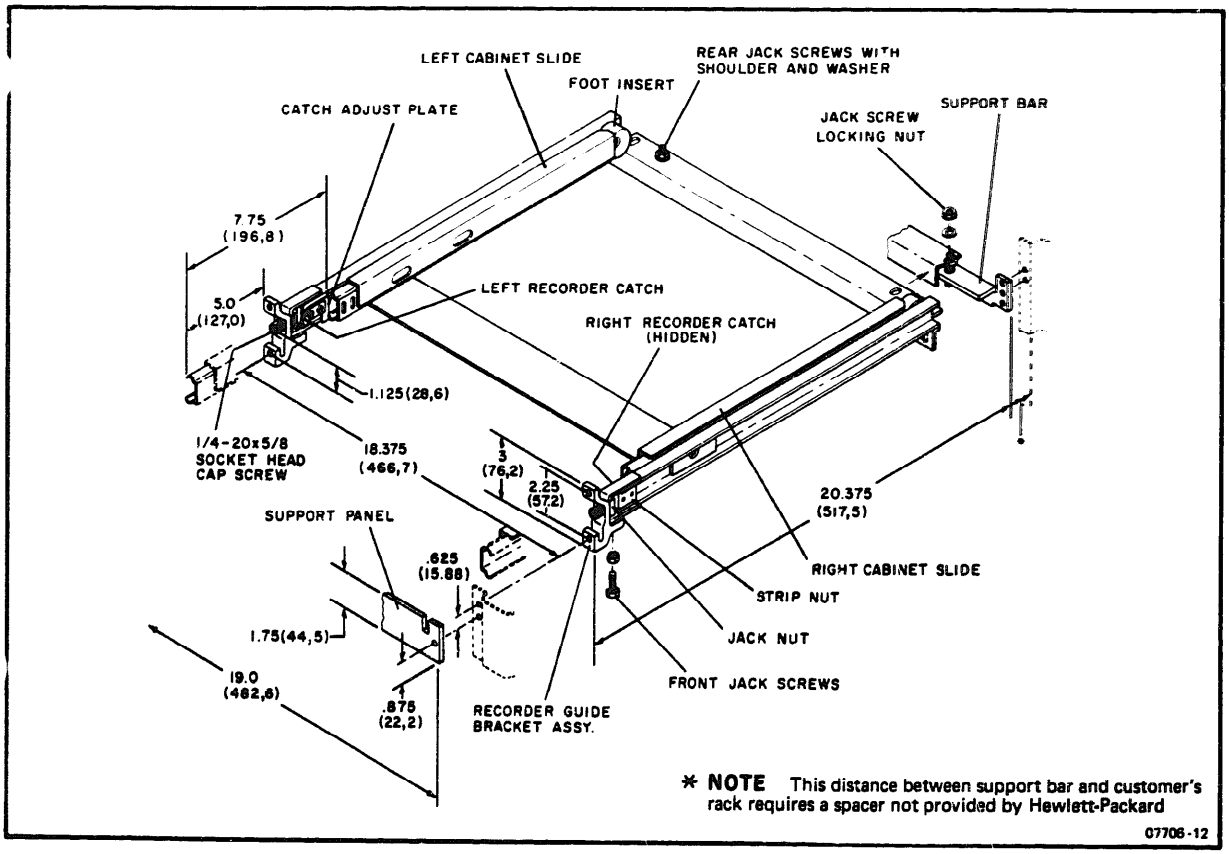
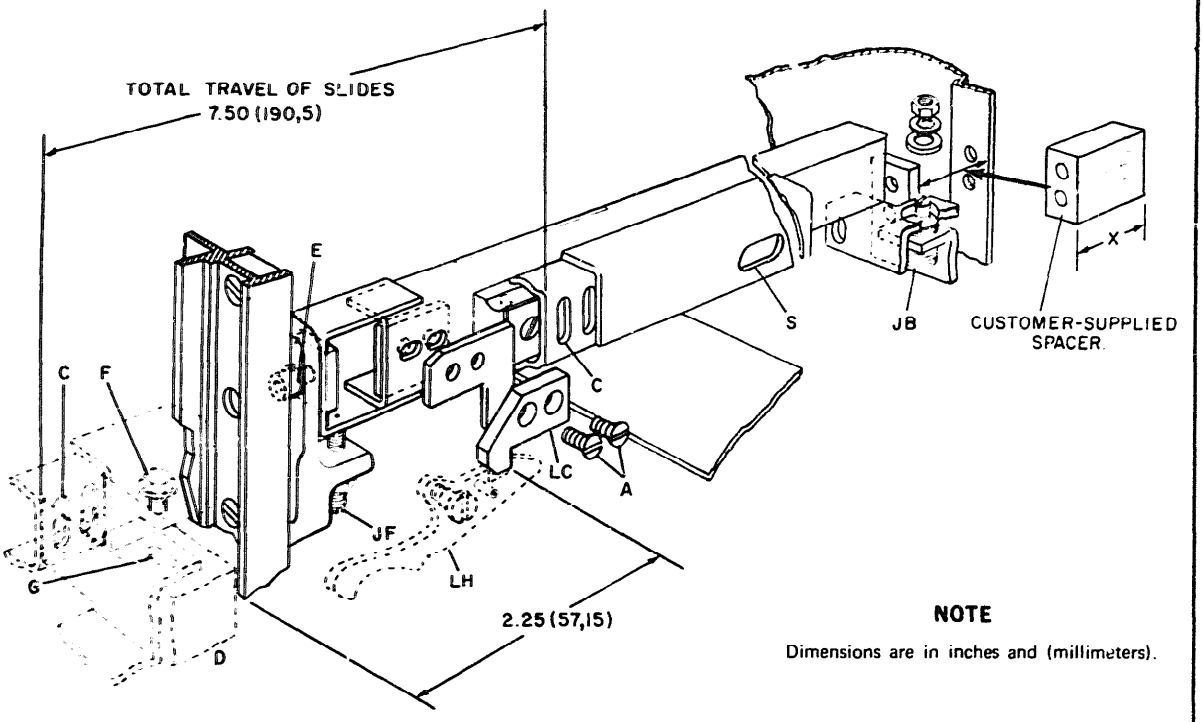


Figure 2-6. Recorder Slide Assembly 01060-60370



NOTE

Dimensions are in inches and (millimeters).

INSTALLATION AND ADJUSTMENT OF RECORDER

When the recorder is properly positioned the front panel fits flush at all points against the lip of the relay rack. The latch handle (LH) will lock the recorder securely when in its full in position.

1. Note critical 2-1/4" (57, 15 mm) dimension. Make this adjustment on both sides of rack before installing recorder.

   Loosen screws (A) and position catch (LC) so that engaging lip will be 2-1/4" (57, 15 mm) from the lip of relay rack. Tighten screws (A).

2. Place recorder on this assembly. Secure it to slide section (note view of slide in extended position) using two #10-32 hex head screws on each side, through slots (C) into square bar (D) which is part of recorder.

   Side adjustment of the recorder with respect to bar (D) is provided by screws (F) in slots (G) located behind paper supply spool.

3. Push recorder into rack. The recorder panel should fit flush at all points to lip of rack. To adjust, find jack screws (JB) at back of support frame and jack screws (JF) at front. Screws (JB) raise and lower the back and screws (JF), the front.

   Loosen check nuts on jack screws. Loosen clamp screws (E). Raise or lower support frame corners with jack screws until recorder panel is flush. Tighten clamp screws (E) and check nuts on jack screws.

4. Push recorder to full retracted position. If latch handle (LH) does not lock recorder securely in this full retracted position advance recorder forward until slot (S) in slides aligns with screws (A) giving access for adjustment of latch catch (LC), as described in step 1.

07706-13

Figure 2-7. Recorder Installation and Adjustment Data for use with System Option 01

2-20. System Without Cabinet System Option 01 is shipped less cabinet. For convenience, use Figure 2-1 2-6 2-7 when mounting the system components in a custom cabinet. The front panel dimensions are referenced to the top of each panel.

2-21. Connections

2-22. INPUT POWER Check that the power line voltage and frequency is the same as shown on the Recorder nameplate (located on the left side of the Recorder (recorder extended)). Systems used with 230 volt line power use a 230-volt step-down transformer (auto transformer) to power the entire system at 115 volts ac.

2-23. The system is provided with a 10 foot (3, 28 meter) power cord. Connect the system to an approved power source, preferably to a 3-wire polarized outlet. If only a 2-wire service is available, use a 3-wire to 2-wire grounding adapter (standard commercial) between the system power cord and the line outlet. Connect the ground wire of the adapter to an electrical ground such as a water pipe or outlet box screw if box is grounded.

2-24. Inside the cabinet, connect the separate instruments of the system to the line power at the ac power strip along the left side of the cabinet. System power cords are shown in Figure 2-8A.

2-25. SYSTEM IN PORTABLE CASES System Option 02 is supplied in portable cases. The Recorder is bolted to the Model 358-1400 Case at the bottom as well as the front and rear. When the Recorder is received in a portable case, use the following procedure to prepare the Recorder for operation Figure 2-5

a. Remove copper shipping screws, one at each side, which hold writing platen during shipment. Access holes are provided at each side of case.

b. Open viewing window and remove tape which holds stylus guard retainer down on platen table (Figure 2-3, 8). Leave window open.

c. Pull out on stylus lift lever (left side of platen table, center), hold platen table with one hand, lift up and out on table lock lever (above stylus lift lever), and lower platen table. Take out spool of Permapaper® and look in through paper compartment to identify two chrome plug buttons Figure 2-3,9 Pry out right button to release motor chain, and interchange with left button. Replace Permapaper® or install new roll (see paper loading instructions in Figure 3-4

d. Remove gummed paper protective covering from viewing window and close window Figure 2-2 10).

e. Reverse above procedure to prepare Recorder for re-shipment or storage.

2-26. For maintenance access to the Recorder, remove case cover using the following procedure:

a. Remove two shipping screws on front panel.

b. Remove two screws at rear panel (inner one at each side near top).

c. Remove four base screws at each side of bottom section.

d. Use handles to lift carrying case cover, exposing Recorder for maintenance.

e. To replace cover, reverse removal procedure.

2-27. INPUT SIGNALS Prepare signal cables and connectors as shown in Figure 2-9 according to the requirements of individual preamplifiers, for guarded or non-guarded input circuits. An access hole is provided in the lower rear panel of the system cabinet for signal cables; a plate must be removed to gain access.

2-28. Input connections are made to the 8848A Preamplifier Power Supply rear panel. Channel 1 through Channel 8 connections are made to J11 through J18, shown in Figure 2-10

2-29. Special cables should be fabricated locally for inputs to preamplifiers, as shown in applicable appendix. The cables carry transducer and bridge excitation and signals. The appendixes also provide information about making preamplifier front panel connections.

2-30. OUTPUT SIGNALS Preamplifier signal outputs are provided to the recorder and other monitors through J34 on the Preamplifier Power Supply Figure 2-10 cable 07727-60010. This cable is shown in Figure 2-8B.

2-31. Remote operation Remote Connector J412 is located on the Driver Amplifier Power Supply Figure 2-10 The typical remote switching arrangements are shown in Figure 2-11 Included is information on remote chart drive, remote standard marker and remote auxiliary marker control.

2-32. AUXILIARY INPUTS AND OUTPUTS Connectors J21 through J28 Figure 2-10 are provided on the Preamplifier Power Supply for providing external inputs (such as an external reference voltage for the phase sensitive demodulator preamplifier) to preamplifier and for connecting auxiliary monitor units such as oscilloscopes and numerical display devices. These connectors also are convenient test points. An auxiliary connector is also provided on signal cable 07727-60010.

2-33 FUSE LOCATIONS

2-34. Before operating the system, check that system fuses are of the proper values, as shown in Figure 2-12.

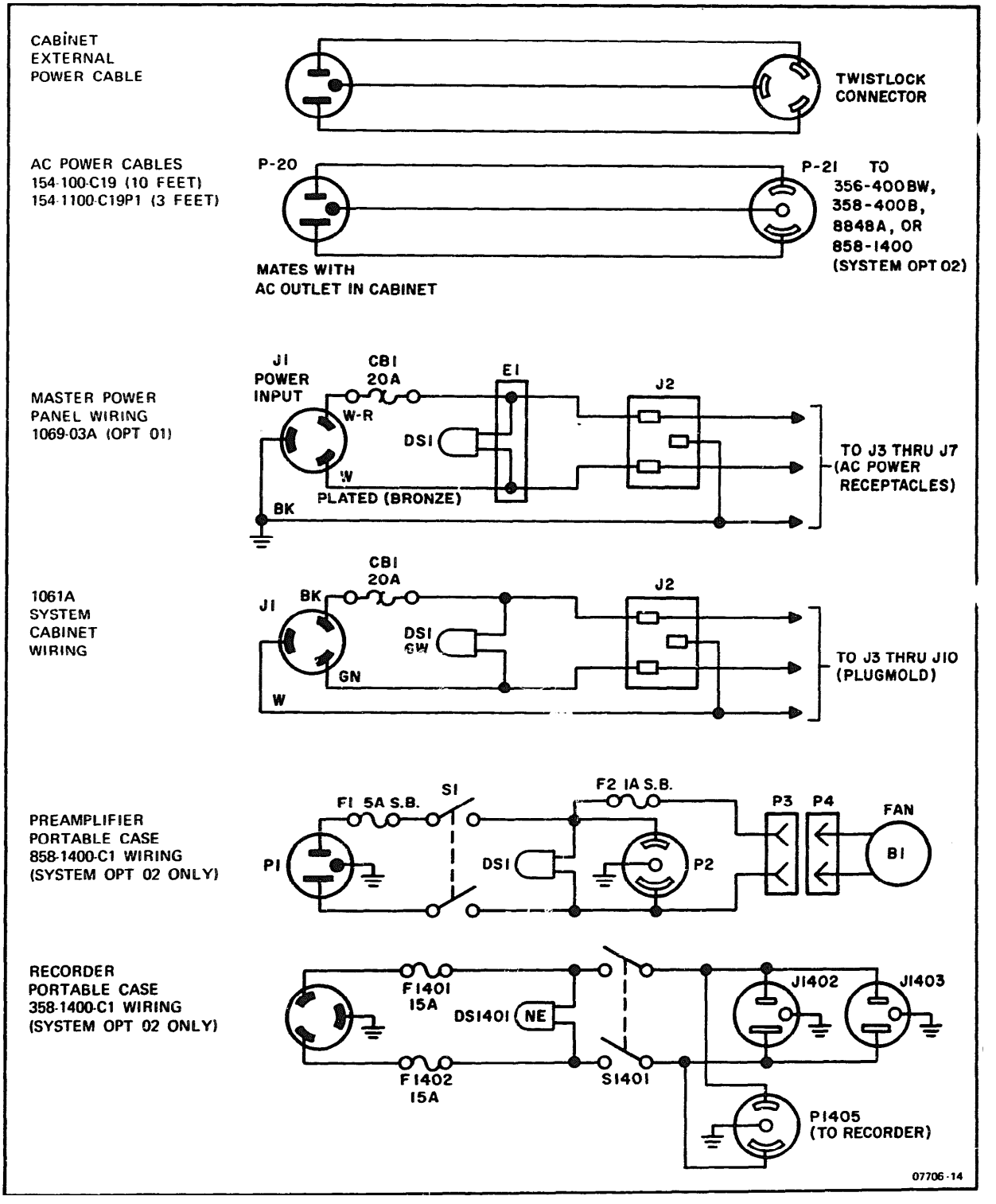


Figure 2-8A System Power Cables, 7706B, 7708B

2-35.

2-36. Review the installation procedure, checking the cables and connectors for tightness. Check that S1 (115/230 volt) switch is set for the correct voltage and that the power cord is connected to the power line.

2-37. The following procedures are used to check Recorder operation. In addition, calibration voltages from the Preamplifiers are used to check the electronics circuits.

a. Press red button at top of System Cabinet to close Power switch. Back lighted button is lit when ac power is applied to System.

b. Set Recorder CHART DRIVE control to MM/SEC position. Red indicator beside speed control should light. Check paper travel at each speed. Repeat with remote controls where applicable.

c. Set CHART DRIVE control to MM/MIN (358-100D and 356-100DW Recorders). Yellow indicator beside speed switch should light. Again check paper travel at each speed. Paper motion may not be apparent at lowest speeds. Repeat with remote controls where applicable. Set MARKER control to 1-MIN position (358-100D and 356-100DW Recorders). Marker arm should record at 1 minute intervals and indicator should blink.

d. Adjust each STYLUS HEAT control at 10 MM/SEC for dense, well-defined baseline.

e. Set MARKER control to MARK position. White indicator to right of control should light and marker arm should record an ac trace (not applicable with 4040A ±dc modification). Repeat with remote circuitry where used. Set MARKER output to 1-SEC position; marker arm should record an ac pulse at 1 second intervals and indicator should blink.

f. Check POSITION control at each Preamplifier (Phase Sensitive Demodulators Preamplifiers must have specified reference voltage applied). With respective ATTENUATOR (or RANGE) control at OFF, and ZERO SUPPRESSION control at OFF, rotate POSITION control throughout control range. Corresponding channel stylus should deflect over full channel width on chart. Set each channel to indicate chart center.

g. Set each ATTENUATOR (or RANGE) control to OFF to remove input signals. If desired, fuse F1 can be removed from 8848A power supply to disable all preamplifiers simultaneously. Run several feet of paper at 10 mm/sec. Inspect recording for baseline stability (no drift or oscillation). Each baseline should be within one division of midscale.

h. Apply a known test signal to each Preamplifier, or use preamplifier calibration signal to check that response on Recorder chart is representive of calibration signal.

i. Press Power switch to remove power from System.

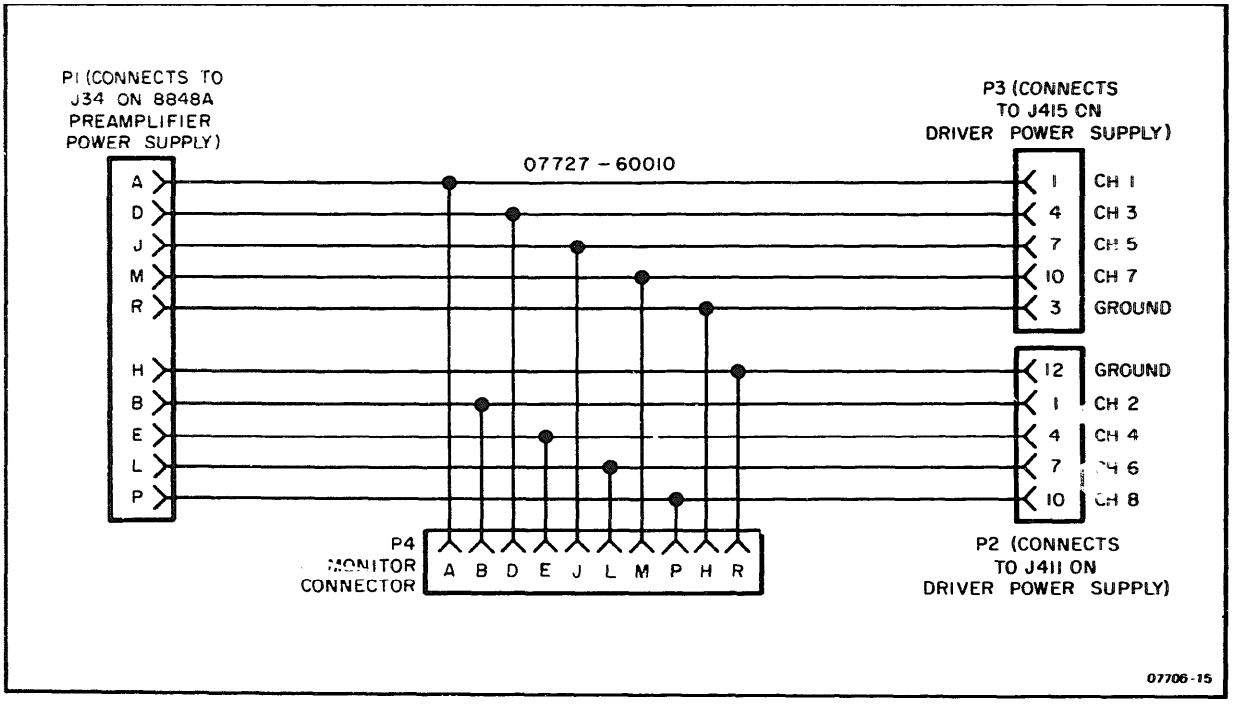
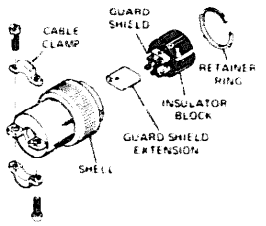


Figure 2-8B. System Signal Cable, 7706B/7708B

SIGNAL CONNECTOR PREPARATION

a. Slide the prepared end of the cable into the cable clamp and through the connector shell. Also slide the end of the cable through the guard shield extension, for guarded input circuits. For non-guarded input circuits, remove and store the guard shield extension.
b. Wire the connector according to the diagram below, according to preamplifier to be used. For guarded input circuits, slide the guard shield extension into place after soldering the signal leads to terminals A and B.
c. Press the connector block carefully into the connector shell.
d. Insert the retaining ring.
e. Tighten the cable screws.
f. Check with an ohmmeter to determine that the cable shields are not shorted to the connector shell or to each other.

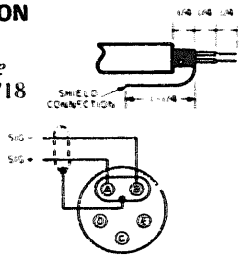
Connector HP 1251-1895



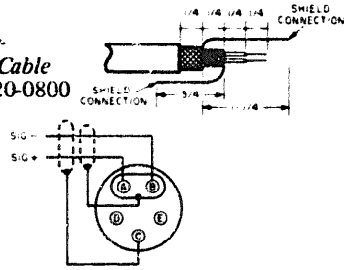
GUARDED CABLE PREPARATION

PREAMPLIFIER MODEL
8803A
8806B *
8807A **

Single-Shield Cable HP 8120-0718



Double-Shield Cable HP 8120-0800



NOTES:

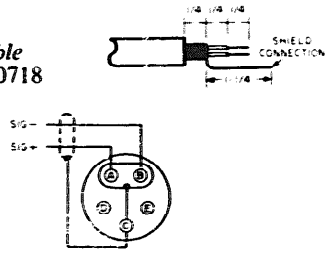
* 1. Connect Ref voltage to pins A and B on auxiliary connector of the power supply.

** 1. AC output available on pin C of auxiliary connector of the power supply.
2. DC input (8807A, Opt 02) available on pins A and B of auxiliary connector of the power supply.

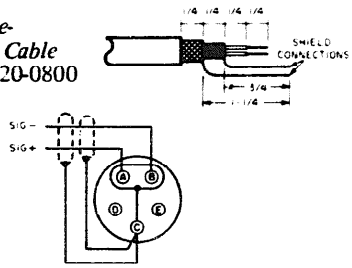
NON-GUARDED CABLE PREPARATION

PREAMPLIFIER MODEL
8801A
8802A
8808A *
8809A *

Single-Shield Cable HP 8120-0718



Double-Shield Cable HP 8120-0800



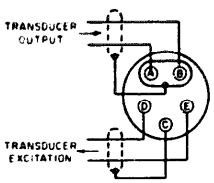
***NOTE:**

Single conductor shielded cable can be used by connecting center conductor to pin A and shield to pin B.

CARRIER PREAMPLIFIER CABLE PREPARATION

PREAMPLIFIER MODEL
8805A

HP Transducers having 5-pin AN connectors (pin pattern ⊙) use Input Adapter 14060B for signal input connections. For other signal sources, connect the input signals as shown. The transducer output leads and transducer excitation leads must be twisted and enclosed in braided shielding.



07706-16

Figure 2-9. Signal Connector Preparation

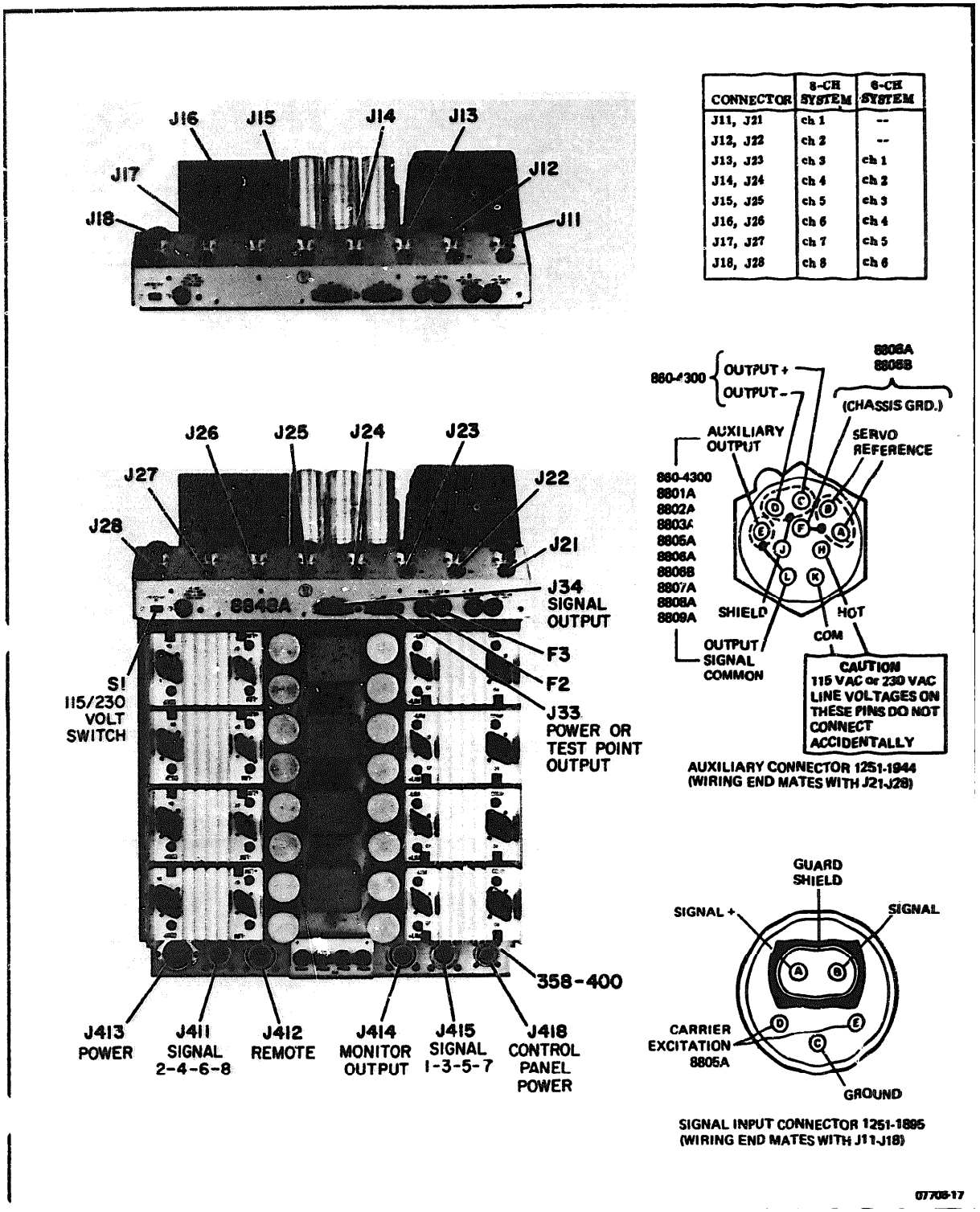


Figure 2-10. System Connectors, Location

REMOTE CHART DRIVE

S2: (SPDT, neut. ctr.) Remote chart drive. Set CHART DRIVE switch on recorder panel to REMOTE for S2 operation. MM/MIN speeds on D, DW models only.

S8, S9, S10, S11: (SPST) Remote chart speed selection. Press REMOTE speed selector button recorder panel, for S8, S9, S10, S11 operation. See chart:

CHART SPEED MM/SEC or MM/MIN	SWITCHES CLOSED			
.25	--	--	--	--
.5	--	S9	--	--
1.	S8	S9	--	--
2.5	--	--	--	S11
5.	--	S9	--	S11
10.	S8	S9	--	S11
25.	--	--	S10	S11
50.	--	S9	S10	S11
100.	S8	S9	S10	S11

REMOTE STD.MARKER

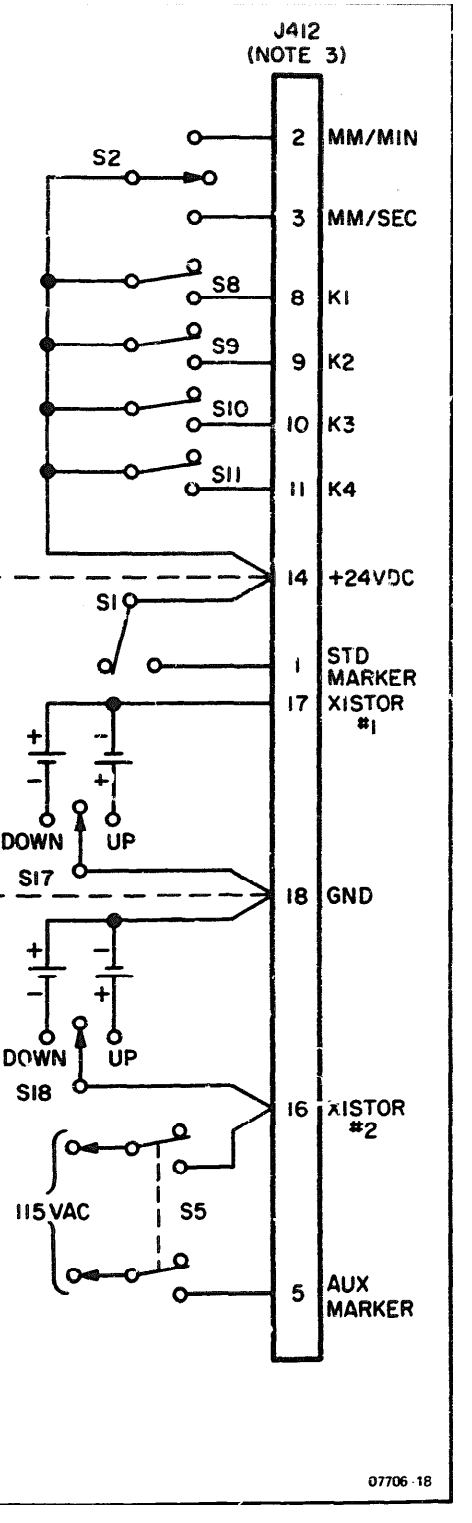
S1: (SPST) Remote standard marker, ac trace, for parallel operation with front panel control. Use any time with no need to set recorder panel control. Does not operate when standard marker is modified with Model 14040A for dc marking.

S17: (SPDT): For ±dc modification with transistor amplifier 14040A. With modification, panel and remote MARK circuits are inoperative.

REMOTE AUX. MARKER

S18: Requires auxiliary marker transistor amplifier plug-in. DO NOT USE WHEN S5 CIRCUIT IS CONNECTED. S18 (SPDT, neut. ctr.) for ±dc modification with transistor amplifies 14040A.

S5: (DPST) For remote ac operation. DO NOT USE WHEN S18 CIRCUIT IS CONNECTED. Requires auxiliary marker transformer plug-in.



NOTE 1:	S17 and S18 circuits shown with 1.5 volt batteries. Higher voltages may be used by adding series resistance at the rate of 3,000 ohms per additional volt.
NOTE 2:	Circuits shown with toggle switches; any equivalent circuit closing device may be used.
NOTE 3:	Mating connector for J412 is Hewlett-Packard Part No. 1251-1707.

Figure 2-11. Remote Control Circuits

SYSTEM CABINET

15A circuit breaker; press to restore service.

PREAMPLIFIERS

Refer to applicable appendix

RECORDER

Fuse	Rating	Circuit	HP Part No.
F101	0.6A Slow Blow	Marker	2110-0016
F102	3.2A Slow Blow	Chart drive	2110-0013
F103	1.5A Slow Blow	Stylus	2110-0059
F104	0.6A Slow Blow	Control	2110-0016
F105*	0.5A	MM/MIN	2110-0012

* F105 in "D", "DW" models only; remove roll of Permapaper for access.

PREAMPLIFIER POWER SUPPLY

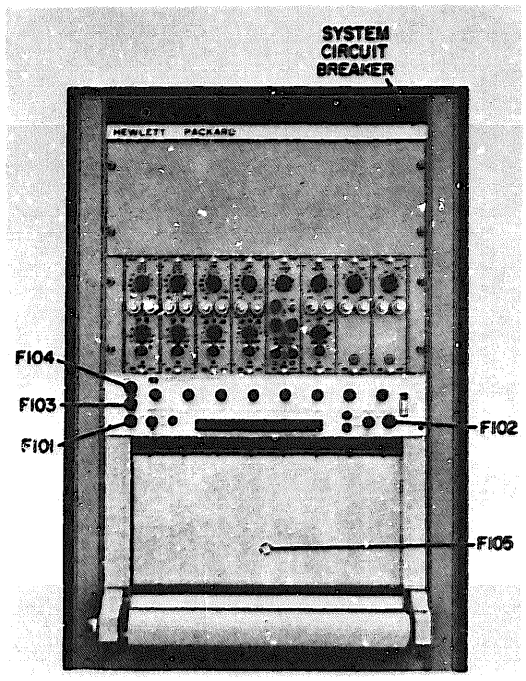
Fuse	Rating	Circuit	HP Part No.
F1	1A Slow Blow	115V line	2110-0231
F1*	0.5A Slow Blow	230V line	2110-0201
F2	1.5A	-18V	2110-0059
F3	1.5A	+18V	2110-0059
F4	1.6A Slow Blow	Osc. Supply	2110-0007
F5	0.25A	Osc. -18V	2110-0004

* F1 for 230V line is alternative fuse.

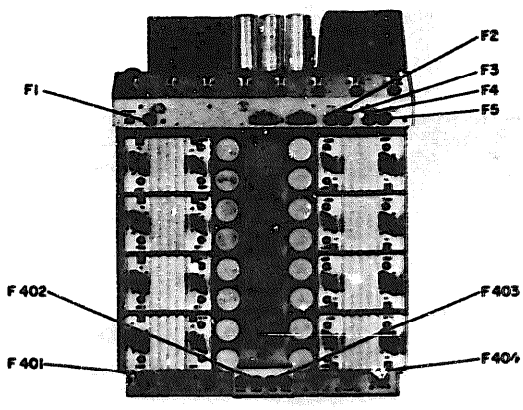
DRIVER AMPLIFIER POWER SUPPLY

Fuse	Rating	Circuit	HP Part No.
F401*	0.5A	ch 1, ch 2	2110-0012
F402	0.5A	ch 3, ch 4	2110-0012
F403	0.5A	ch 5, ch 6	2110-0012
F404	0.5A	ch 7, ch 8	2110-0012

* F401 absent on 6-channel systems.



FRONT VIEW



REAR VIEW

07708-19

figure 2-12. Fuse Locations

SECTION III
OPERATION

3 - 1 . INTRODUCTION

3 - 2. Operating procedures in this section assume hat the installation is completed.

3 - 3. **Parts of the Recording System.**

3 - 4. System Operation is performed entirely at the front panels of the System. Internal adjustments are typically a part of maintenance (Section V). Basically, the major components of the System, shown in Figure 3-2 do the following things:

a. **System Cabinet**. controls power ON/OFF function (Master Power Panel 1069-03A in Option 01, Portable Case Power switches in Option 02).

c. **6- or 8-Channel Recorder**. provides permanent readout of the conditioned signals.

3 - 5. **Duplicating Permapaper Recording.**

3 - 6. A recording on Permapaper® can be copied if it has a dense, sharply defined trace, and if the paper is free of creases, smudges, and wrinkles. Experimentation at the recorder and at the duplicator can improve the quality of the reproduction. Refer to Table 3-1 for information on different processes for reproducing all Permapaper recordings. Note that recordings on orange grid paper require different handling than those on black or green grids.

3 - 7 . Figure 3-1 shows a section of Permapaper recording reproduced by the offset printing method.

3 - 8. **Using the Recording System.**

3-9. PRELIMINARY CHECK A system check is recommended at the start of each operating day, and prior to a series of measurements. To check out the system, perform the procedure in paragraph 2-36.

3-10 OPERATION Refer to figure 3-2 for location and identification of the System controls, and Figure 3-3 for system operating procedure.

3 - 1 1 . PAPER LOADING Use the procedure illustrated in figure 3-4 for paper loading. To remove an old recording and start paper for a new one, follow the instructions in Figure 3-5

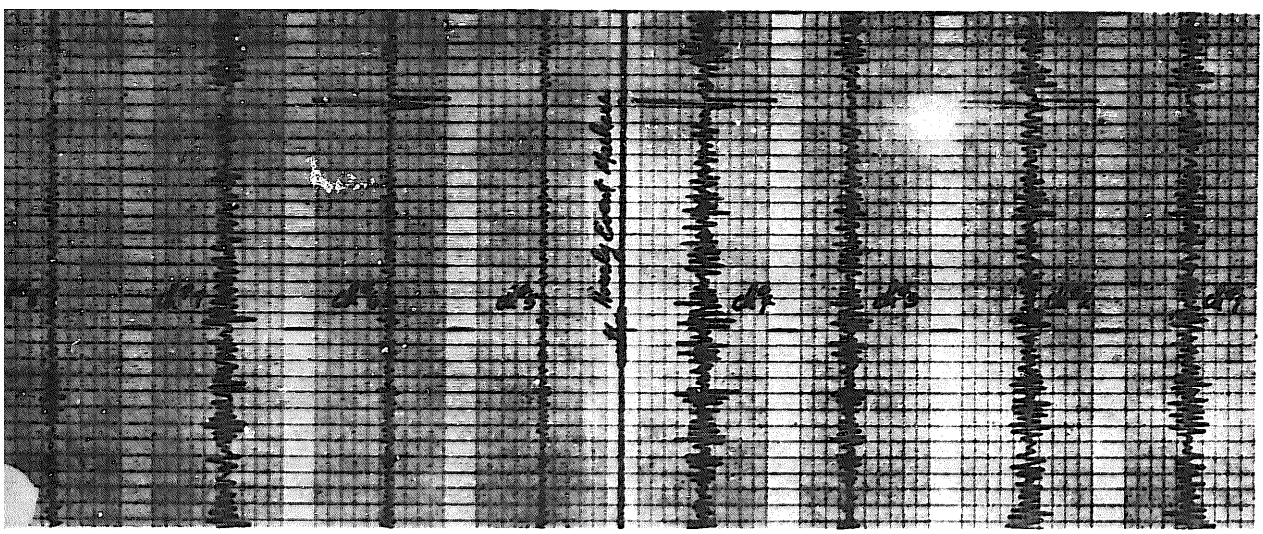
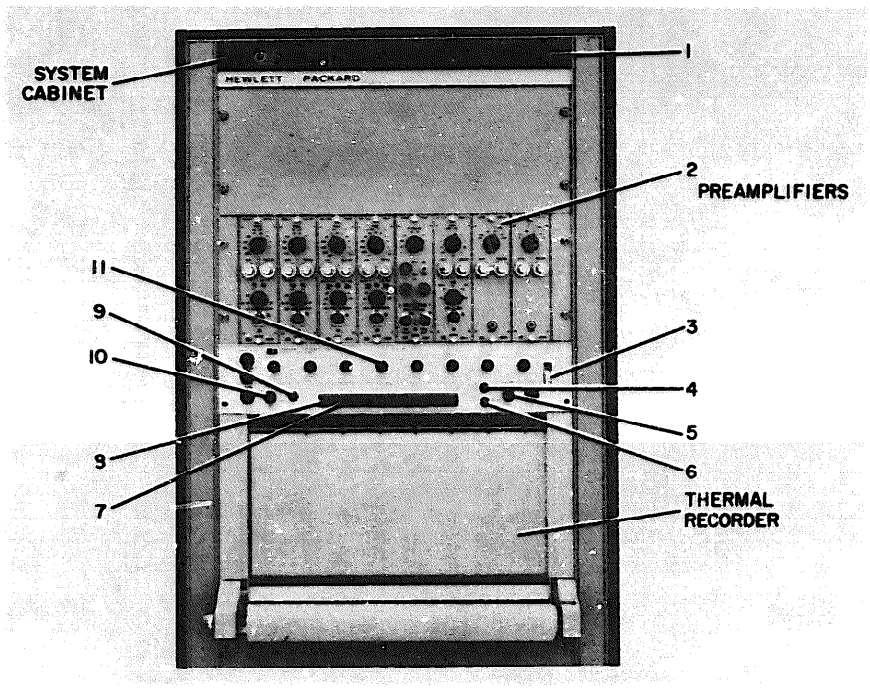


Figure. 3-1. Recording Sample

Table 3-1. Reproduction of Permapaper Charts

METHOD	QUALITY	RECOMMENDED FOR	SPECIAL INSTRUCTIONS FOR TRANSLUCENT (ORANGE) PERMAPAPER	REMARKS
Letter press or offset printing	Good to excellent	Large number of high-quality copies.	Place black paper or film behind recording during photography.	
Photographic duplicator, direct	Good to excellent	Small number of high-quality copies.	Duplicator must operate by reflection. Place black paper or film behind recording before passing through duplicator.	Requires handling the recording for each copy made; see two-step process (below) to reduce handling.
Photographic duplicator, two-step	Some loss compared with direct copies.	Small number of copies, with minimum handling of original.	Same	Make intermediate copy for use as a new original; original handled once only.
Photographic and diazo duplicators	Good	Moderate number of copies using standard engineering laboratory equipment.	Same	Make intermediate copy (as above), on film or translucent stock, then pass this copy through diazo duplicator. Original handled once only.
Electrostatic duplicators	Fair to good	Moderate number of copies.	Generally not satisfactory.	---
Thermal duplicators	Poor to fair	Moderate number of copies.	Generally not satisfactory; danger of damaging the recording.	---
Diazo duplicators, translucent (orange) Permapaper only.	Translucent Permapaper is designed primarily for diazo reproduction. More stylus heat may be needed than with other Permapapers. Use a clear acetate sheet over the Permapaper to prevent sticking to the printing cylinder. Reversing the recording will improve quality, but with time axis reading right-to-left. If this reversed copy is on film or translucent stock, it can be used as a reversed original for as many final copies as wanted, with time axis reading left-to-right, and no further handling of original needed.			



1. Master Power Switch: A combined circuit breaker, power switch and power indicator light. Press to apply power. Press again to remove power. Press to reset circuit breaker if necessary.

2. Preamplifiers: Refer to the applicable appendix for the separate instruments for control location and identification.

3. Paper Footage Indicator: Red section shows amount of recording paper still available.

4. Red Indicator: Lights when recorder is switched to a mm/sec speed.

5. CHART DRIVE Switch: Positions are OFF, MM/MIN, MM/SEC, OFF, and REMOTE. Switch selects drive motor and turns it on or off, or allows control from a remote location. MM/MIN position is active in recorder D and DW models only (System Option 11).

6. Yellow Indicator: Lights when recorder is switched to a mm/min speed (D, DW models).

7. CHART SPEED Control Buttons: Select one of nine speeds between .25 and 100 mm/sec; (only D and DW models provide speeds in both mm/sec and mm/min.)

8. REMOTE Button: Transfers speed selection functions to a remote circuit.

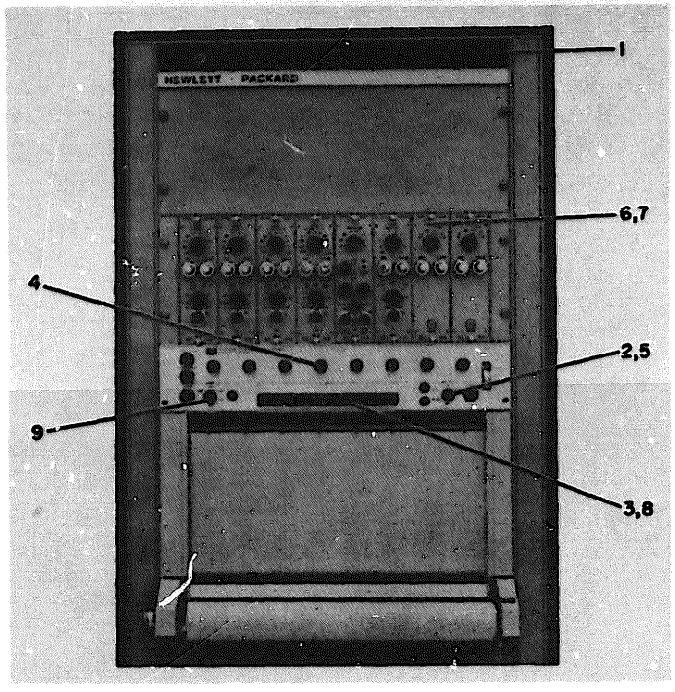
9. White Indicator: Lights for duration of marking trace, blinks at instant of each timing mark.

10. Timer/Marker Switch: Positions are MARK, OFF, 1-SEC TIMER, 1-MIN TIMER, and OFF. At MARK, an ac marking trace appears at margin of chart as long as switch is in MARK position. At 1-SEC TIMER, a brief timing mark appears at 1-sec intervals. At 1-MIN TIMER, a timing mark appears at 1-min intervals (D, DW model recorders).

11. STYLUS HEAT Controls: Adjust density and definition of recording trace; a separate heat control is provided for each channel.

07708-21

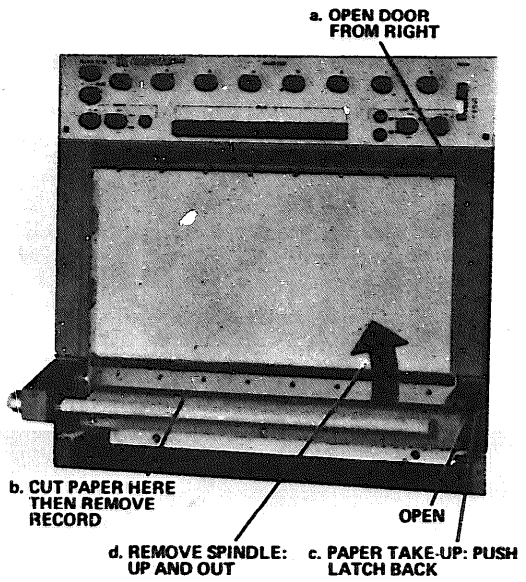
Figure 3-2. System Controls - Location and Identification



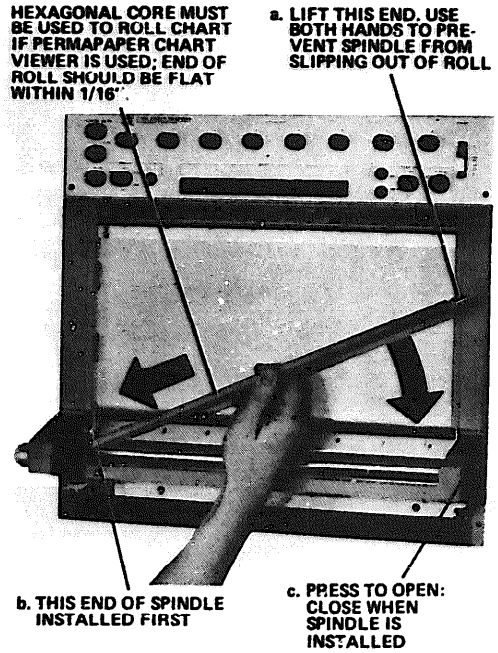
1. Press Master Power Switch.
2. Set CHART DRIVE to MM/SEC.
3. Press 10 MM/SEC speed button.
4. Adjust STYLUS HEAT controls for dense, well-defined traces.
5. Set CHART DRIVE to OFF.
6. Set Preamplifier attenuator controls (range controls) to OFF position.
7. Perform the following steps for each preamplifier:
   a. Adjust Preamplifier POSITION control to set corresponding channel stylus at zero reference.
   b. Calibrate preamplifier in accordance with instructions given in applicable appendix.
   c. Set Preamplifier attenuator control to the least sensitive position.
   d. Apply input signal to be monitored.
   e. Reset attenuator control as necessary for a convenient stylus deflection. Make a note of the setting for later reference.
8. Press desired CHART SPEED switch. Select low speeds for slowly changing variables and high speeds for higher frequencies.
9. Use the MARK position of MARKER/TIMER control to identify sections of recording or set to a Timer position for periodic marking of record.

07708-22

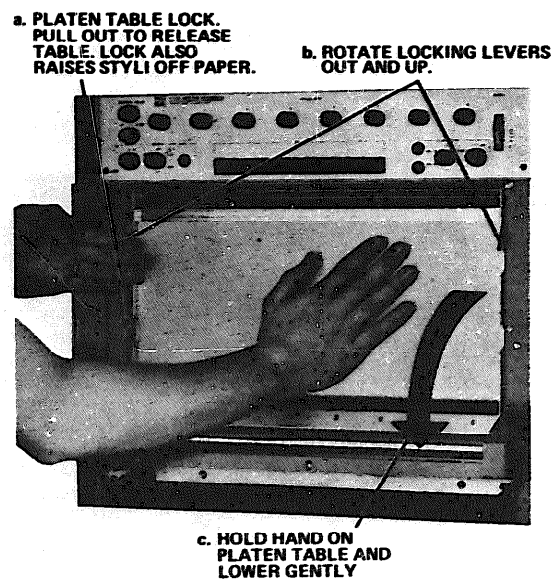
Figure 3-3. System Operation

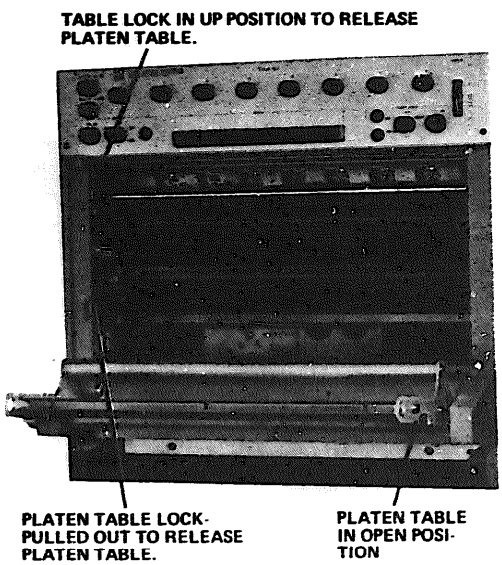


1. REMOVING OLD RECORD



2. INSTALLING PAPER TAKE-UP SPINDLE





3. RELEASING PLATEN TABLE

07708-23

Figure 3-4. Paper Loading Procedure (sheet 1 of 3)

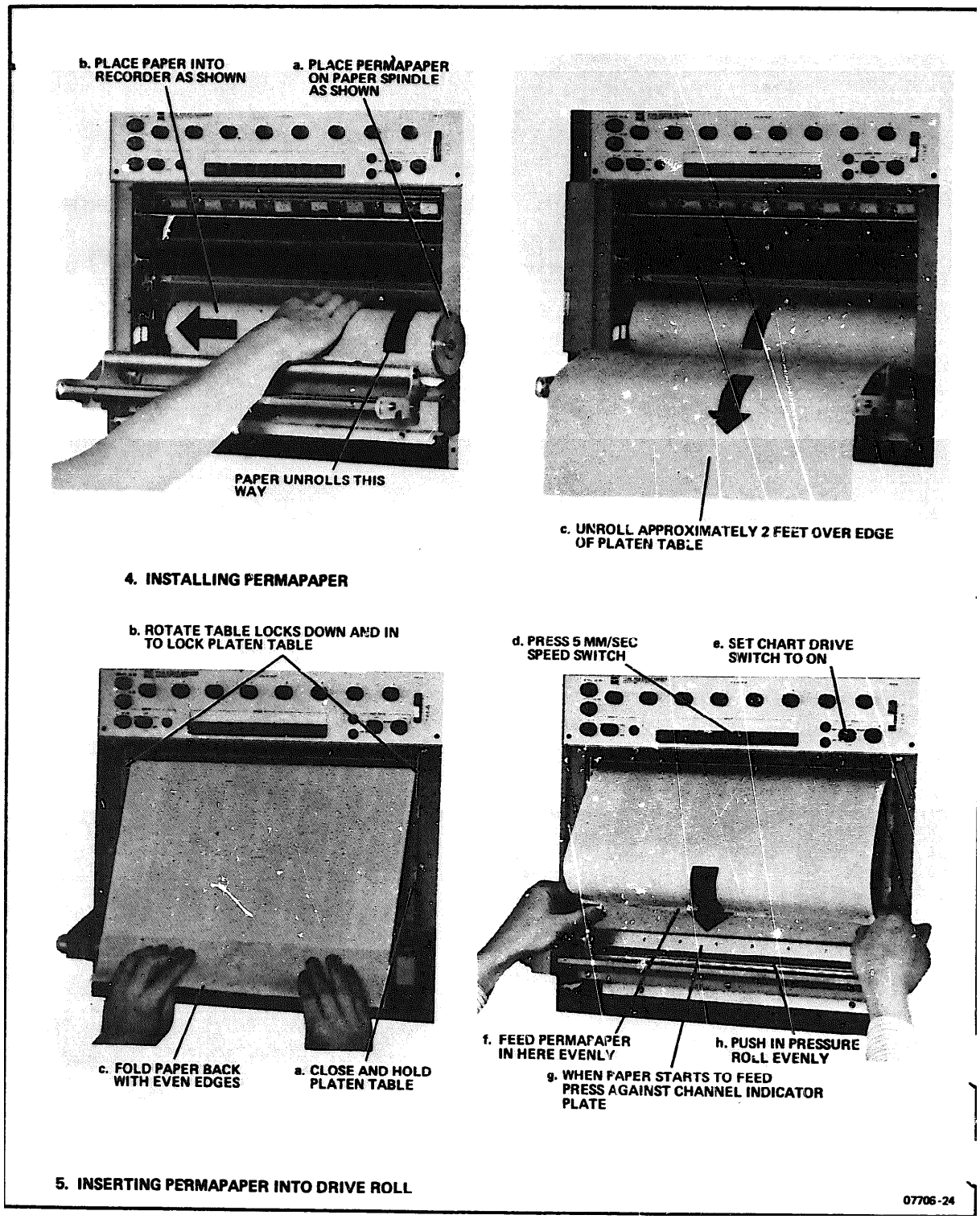


Figure 3-4. Paper Loading Procedure (sheet 2 of 3)

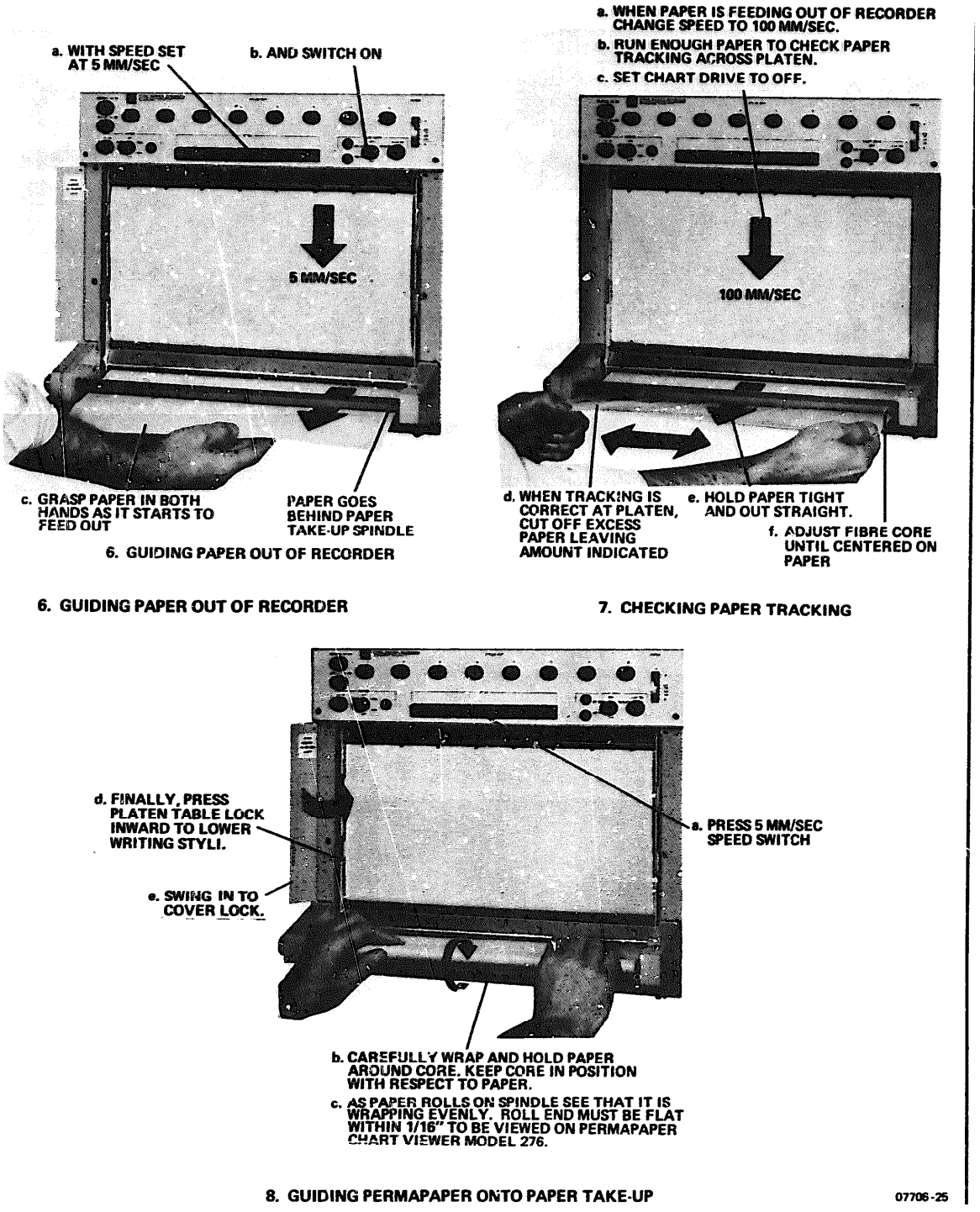


Figure 3-4. Paper Loading Procedure (Sheet 3 of #)

Figure 3-5. Removing And Old Recording And Starting A Now One

SECTION IV

PRINCIPALS OF OPERATION

4-1. SYSTEM OF OPERATION

4-2. Figure 4-1 is a functional diagram showing the operation of one channel in a thermal recording system. All channels of the system have the same configuration from the preamplifier output onward. The system operates in the following way:

a. An input signal previously conditioned by a preamplifier is fed into the Driver Amplifier through a limiter circuit and voltage divider, and mixed with a composite-feedback signal.

b. The resulting signal is amplified, causing an output current flow through the galvanometer drive coil and resistor R24.

c. The current flow through the drive coil causes the galvanometer to move a writing arm toward a final value (representative of signal input) on a chart.

d. The composite-feedback signal consists of voltages developed across R24 and the galvanometer velocity coil. When properly adjusted, this feedback voltage (as modified by the frequency compensation network in the upper-frequency range) results in the galvanometer approaching a final value quickly, and settling at this final value with a slight overshoot (about 4%).

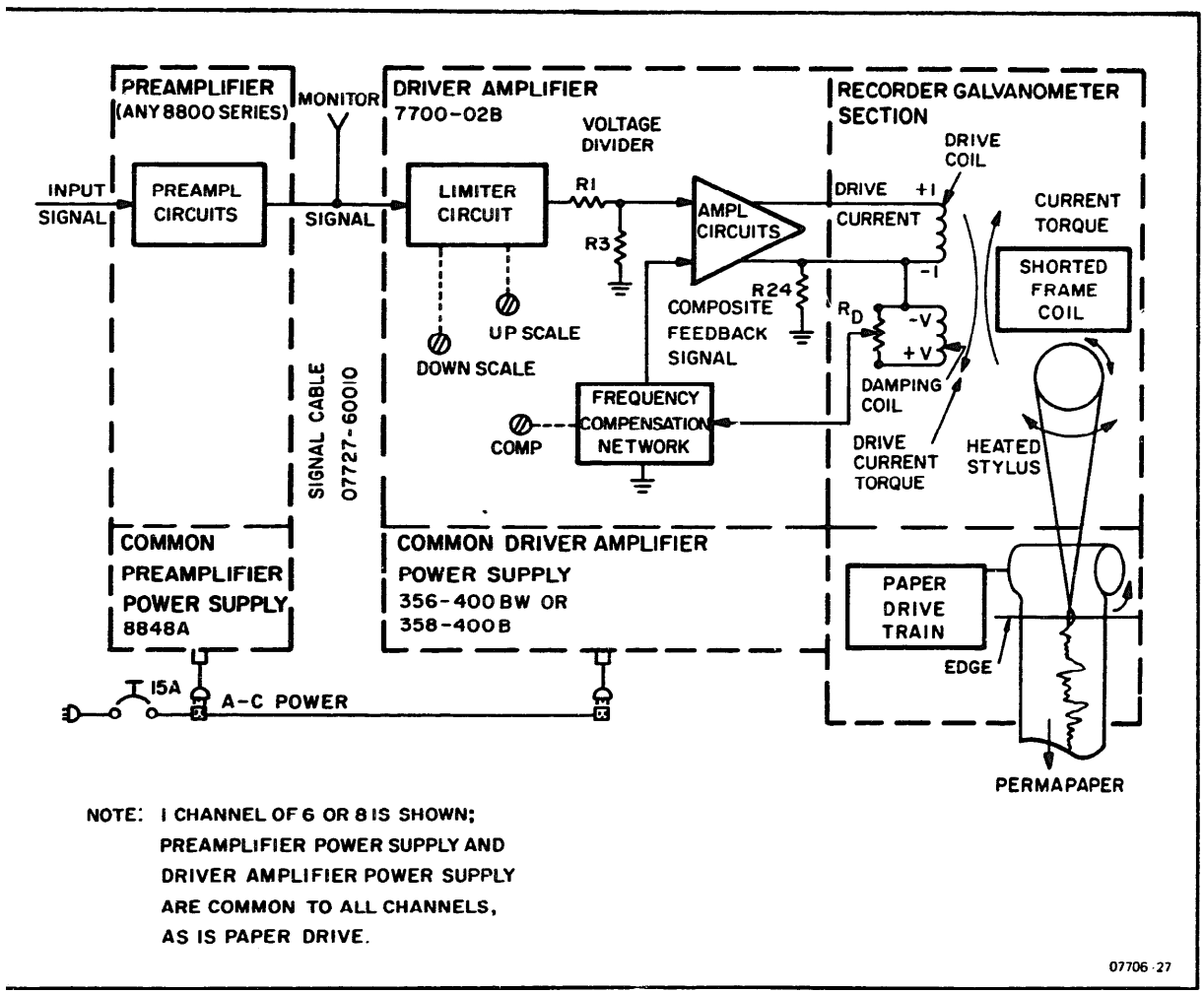


Figure 4-1. Thermal Recording System, Functional Diagrams

4 - 3 . System Components.

4 - 4. The system components, described briefly here, are fully discussed later in this section, except Preamplifier theory of operation, which is given in the applicable appendix for each preamplifier.

4-5. PREAMPLIFIERS (choice of 8800 Series). The Preamplifiers (one per channel) are interchangable, solid-state plug-in units which amplify or otherwise condition the input signal. Signal and power connections are provided at the rear of the Preamplifier, which plugs into the Preamplifier Power Supply.

4-6. PREAMPLIFIER POWER SUPPLY or 8848a. The Preamplifier Power Supply 8848A (one per system) provides all power requirements for up to eight plug-in Preamplifiers. It also functions as a transfer chassis for input, output, and monitoring circuits. The 8849A Power Supply, used in some portable systems, supports one 8800-Series Preamplifier.

4-7. DRIVER AMPLIFIER. The Driver Amplifier (one per channel) is a solid-state plug-in unit which normally remains in place during the life of the system. The amplifier (1) provides power amplification for driving the galvanometer, (2) accepts a velocity-voltage feedback input for optimum galvanometer damping, (3) includes a compensation circuit to extend recorded frequency response, and (4) provides electrical limiting for the recorder.

4-8. DRIVER AMPLIFIER POWER SUPPLY The Driver Amplifier Power Supply (one per system) and the Driver Amplifiers which mount on it are located on the rear of the Recorder. The Power Supply provides all operating power for up to eight Driver Amplifiers, and acts as a transfer chassis for input, output, monitoring, and input line power circuits.

4-9. RECORDER The Recorder (one per system) includes up to eight galvanometers for recording up to eight variables, with multi-speed chart drive electrically selected by pushbuttons. Each galvanometer, driven by a separate Driver Amplifier, operates a recording stylus (see paragraph 4-11).

4-10. SYSTEM CABINET The System Cabinet or portable case set houses the entire system, and provides the cabling facilities needed for operation as a complete system.

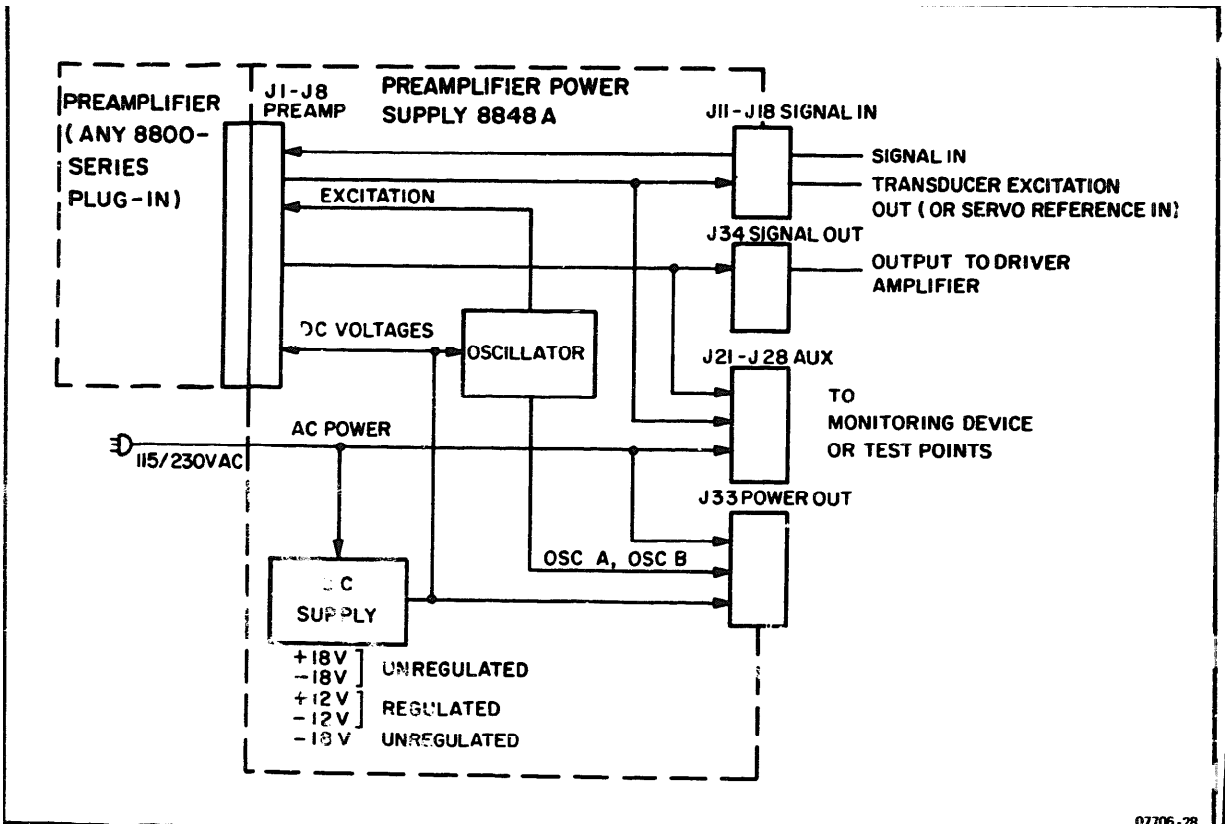


Figure 4-2. Preamplifier Power Power Supply, Block Diagram

4-11. Principals of Thermal Recording

4-12. Hewlett-Packard thermal recording processes use a permanent, rectilinear-coordinate, multichannel recording paper. The standard Permapaper® uses a base paper which is coated with a black surface, that surface is then coated with a white, opaque plastic. Grid lines are printed on this white coating. Application of heat melts the plastic, revealing the black surface to form the recorded line. A translucent paper is also available, which uses a transparent base stock, coated with a semi-opaque plastic. Application of heat melts the plastic to allow light to pass through paper for reproduction in a standard ammonia process duplicator.

4-13. The hot-wire element which creates the recording is carried at the end of a movable writing arm. The writing arm is set into motion by the turning action of the galvanometer. The hot-wire element bears against the Permapaper constantly, as the paper passes over a knife-edge writing surface. Because this knife-edge is oriented along the amplitude lines of the recording, perpendicular to the time-axis, the hot-wire writing surface at any moment will always be at some amplitude along the

4-14. PREAMPLIFIER POWER SUPPLY OPERATION

4-15. The 8848A Preamplifier Power Supply acts as an input, output, and power transfer chassis, and supplies dc and ac operating power for up to eight Preamplifiers. The 8849A Power is basically the same, except that it has only one channel.

Figure 4-2

operation of the Preamplifier Power Supply at the block diagram level.

4-16. Guarded input Circuits

4-17. The Preamplifier Power Supply includes a guard circuit in the input signal cabling for each channel. This circuit helps maintain the common-mode rejection of floating input Preamplifiers such as the Model 8803A. Note that J21 through J28 output connectors are used both for signal supply to auxiliary monitors and as a system test point. Connectors J1 through J8 and J11 through J18 include a guard shield sleeve as part of the connector.

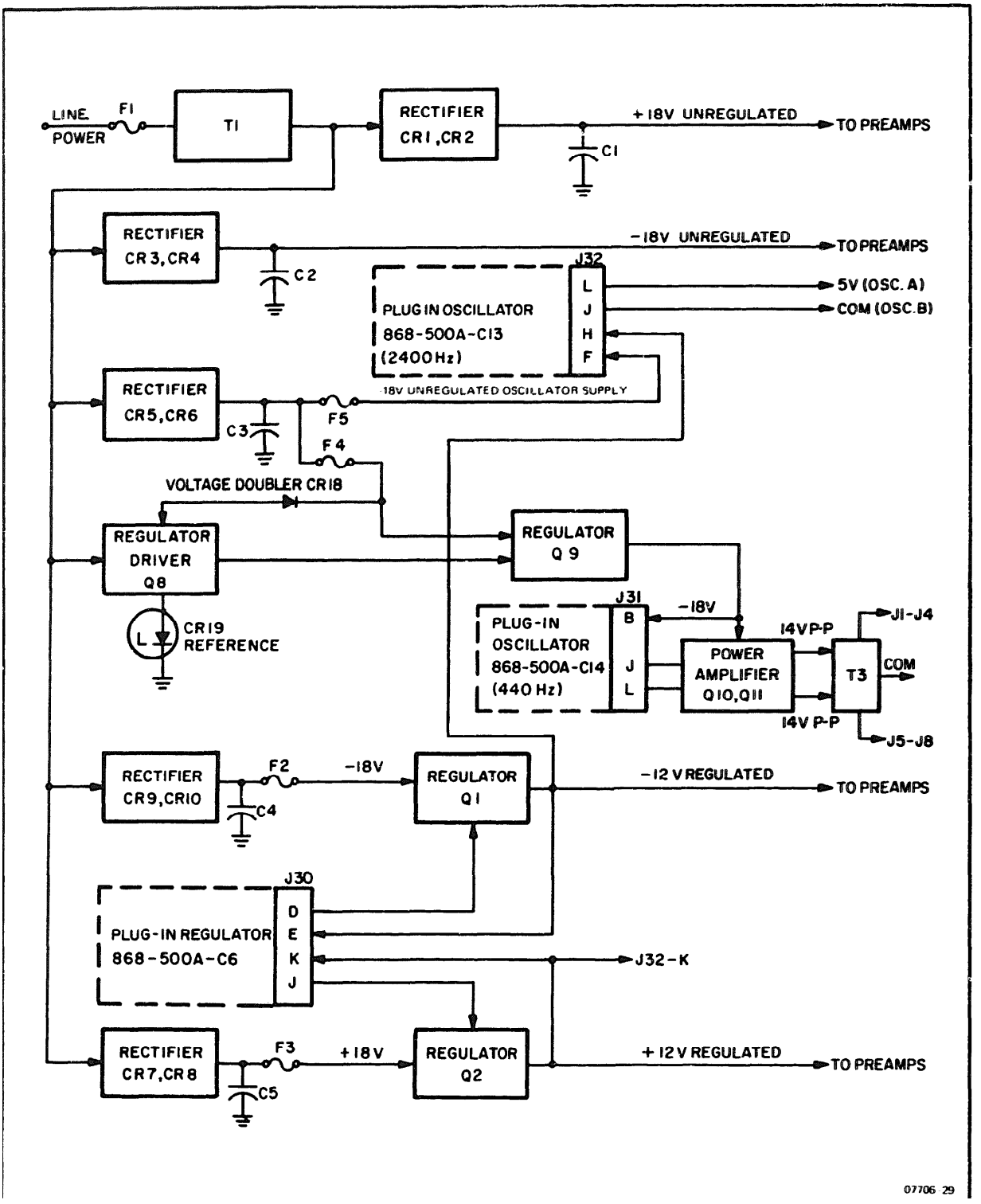


Figure 4-3. Preamplifier Power Supply 8488A, Simplified Schematic

4-18. Unregulated +18 and -18 Volt Preamplifier Supplies

4-19. The unregulated +18 and -18 volt Preamplifier supplies are shown in simplified schematic Figure 4-3. Each supply uses a full-wave solid-state rectifier circuit, with a single capacitor as filter. The output provides operating power for up to eight Preamplifiers. Line power for these supplies, and for all the other supplies in the unit, enter through input fuse F1 and are applied to the rectifier circuits through the common power transformer T1.

4-20. Unregulated -18 volt Oscillator Supply.

4-21. The unregulated -18 volt oscillator supply is shown in simplified schematic Figure 4-3. This supply uses a circuit having the same configuration as that of the 18 volt Preamplifier supplies described above. The output provides operating power to plug-in oscillators in J31 and J32, when excitation is required by the Preamplifiers used in the system.

4-22. Regulated +12 and -12 Preamplifier Supplies.

4-23. The regulated -12 and +12 volt Preamplifier supplies are shown in simplified schematic Figure 4-3. Each supply uses a full-wave solid-state rectifier, with a single capacitor as filter, for a positive and a negative output in the vicinity of 18 volts. Each output is regulated and applied to all Preamplifiers through a regulator transistor which is under the control of the plug-in regulator circuits discussed in the following paragraph.

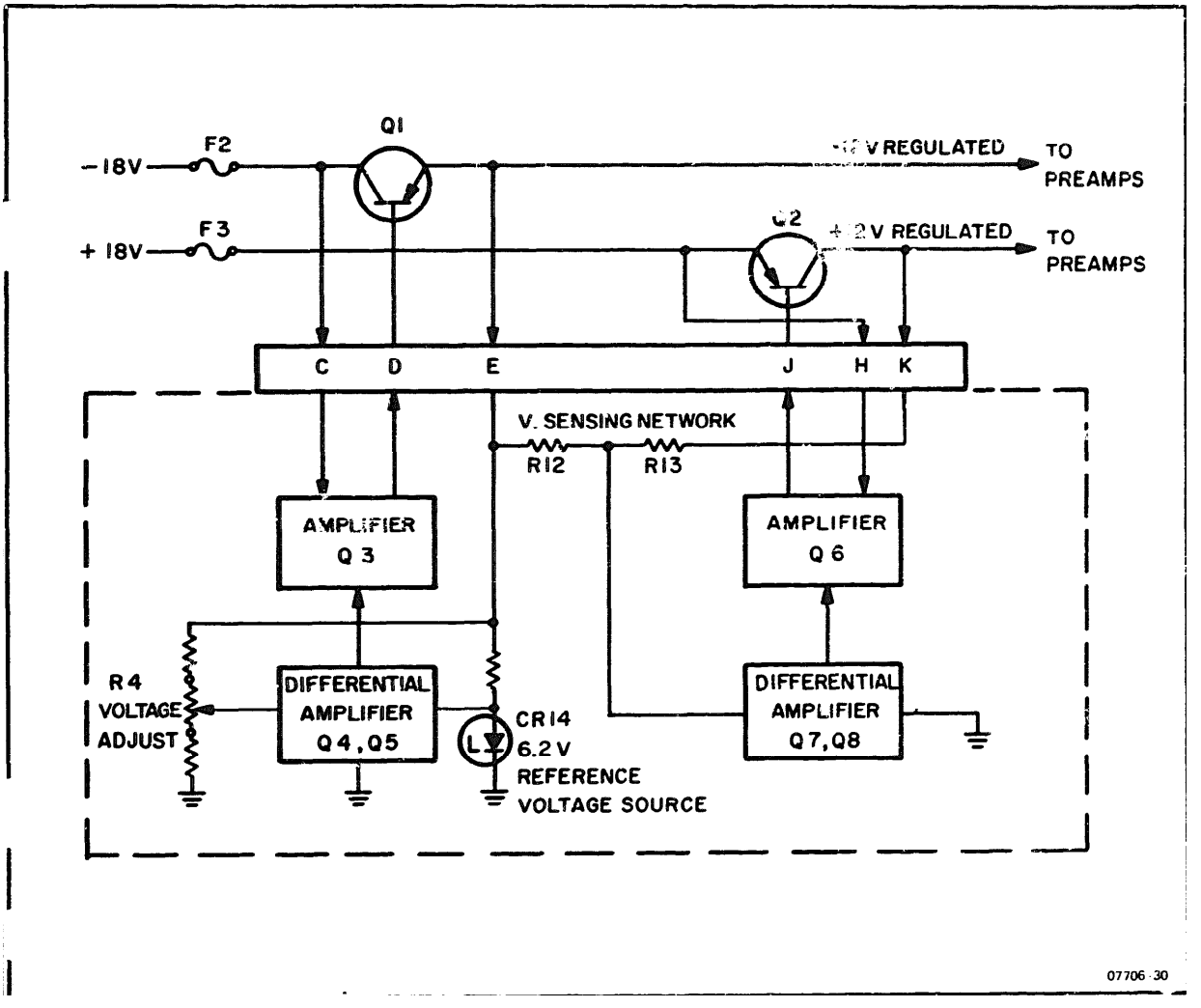


Figure 4-4. Regulated Plug-in Card, Simplified Schematic

4-24. Regulator Plug-in Card.

4-25. The regulator plug-in card (868-500A-C6) is shown in Figure 4-4 The -12 and +12 volt regulated supply is furnished to the Preamplifiers through transistors Q1 and Q2, each of which is controlled by the plug-in card circuits. Both regulated voltages are controlled by the one VOLTAGE ADJUST control R4. One input of differential amplifier Q4, Q5 is maintained at 6.2 volts by Zener diode CR14; the other input is maintained at a fraction of the -12 volt regulated output, as determined by the setting of R4. If the -12 volt regulated output voltage should vary slightly, this will appear as a change in input signal levels between the inputs to Q4 and Q5. This change is further amplified by Q3, and applied to the series control transistor Q1, with such polarity as to return the -12 volt regulated output toward its original value. The +12 volt regulated line is controlled in the same manner. In this case, one input of the differential amplifier Q7, Q8 is at ground potential, and the other input is held at a value determined by the voltage divider R12, R13. Assuming regulation of the -12 volt line, if the +12 volt output should vary slightly, this will appear as a change in input signal levels at the input to Q7, Q8. This change is further amplified by Q6, and applied to the series control transistor Q2 with such polarity as to return the -12 volt regulated output toward its original value.

4-26. 440 Hz Oscillator Plug-in Card

4-27. The 440 Hz oscillator plug-in card (868-500A-C14) is shown in Figure 4-5 Oscillations are generated by push-pull oscillator Q12, Q13, at a frequency determined by oscillation transformer T4 and capacitor C15. Thermistors TM1, TM2 provide oscillator stability. Output from T4 drives the power amplifier Q10, Q11. Diodes CR21, CR22 control the amplitude of oscillation at a level determined by Zener diode CR23. Oscillator power is provided from the -18 volt unregulated oscillator supply line, through regulator Q9. The base of Q9 is held at 16 volts by Zener diode CR19 as shown in the figure. This base voltage is supplied from the voltage-doubling rectifier C13, CR18, and its following filter, operating from one side of the power transformer T1 and the -18 volt unregulated oscillator supply line.

4-28. 2400 Hz Oscillator Plug-in Card.

4-29. The 2400 Hz oscillator plug-in card (868-500A-C13) is shown in Figure 4-6 Oscillations are generated by push-pull oscillator Q20, Q21, at a frequency determined by oscillation transformer T7, and capacitors C18 and C19 in parallel. Thermistors TM7, TM8 provide oscillator stability. Output from

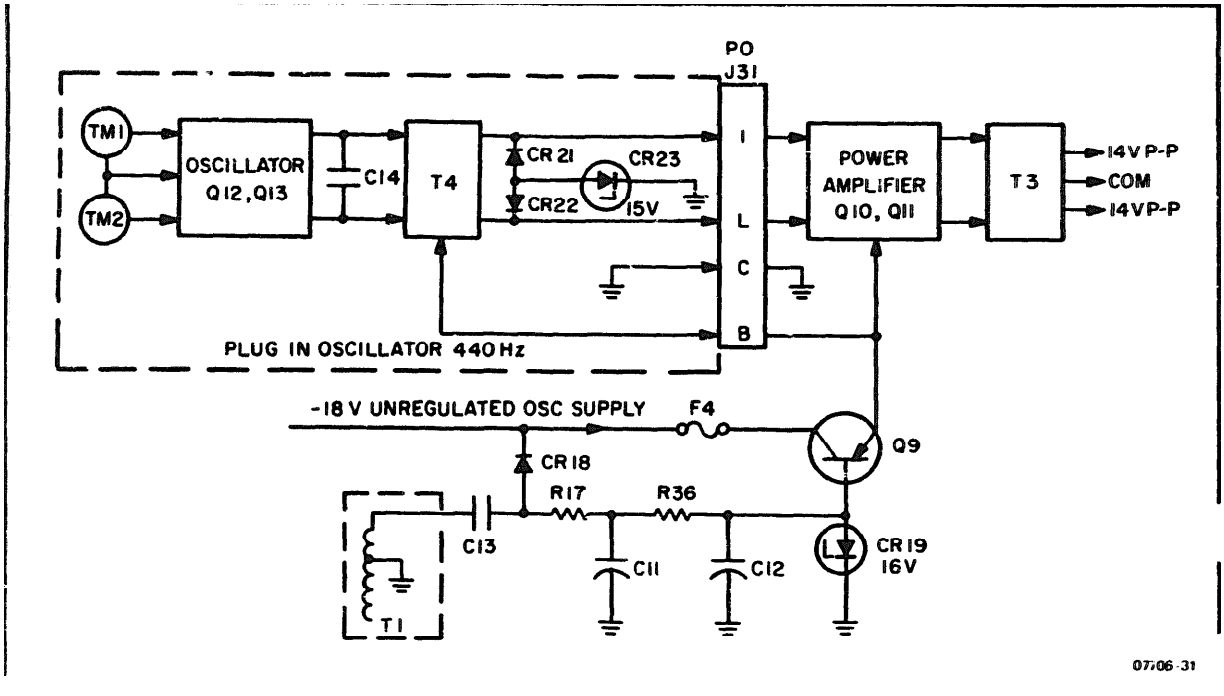


Figure 4-5. 440Hz Plug-in Card Block Diagram With Associated Circuits

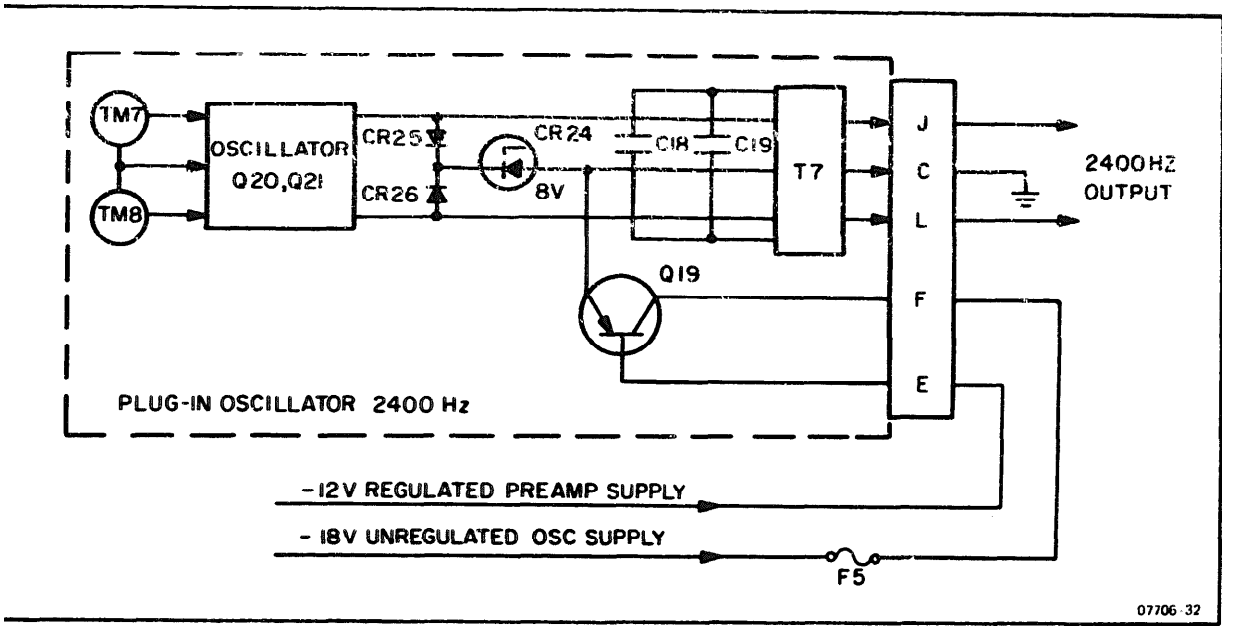


Figure 4-6. 2400Hz Plug-in Oscillator Block Diagram

T7 is a balanced ac voltage with respect to ground, which is used to furnish excitation to the Preamplifiers used with the system. The Preamplifiers reamplify this excitation for use with transducers. Diodes CR25, CR26 control the amplitude of oscillation at a level determined by Zener diode CR24. Oscillator power is provided from the -18 volt unregulated oscillator supply line, through regulator Q19, located on the plug-in card. The base of Q19 is held at a regulated -12 volts from the regulated Preamplifier supply, for a regulated supply voltage to Q20, Q21.

4-30. DRIVER AMPLIFIER POWER SUPPLY THEORY OF OPERATION

4-31. The Driver Amplifier Power Supply (358-400B) is shown in the block diagram, Figure 4-7.

One Power Supply furnishes all operating voltages for up to eight Driver Amplifiers. The Supply is mounted on the rear of the Recorder; the Driver Amplifiers plug into the Power Supply.

4-32. Two separate unregulated lines are supplied each individual Driver Amplifier, at approximately +17.5 and -17.5 volts, for a total of sixteen unregulated supplies in an eight channel system. At the same time, two regulated lines provide ±12 volts to each pair of Driver Amplifiers, for a total of eight regulated lines in an eight channel system.

4-33. Unregulated Supply Voltage

4-34. Unregulated supply voltages are shown in the block diagram, Figure 4-7. The circuit is the same for each side-by-side pair of Driver Amplifiers. Each such pair is fed from a common power transformer, through individual rectifier and filter circuits as shown. Note that when the Driver Amplifier is removed, the filter capacitor is disconnected, to eliminate the peak capacitor voltages which would otherwise be present.

4-35. Regulated Supply Voltages.

4-36. Regulated supply voltages are shown in the block diagram, Figure 4-7. The circuit is the same for all the upper side-by-side pairs of Driver Amplifiers, and differs only for the +12 volt regulated line which feeds the lowest pair of Driver Amplifiers. In all cases, the regulated voltage is developed across a Zener diode voltage regulator source, which feeds the Driver Amplifier load directly. In the case of the +12 volt supply for the lowest pair of Driver Amplifiers, a pair of 6.2 volt Zener diodes are used. Potentiometer R9 regulates the +12V supply to control panel connector J18.

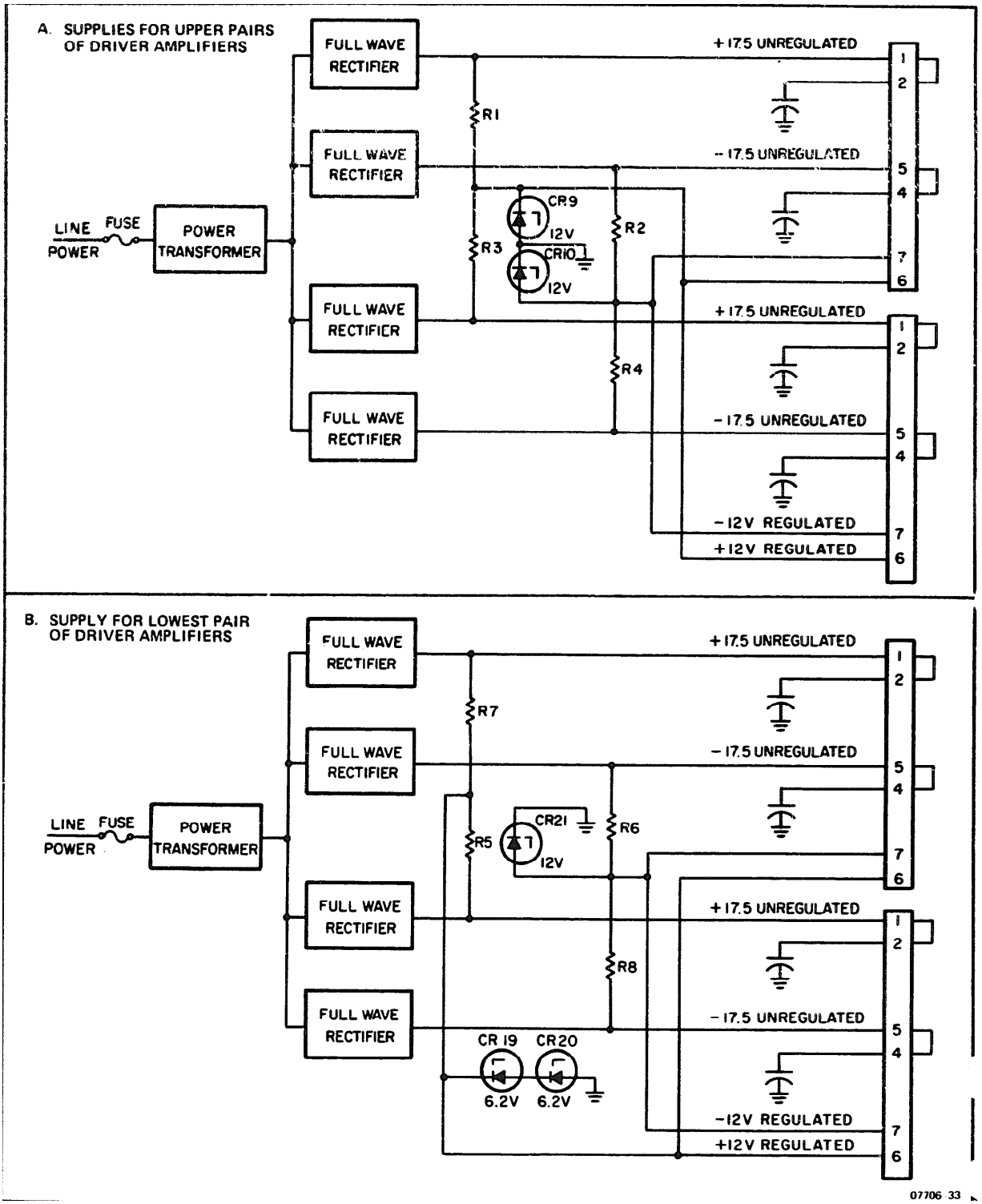


Figure 4-7. Driver Amplifier Power Supply, Block Diagrams.

4-37. DRIVER AMPLIFIER THEORY OF OPERATION

4-38. The Driver Amplifier (7700-02B) is shown in the block diagram, Figure 4-8

The Driver Amplifier operates from two input signals: (1) the input signal derived from the Preamplifier and (2) the feedback signal returned from the velocity-voltage coil in the galvanometer and from the current feedback resistor located within the Driver Amplifier.

4-39. Driver Amplifier Circuit Description.

4-40. The following description covers the operation of the Driver Amplifier circuits.

4-41. LIMITER CIRCUIT Q8-Q9 and Q10-Q11. This circuit limits the input signal to an amplitude which will not load the Amplifier or drive the galvanometer writing arm excessively.

4-42. The negative portion of the input signal is limited by emitter-follower Q8-Q9 at a magnitude determined by R12, R13 and R26. Diode CR1, in series with the emitter of Q8, prevents base-emitter voltage breakdown in Q8 if very large negative signals are applied. When the negative excursion of the input signal to the base of Q8 reaches a predetermined level, the emitter bias cuts off the emitter-collector current. This bias point is adjustable by R26. Q8 is clamped in this cut-off condition until the negative excursion of the input signal drops below the level of limiting.

4-43. The positive portion of the input signal is limited by emitter-follower Q10-Q11 to a magnitude determined by R1, R3, R25 and R27. Diode CR2 compensates for the temperature-dependent voltage drop introduced by CR1 in the downscale circuit. When the positive excursion of the input signal to the base of Q10 reaches a predetermined level, the emitter bias cuts off the emitter-collector current. This bias point is adjustable by R25. Q10 is clamped in this cut-off condition until the positive excursion of the input signal drops below the level of limiting.

4-44. AMPLIFIER Q1-Q2. This circuit operates as follows: The input signal is applied to the base of Q1 via input network R1, R2, and R3. A voltage divider (R1 and R3) attenuates the input signal approximately 2.5-to-1. Resistor R2 matches the base-to-ground impedance of Q1 to approximately that of Q2. This impedance match insures that the no-signal base potentials of Q1 and Q2 are essentially equal for balanced amplifier operation. The composite feedback signal is applied to the base of Q2. Since Q1 and Q2 are connected as a differential amplifier, the signal across the collectors of Q1 and Q2 is proportional to the difference between the two inputs at the bases.

4-45. Capacitor C4, across the collectors of Q1-Q2, and capacitor C5, in the base circuit of Q2, cause a sharp fall off in high frequency gain beyond the bandpass of the amplifier. This characteristic guards against the possibility of high-frequency oscillation, and removes any high frequency noise from the amplified signal.

4-46. AMPLIFIER Q3-Q4. This circuit operates as follows: The difference voltages from the collectors of Q1-Q2 is applied to the bases of differential amplifier Q3-Q4, and amplified. Conversion from push-pull input to single ended output is accomplished by taking the amplified signal from the collector of Q4 only.

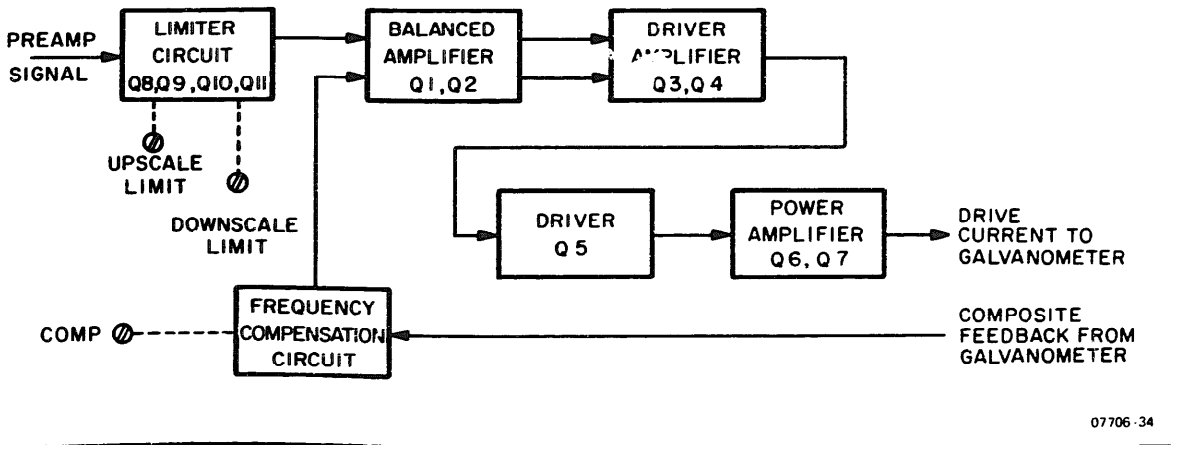


Figure 4-8. Driver Amplifier Block Diagram

4-47. AMPLIFIER Q5 This circuit amplifies the single ended input from Q3-Q4, and develops sufficient power to drive power amplifier Q6-Q7.

4-48. AMPLIFIER Q6-Q7. This circuit is a Class B power amplifier. Current flow through either Q6 or Q7 is approximately zero in the absence of an input signal. Q6 conducts on the negative portion of the input signal, and Q7 on the positive portion. Single ended output is taken from the common emitters of Q6-Q7, and applied to the drive coil of the galvanometer.

4-49. FEEDBACK AND DAMPING The driver amplifier includes a feedback circuit to provide an adjustable amount of galvanometer damping and frequency compensation which obtains optimum galvanometer transient and frequency response. The damping control R_D in the Recorder is adjusted for the best transient response, and the frequency compensation control R5 in the Driver Amplifier is adjusted for the best frequency response.

4-50. GALVANOMETER DAMPING. Approximately 71% of critical damping is required to provide optimum operation. Of this, 27% is provided by the shorted-coil frame on the galvanometer, and the remaining 44% by the composite-feedback voltage. Figure 4-12 shows galvanometer response both in frequency and time for different degrees of damping.

4-51. Underdamped Galvanometer. An underdamped galvanometer has a peaked frequency response and an oscillatory transient response. This type of damping (27%) is supplied by the shorted coil frame on the galvanometer. Currents induced in the coil frame develop a damping torque which is proportional to the coil velocity, and in a direction that reduces the velocity. In this case, the galvanometer oscillates around its final position before coming to rest.

4-52. Overdamped Galvanometer. An overdamped galvanometer has a frequency response which drops off too soon at high frequencies, and a slow transient response. In this case, the galvanometer approaches its final position slowly, giving too slow a rise time for the recording of short period transient voltages.

4-53. Optimum Damping. Optimum operation occurs at approximately 71% of damping where the frequency response is down 3 dB at the natural frequency (ω_n), see Figure 4-9 (A), and where the response to a pulse input has approximately 4% overshoot as shown in Figure 4-9 (B). In this case, the galvanometer approaches the final value quickly and settles to the final value with a slight overshoot.

4-54. COMPOSITE FEEDBACK CIRCUIT The composite-feedback voltage is derived from two sources: the galvanometer velocity coil and the voltage drop across R24. The voltage developed across the galvanometer velocity coil is proportional to galvanometer coil velocity through a magnetic field, and is fed back to the Amplifier at a polarity to damp galvanometer motion. The voltage developed across R24 is proportional to the drive current (approximately 400 milliamperes at full scale) through the galvanometer drive coil.

4-55. The composite-feedback voltage passes through the frequency compensation network, which determines the amplitude of upper-frequency feedback voltages returned to the base of Q2. This network (R4, R5, R6, R7, C1, and C2) is a low pass, pi-type filter with a cut-off point in the upper frequency range of the amplifier. At the lower and middle frequencies of the input signal, the network has negligible effect. In the upper-frequency range, the network reduces feedback, thus increasing the closed-loop gain, which compensates for the galvan-

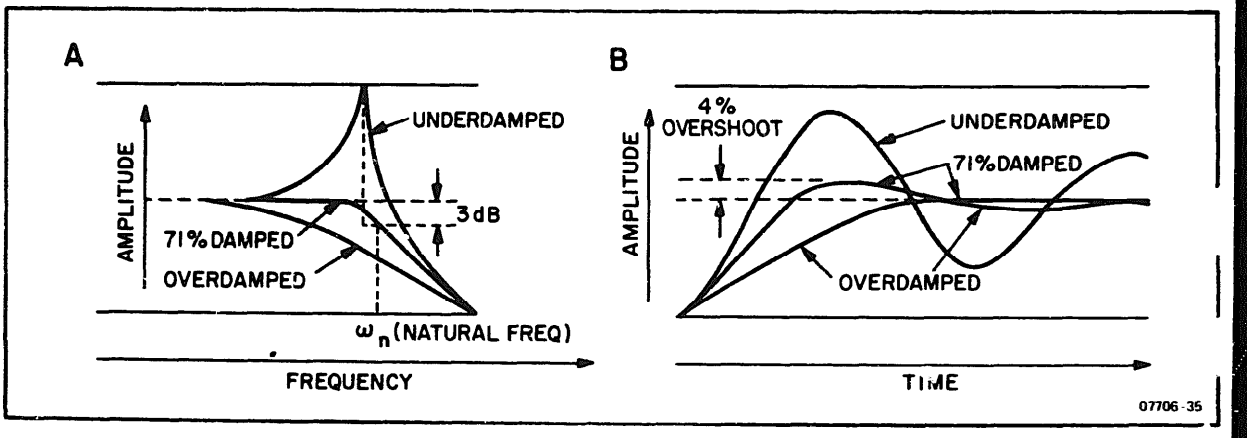


Figure 4-9. Galvanometer Response Versus Damping

ometer response rolloff at higher frequencies by increasing galvanometer drive power.

4-56. Since the Amplifier is linear only over a limited range of output current (primarily due to saturation of power transistor stage Q6-Q7), the frequency compensation network will boost the Amplifier output to the saturation level at a lower frequency when the peak-to-peak stylus excursion becomes larger. This effect is shown in Figure 4-10, which illustrates frequency response of a typical channel in a recording system. Note that the response starts to fall off at a lower frequency as the stylus excursion becomes larger.

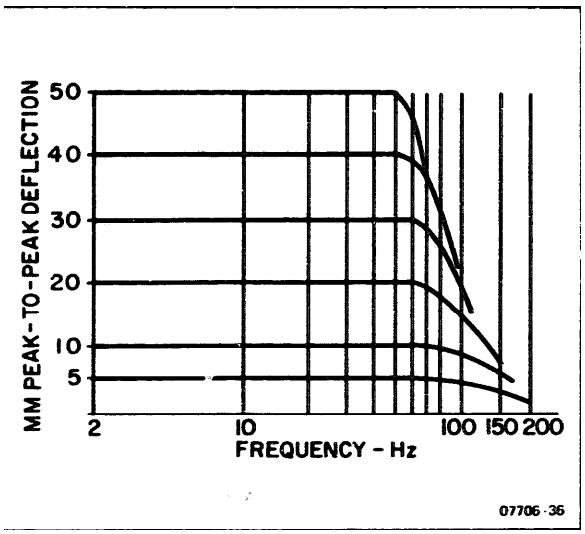


Figure 4-10. Frequency of Typical 6-Channel Recording System

4-57. RECORDER THEORY OF OPERATION

4-58. The Recorder theory of operation includes explanations of the following mechanisms and circuits:

a. Chart drive circuits: This includes the drive motors, and the circuits for turning them on and off. (See paragraphs 4-59 to 4-65)

b. Motor coupling mechanisms: These include the sprockets and chains between the motors and the input to the gearbox. (See paragraphs 4-66 to 4-72)

c. Gearbox mechanism: This includes the variable-ratio gear assembly, solenoid-operated, for choosing any one of the chart drive speeds available. (See paragraphs 4-73 to 4-82)

d. Chart drive mechanism: This includes the gearing and drive rolls which couple the gearbox output to the moving chart paper. (See paragraphs 4-83 to 4-85)

e. Chart speed selection circuits: These include the switch, relay, and solenoid circuits which actuate the speed-selection mechanisms of the gearbox. (See paragraphs 4-86 to 4-89)

f. Stylus heat circuits: These include circuits which maintain trace density at different chart speeds, and the circuits which permit setting the recording for the desired density. (See paragraphs 4-90 to 4-95)

g. Power supply circuit: This includes the +24 Vdc supply for operating relays and solenoids. (See paragraphs 4-96 to 4-97)

h. Galvanometer and galvanometer circuits: These are the mechanisms which move the recording arm across the recording chart. (See paragraphs 4-98 to 4-101)

i. Standard timer/marker circuits: These include the circuit elements which provide timing and marking facilities during the recording, in addition to the galvanometer recordings. (See paragraphs 4-102 to 4-105)

j. Special timer/marker circuits: These include the standard additions to item (i) above. (See paragraphs 4-106 to 4-110)

4-59. Chart Drive Circuits.

4-60. The chart drive circuits are shown in block diagram Figure 4-11. These circuits control the one ("C", "CW" recorder models) or the two ("D", "DW" recorder models) chart drive motors in the recorder. The discussion which follows will assume a "D" or "DW" model, having both MM/SEC and MM/MIN chart drive speeds.

4-61. When the CHART DRIVE selector switch S102 is at either of its two OFF positions, motor relays K1306 (MM/SEC) and K101 (MM/MIN) are inactive, and the corresponding chart drive motors do not operate.

4-63 When the CHART DRIVE switch is at its MM/SEC position, motor relay K1306 will close, and apply power to the chart drive motor B701 and indicator I102, for a chart travel speed indicated on the recorder panel in millimeters per second. AC power flows to this motor through a jumper on the standard marker plug, or through a wattmeter connected in place of this jumper. The MM/MIN motor is inactive in this position.

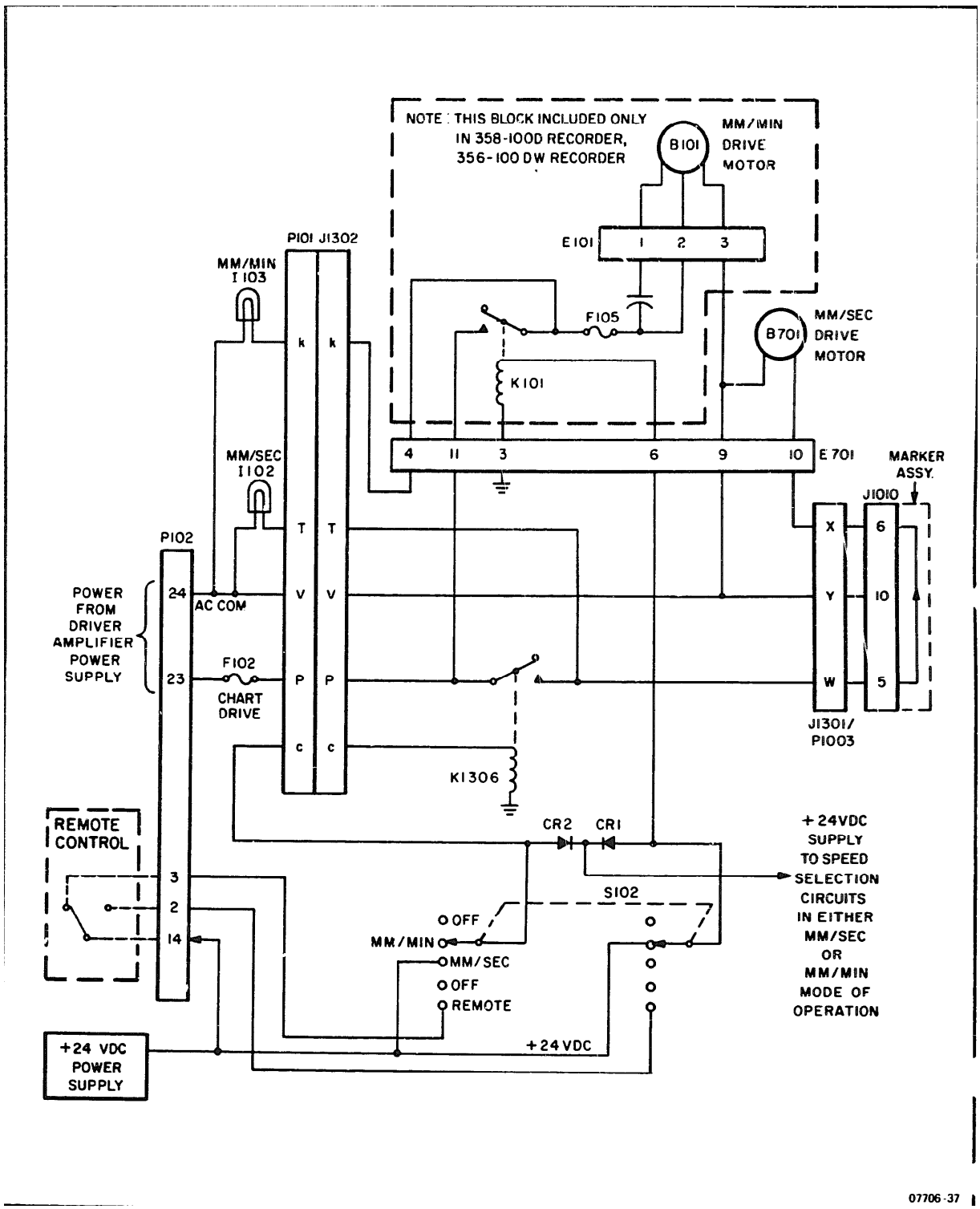


Figure 4-11. Chart Drive Circuits

4-63. When the chart drive switch is set in its MM/MIN position ("D", "DW" models only), motor relay K101 will close and apply power to the chart drive motor B101 and indicator I103, for a chart travel speed indicated on the recorder panel in millimeters per minute. The MM/SEC motor is inactive in this position.

4-64. When the CHART DRIVE switch is at its REMOTE position, either the MM/SEC or the MM/MIN motor may be turned on by a remote SPDT switch (with neutral center), or equivalent.

4-65. When either motor is in operation, whether from a setting of the CHART DRIVE switch or from a setting of a remote switch, the +24 volt relay supply voltage is fed to the speed selection circuits through diode CR2 (MM/SEC) or CR1 (MM/MIN). This allows power flow to speed selection circuits only when one of the chart drive motors is turned on.

4-66. Motor Coupling Mechanism.

4-67 Recorders are supplied with two models of motor drive mechanism: the "C" and "CW" models use one MM/SEC motor; the "D" and "DW" models use one MM/SEC motor and one MM/MIN motor. A power flow diagram for "C" and "CW" models is shown in Figure 4-12

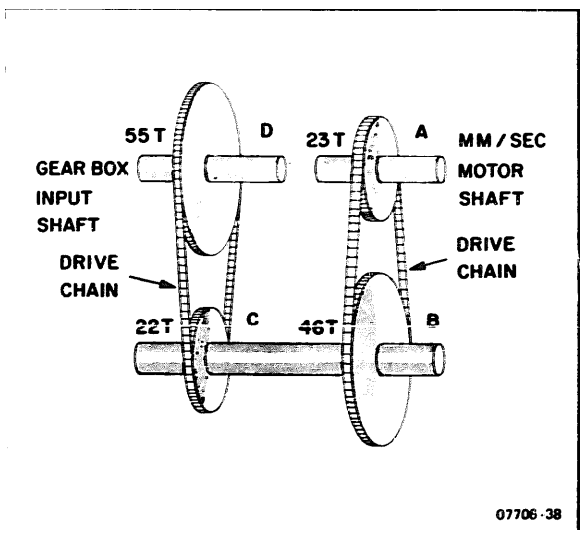


Figure 4-12. Power Flow Diagram From MM/SEC Motor to Gearbox, "C" and "CW" Model Recorder

4-68. As shown in the power flow diagram, torque from the MM/SEC motor is coupled to the gearbox input shaft through sprockets which are coupled by drive chains, as shown. Speed reduction ratio from motor to gearbox input is 5:1.

4-69 The "D" and "DW" models of the Recorder operate with a motor-to-gearbox mechanism which allows the use of a MM/SEC and a MM/MIN motor. This is shown in Figure 4-13.

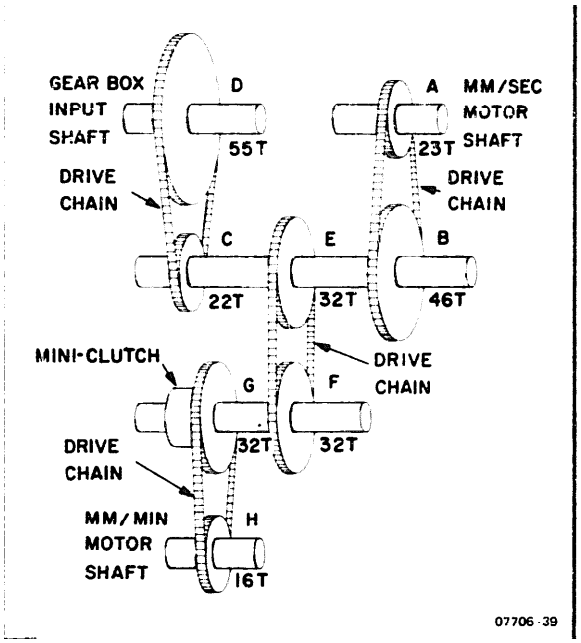


Figure 4-13. Power Flow Diagram From MM/SEC and MM/MIN Motors to Gearbox

4-70. When the recorder is used at MM/SEC speeds, the MM/SEC motor is turned on, the MM/MIN motor is turned off, and the power flow proceeds through sprockets "A", "B", "C", and "D", exactly as shown in Figure 4-13. At the same time, this turns sprocket "E", which drives sprocket "F" through its drive chain. Rotation of sprocket "F" will turn its shaft to disengage its miniclutch. With the miniclutch disengaged, sprocket "G" will not turn, and both its drive chain and sprocket "H" will also remain at rest. This protects the MM/MIN motor by isolating it from the flow of power.

4-71. When the recorder is used at MM/MIN speeds, the MM/MIN motor is turned on and the MM/SEC motor is turned off. Since the miniclutch shaft is now not being driven by the MM/SEC motor, the miniclutch will engage, and the power flow will now proceed through sprockets "H", "G", "F", "E", "C", and "D". At the same time, sprocket "B" will continue to turn from the rotation of its shaft. As a result, sprocket "A" and the MM/SEC motor will be driven into rotation from the MM/MIN motor. Since the speed of this rotation is only 1/60 of its normal operating speed, this will neither damage the motor nor will it place any significant mechanical load on the MM/MIN motor.

4-72. Speed reduction ratio of the motor coupling mechanism is 5:1 from either motor to the gearbox input.

4-73. Gearbox Mechanism.

4-74 The same gearbox design is used in "C", "CW", "D", and "DW" models of recorder. This unit provides a series of electrically selected step-down ratios between its input and its output, to furnish a range of chart drive speeds.

4-75. Viewing the gearbox from the output side (left side of recorder) the ten shafts of the gearbox are located as shown in Figure 4-14 which shows the possible paths of power flow through the gearbox. The solid lines show the basic sequence of power flow, with all solenoids (K701, K702, K703, K704) activated. This basic sequence gives the highest chart drive speed.

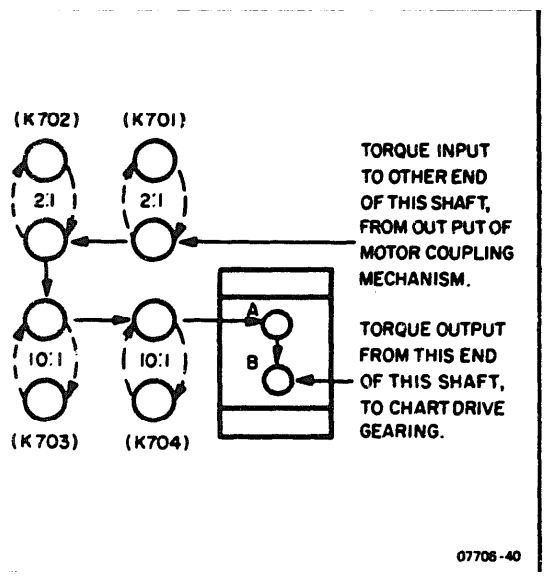


Figure 4-14. Gearbox Side View, Showing Basic and Auxiliary Sequence of Power Flow

4-78. The dotted lines show the auxiliary sequence of power flow at each pair of shafts. Each time an auxiliary sequence is used, a speed reduction is inserted into the power flow, as indicated by ratios shown in the figure. The range of recorder chart speeds is provided by selecting combinations of the basic and the auxiliary sequence. Each auxiliary sequence is under the control of a solenoid, identified on the figure. "Solenoid-OFF" introduces the auxiliary (step-down) sequence. "Solenoid-ON" restores the basic sequence. The four solenoids (K701, K702, K703, K704) are under the control of the speed change circuits. Operation of solenoids, with the shaft speeds which result, are shown in Table 4-1

Table 4-1. Solenoid Operations and Resulting Chart Speeds

CHART DRIVE MM/SEC or MM/MIN	SOLENOID K701	K702	K703	K704
.25	OFF	OFF	OFF	OFF
.5	OFF	ON	OFF	OFF
1.	ON	ON	OFF	OFF
2.5	OFF	OFF	OFF	ON
5	OFF	ON	OFF	ON
10	ON	ON	OFF	ON
25	OFF	OFF	ON	ON
50	OFF	ON	ON	ON
100	ON	ON	ON	ON

4-77. Recorders supplied on special order, having speeds other than those in the table, will follow the same order of speed ratios, with the final chart drive speeds marked on the panel at the speed selection switches.

4-78. Each pair of shafts in Figure 4-14. contains gears and clutches as shown in Figure 4-15. These gears and clutches operate either in a main sequence of power flow for "straight-through" in operation, or in an auxiliary sequence for speed reduction between input and output.

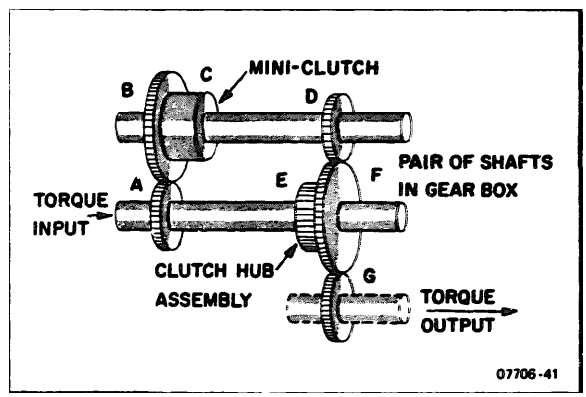


Figure 4-15. Power Flow Through Gearbox Shafts

4-79. In the main sequence of power transmission, the solenoid (not shown) is activated (solenoid-ON), to clamp the clutch hub assembly "E" to its shaft. Under these conditions, the torque input to the lower shaft will drive the output gear "F" directly, for a power output through gear "G" and the torque output shaft. The miniclutch "C" on the upper shaft will

automatically disengage, because its output side will be turning faster than its input side; this removes the upper shaft and its gearing from the path of power flow.

4-80 In the auxiliary sequence of power transmission, the solenoid (not shown) is not activated (solenoid-OFF), to allow gear "F" to float on its shaft. The miniclutch "C" will now engage, because of the load placed on its output side. The power transmission path now passes through the gears in the sequence "A", "B", "D", and "F", for a power output through gear "G" and the torque output shaft.

4-81 All gears discussed to this point are located inside the gearbox, and are subject to solenoid control. The last pair of gears in the sequence of power flow is located outside the gearbox, and is not subject to solenoid action. These gears are mounted on shafts "A" and "B" in Figure 4-14 The standard gears, for 60 Hz recorders, provide a 3:1 step-down ratio. Recorders designed for 50 Hz use include a different pair of gears chosen for a 2.5:1 step-down ratio. This provides the same gearbox output, in RPM, at any one selected chart drive speed, with both 60 Hz and 50 Hz recorders.

4-82 Torque output from the gearbox is taken from a 3/4" diameter gear at the end of shaft "B". This gear mates with the train of gears which are part of the chart drive mechanism.

4-83 Chart Drive Mechanism.

4-84 The chart drive mechanism couples the gearbox output to the recording Permapaper chart. The power flow diagram is shown in Figure 4-16 including motion of the recorder chart: Gear "A" is the torque output gear at the end of the gearbox output shaft (identified as shaft "B" in Figure 4-14). This gear mates with input gear "B" of the "B", "C", "D", "E", "F", "G", string of gears which follow, with an initial 2:1 step-down ratio. Gear "G" turns chart drive roll and a paper take-up pulley. The chart drive roll pulls the recording chart through the recorder. The paper take-up pulleys are coupled through a take-up drive belt, adjusted for a preset slippage by the paper take-up tension adjustment, so that the paper will wind tightly on the take-up shaft.

4-85 The Permapaper chart passes through a series of mechanisms as it moves from the supply roll out to the paper take-up:

a. The recording paper is drawn from the paper supply roll which is installed on a paper supply spindle. The roll itself is held firmly between a pair of spindle discs, one at each end of the supply roll, to prevent side-to-side motion of the roll.

b. From the roll, the paper moves upward, where it is held against a paper brake by a pressure roller to insure reliable braking. The braking action is adjustable, to obtain the correct paper tension.

c. From the paper brake, the paper moves up and over the sharply-rounded writing edge. As the tight paper passes over this edge, it presents a minimum area to the hot-wire writing surface of the writing arm, for best recording definition.

d. From the writing edge, the paper moves down over a flat surface for approximately 8", to present the chart for visual inspection as soon as the recording has been made.

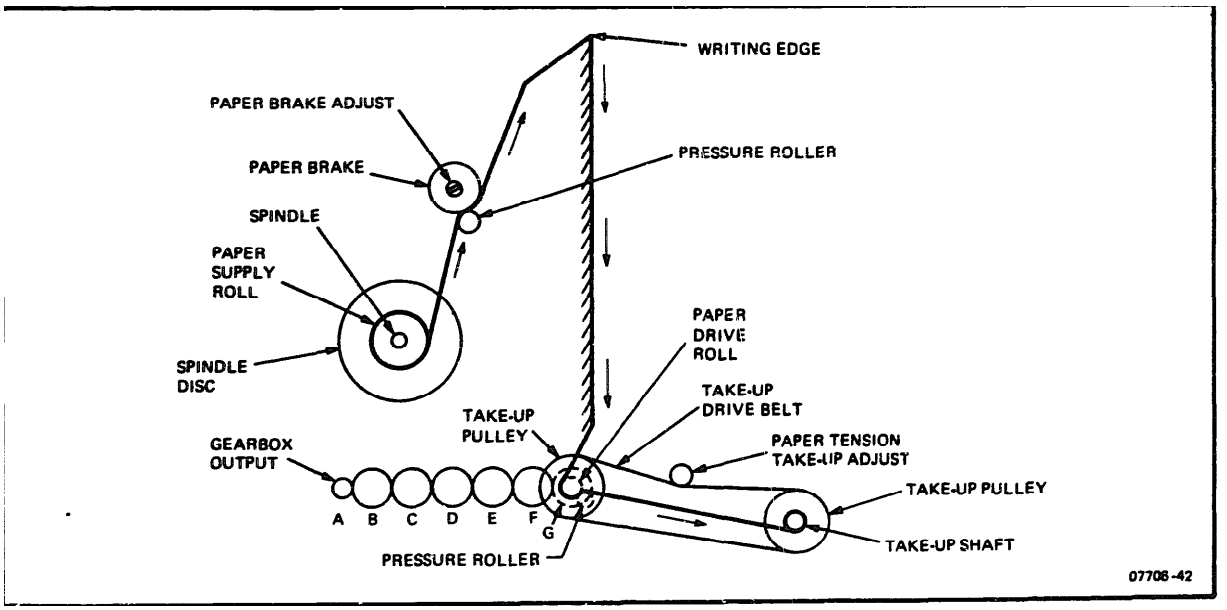


Figure 4-16. Power Flow Diagram, From Gearbox Recording Permapaper Chart.

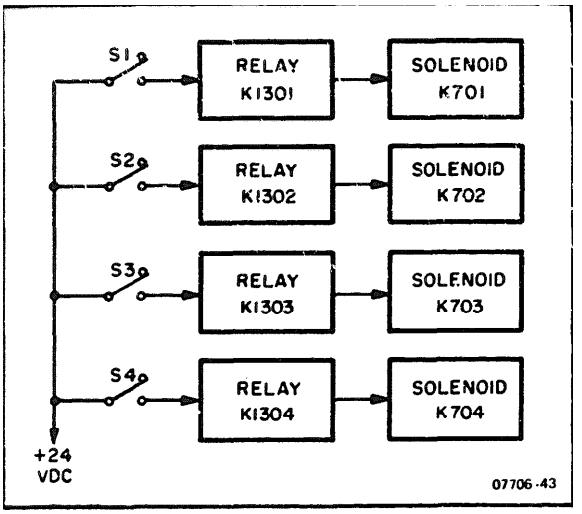


Figure 4-17. Chart Speed Selection Block Diagram

e. After leaving the viewing surface, the chart passes around the rubber-surfaced paper drive roll. A pressure roller holds the paper against the roll for maximum area of contact to prevent slippage.

f. The paper take-up shaft then collects the paper as it exits from the recorder, and winds it tightly around the take-up shaft. This recording can be removed from the take-up shaft as required.

4-86. Chart Speed Selection Circuits.

4-87. Chart speeds are selected electrically either by the chart speed switch buttons on the recorder panel or by an electrically equivalent circuit connected from a remote location. With either control location, the operation is as shown in the block diagram, Figure 4-17.

4-88. Closing any combination of switches S1, S2, S3, S4, will close relays to operate a combination of solenoids as shown. Each solenoid operates a clutch inside the gearbox, to choose a main or an auxiliary mode of power transmission for the gears affected; see paragraph on theory of gearbox operation. Additional sets of contacts on the relays automatically increase the stylus heat at the higher chart speeds to maintain constant trace definition.

4-80. Chart speed selection circuits are shown in Figure 4-18 This circuit uses a row of multi-contact switches, which are mechanically interlocked, so that pressing one switch button automatically locks the others in the OUT position. Pressing the REMOTE switch button allows remote selection of chart speed by a series of switches, as shown in the figure. The same sequence of switch buttons is used for both the MM/MIN and the MM/SEC speeds.

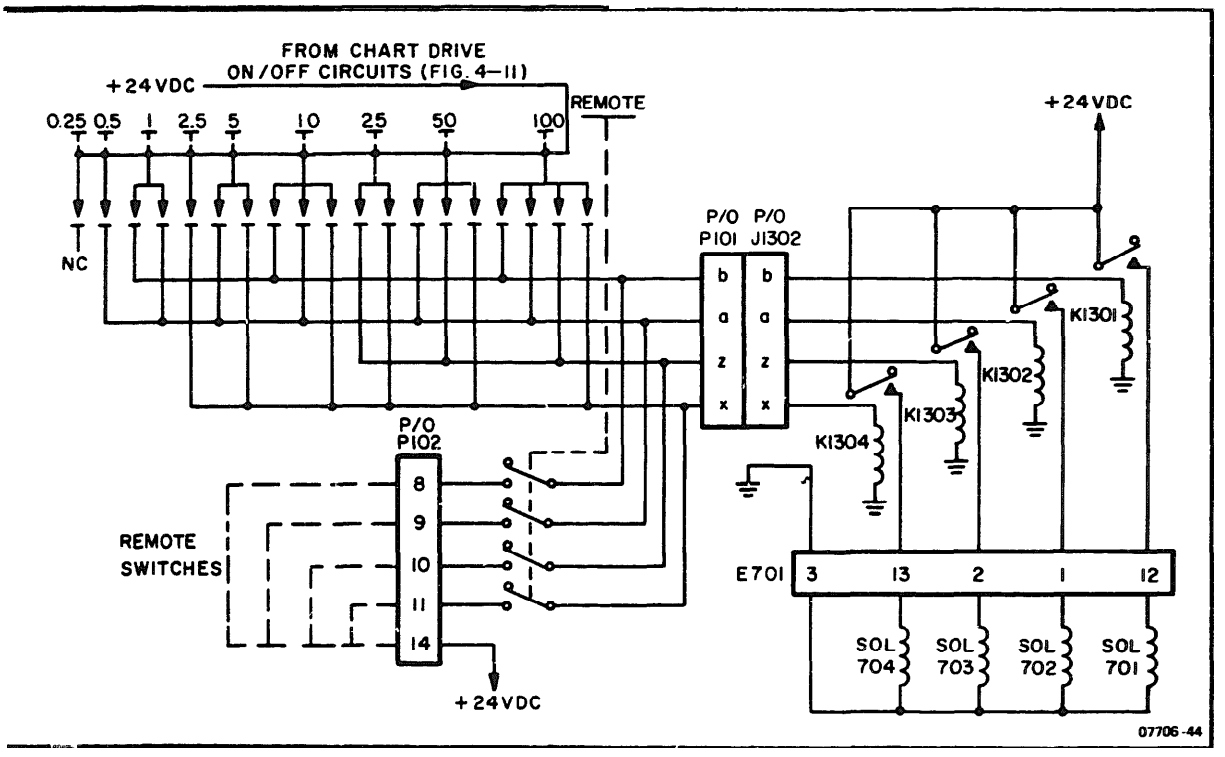


Figure 4-18. Chart Speed Selection Circuits

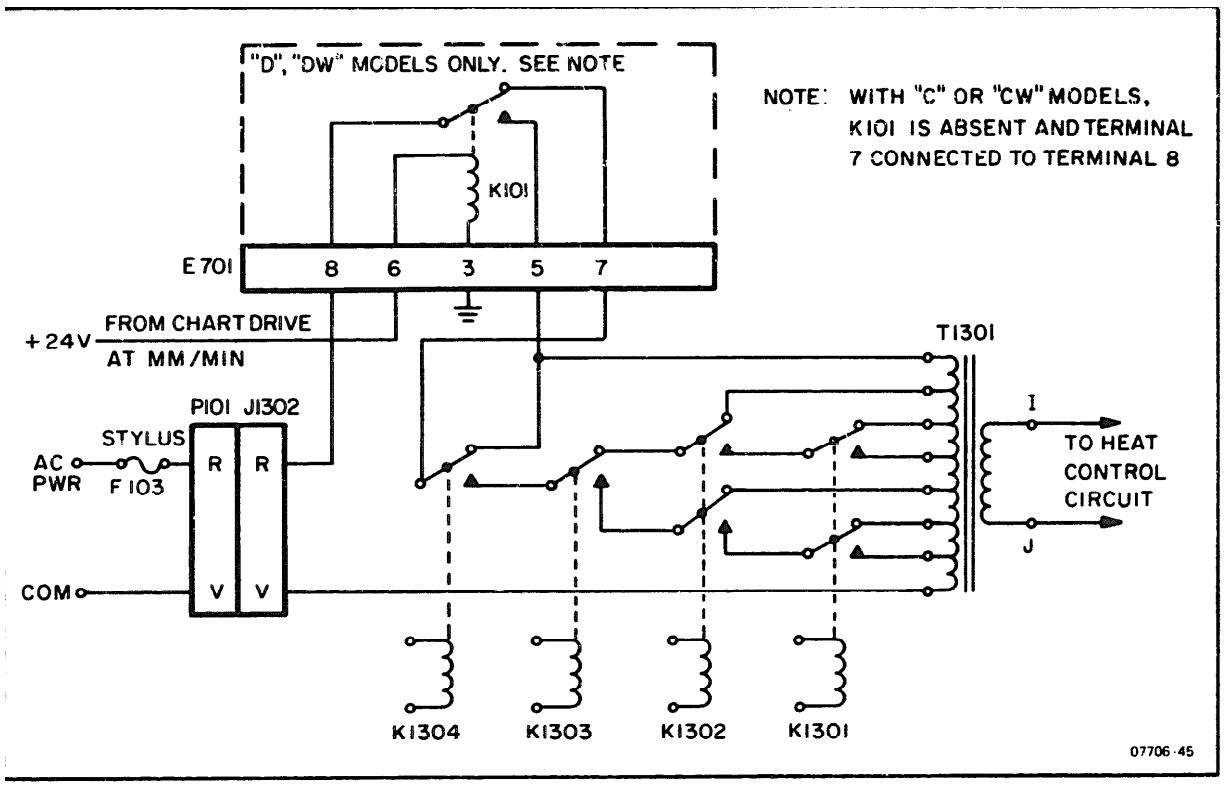
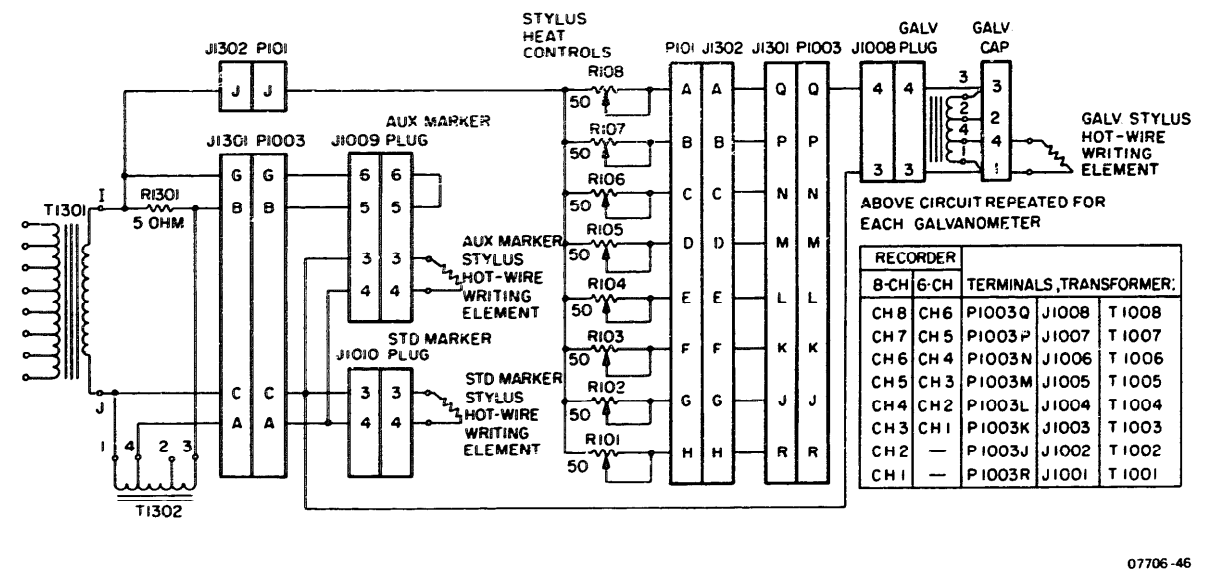


Figure 4-19. Stylus Heat Relay Circuit



RECORDER		TERMINALS, TRANSFORMER:		
8-CH	6-CH			
CH 8	CH 6	P1003Q	J1008	T1008
CH 7	CH 5	P1003P	J1007	T1007
CH 6	CH 4	P1003N	J1006	T1006
CH 5	CH 3	P1003M	J1005	T1005
CH 4	CH 2	P1003L	J1004	T1004
CH 3	CH 1	P1003K	J1003	T1003
CH 2	—	P1003J	J1002	T1002
CH 1	—	P1003R	J1001	T1001

Figure 4-20. Stylus Heat Control Circuit

4-90. **Stylus Heat Circuits.**

4-91. The temperature of the hot-wire elements of the recording stylus must be adjustable, to allow setting for optimum definition, and to accommodate the preferences of the operators. The temperature must also be automatically increased at the higher chart speeds, to allow speed changes without resetting the STYLUS HEAT controls. The stylus heat circuits include a relay switching circuit, and a stylus heat control circuit. The relay switching circuit is shown in Figure 4-19

4-92 When the MM/MIN chart drive motor is turned on, the relay K101 ("D", "DW" models only) is closed to bypass the action of switching relays K1304, K1303, K1302, K1301. This provides the greatest possible voltage step-down ratio through tapped transformer T1301. This ratio remains constant at all MM/MIN speeds, as these speeds are all low enough to operate at a fixed stylus temperature. At MM, SEC speeds, relay K101 will open, and chart speed selection relays K1304, K1303, K1302, K1301 select combinations of taps on the primary of T1301 for a voltage step-down ratio which decreases at the higher speeds, for an automatically increased temperature at the writing surface of the stylus.

4-93 The stylus heat control circuit is shown in Figure 4-20 Input power comes from the tapped transformer T1301, which feeds the standard marker stylus, the auxiliary marker stylus (if used), and all the galvanometer styli.

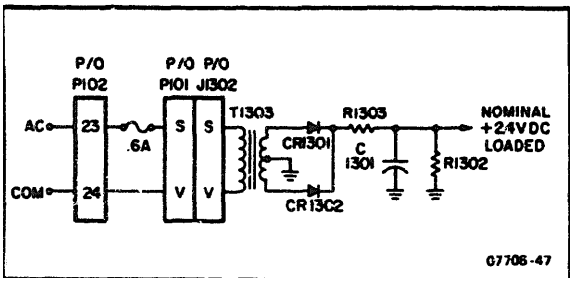


Figure 4-21 Recorder Power Supply Circuit

4-94. Each galvanometer stylus is heated through its individual step-down auto-transformer, as shown. The heat at each galvanometer stylus is individually controlled by the STYLUS HEAT control in the primary circuit of its auto-transformer. The standard marker stylus is heated through its individual auto-transformer T1302.

4-95. When no auxiliary marker is used, the resistor R1301 is present to control the power supplied to the standard marker stylus. When the auxiliary marker stylus is included in the recorder, this stylus is heated from the same terminals as is the standard stylus, and the resistor R1301 is shorted out at the auxiliary galvanometer plug, to allow an increase of marker stylus circuit power. Temperatures of marker styli are not adjustable, other than the automatic temperature change as a function of paper speed.

4-98 **Power Supply Circuits.**

4-97 The recorder includes one power supply circuit which provides a +40 Vdc line to operate relays and solenoids. The power supply circuits are shown in Figure 4-21 The circuit uses a conventional full-wave rectifier circuit with solid-state diodes, followed by a conventional filter. When loaded, the supply voltage is nominally about +24 Vdc.

4-98 **Galvanometer and Galvanometer Circuits.**

4-99 The Galvanometer drives the writing arm and its hot-wire element across the moving recording chart, to form the finished recording. This galvanometer is a D'Arsonval movement, similar to that found in most dc meters. Construction of the galvanometer differs from the meter movement in five important particulars:

(1) In order to operate at high writing speeds, to record high frequencies, the galvanometer requires an extremely stiff suspension. This increases the galvanometer natural resonant frequency, and increases its drive power requirements.

(2) In order to generate the forces needed for operation with this stiff suspension, the Hewlett-

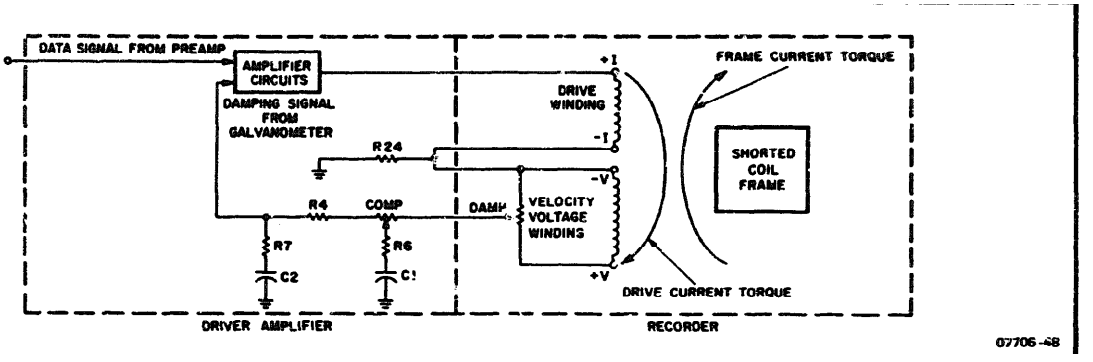


Figure 4-22. Driver Amplifier And Galvanometer Circuits, and Showing Damping and Compensation Adjustments

Packard galvanometer coil must be many times larger and heavier than the corresponding elements of a dc meter movement, as much as 50 times heavier, by weight measurement alone. This increase in mass lowers the galvanometer natural resonant frequency, and increases its drive power requirements.

(3) Because of the power required to operate this galvanometer, the magnetic structure must be of tremendous size and weight, compared with a dc meter movement; the magnets weigh several pounds.

(4) A D' Arsonval movement requires damping to control the transient and frequency response. A part of the damping in this galvanometer is obtained by winding the galvanometer coil on a short-circuited coil frame. The currents induced in this frame as the coil moves in its magnetic field will develop a force which opposes this motion, to provide approximately 27% damping.

(5) The remaining damping required is obtained from the galvanometer coil itself by adding a winding whose output is proportional to the rotary velocity of the coil. The voltage induced in this winding as it moves through the magnetic field is fed back into the galvanometer drive circuit, with such phase relation that it develops a current component at the Driver Amplifier output which causes opposition to the motion. The amount of velocity-damping voltage fed back is adjustable, to allow setting the amount of galvanometer damping.

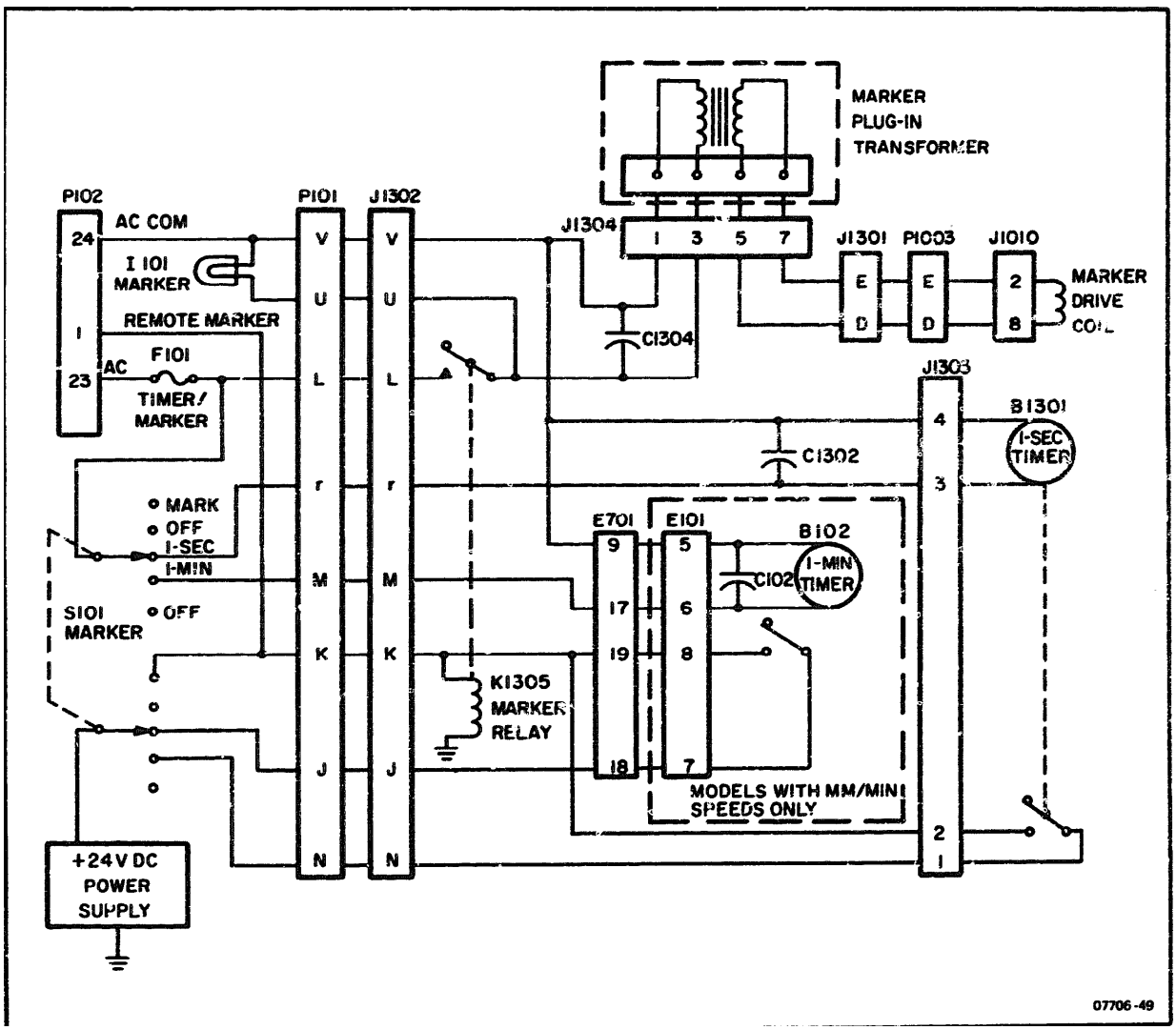


Figure 4-23. Standard Timer/Marker Circuits

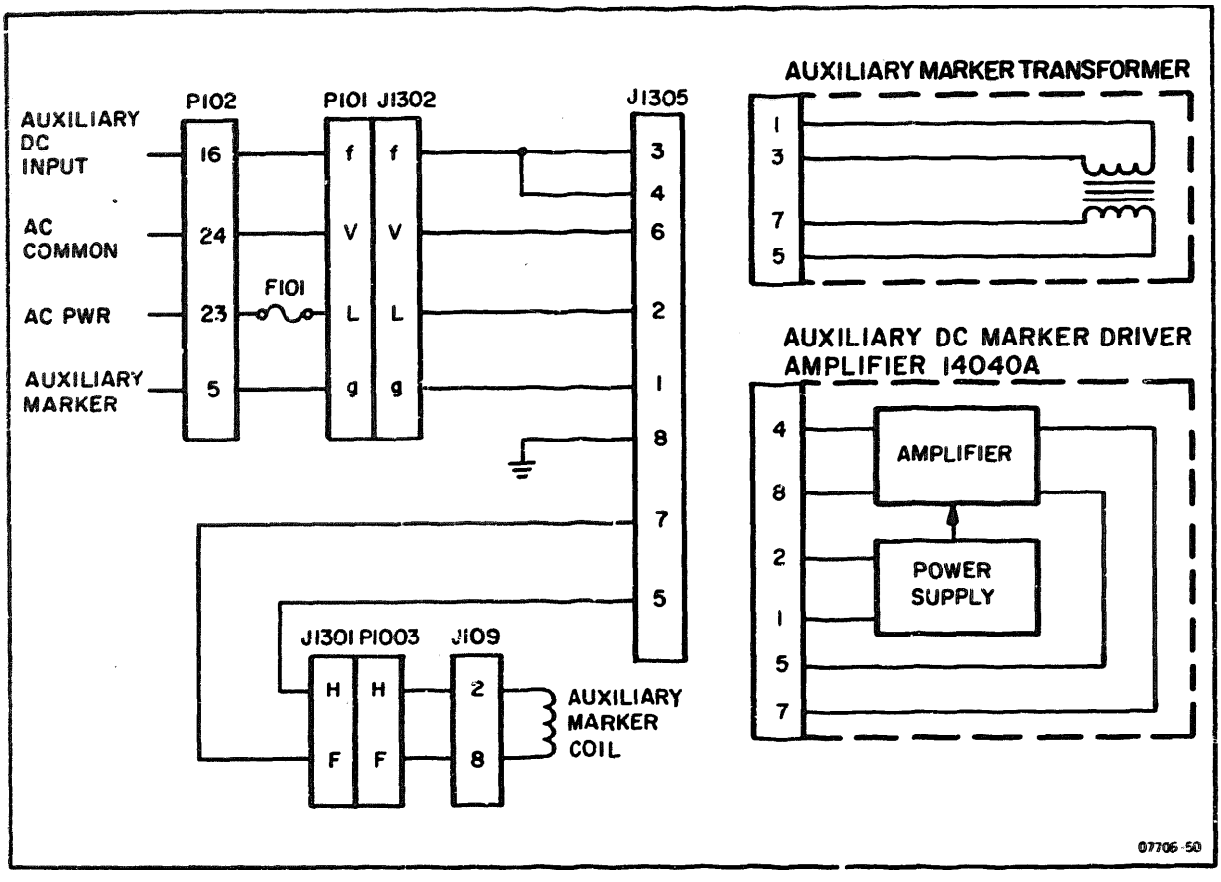


Figure 4-24. Modification of Auxiliary Marker

Further information on Items (1), (2), and (3) above may be found in any standard electronic textbook under the heading "D'Arsonval galvanometer".

4-100 For a discussion of galvanometer damping refer to paragraphs 4-50 through 4-53 and see Figure 4-9.

4-101. A block diagram of the Driver Amplifier and Galvanometer is shown in Figure 4-22 including the damping and compensation adjustments. One channel only is shown; all channels of the recorder have the same configuration.

4-102 Standard Timer/Marker Circuits.

4-103 The standard timer/marker provides a line-frequency marking at the right edge of the recording chart.

4-104 For "marker" operation, the operator closes a local or remote spring-return switch to close the marker relay K1305 and record a line-frequency marking on the chart. This mark continues as long as the relay is held closed. The marking is used to identify points of interest in the recording, the start of a new series of measurements, a change in test conditions, etc., or as an added channel to record on-off events.

4-105 For "timer" operation, a motor driven switch closes the marker circuit briefly to record a burst of line frequency signal which serves as the timing mark. Timing intervals are at one-second intervals (MM/SEC chart drive) or at one-minute intervals (MM/MIN chart drive). These marks provide a timing reference for interpretation of the recording, and for identifying the chart speed. Figure 4-23 shows the timer/marker circuits which perform these functions.

4-108

4-107 The special timer/marker circuit is associated with the standard timer/marker or an auxiliary marker. Circuits using the standard marker are shown in Figure 4-23 Operation of the standard marker is independent of the auxiliary marker (when used):

a. Standard use of the standard timer/marker uses a transformer plugged into J1304, as shown in Figure 4-23 and 4-25 This provides timing and marking indications at line frequency.

b. The standard transformer can be replaced by a "±DC" transistor amplifier, Model 14040A (see Figure 4-26 This provides an up-scale marking deflection with + 1-1/2 volts input voltage, a down-scale marking deflection with a -1-1/2 volts input voltage, and a return to neutral when voltage is removed. Timer circuits do not operate with this marker coil when using this modification. Input current required is 0.5 mA.

4-108 The auxiliary marker is supplied on special order only, and is usually installed between channels 1 and 2. Circuits using the auxiliary marker are shown in Figure 4-24 Operation of the auxiliary marker is independent of the standard marker.

a. The auxiliary marker may be used with a transformer as shown in Figure 4-24. This provides marking indications only, at line frequency, by connecting 115 Vac to the input terminals.

b. Alternatively, the "±DC" transistor amplifier Model 14040A can be used.

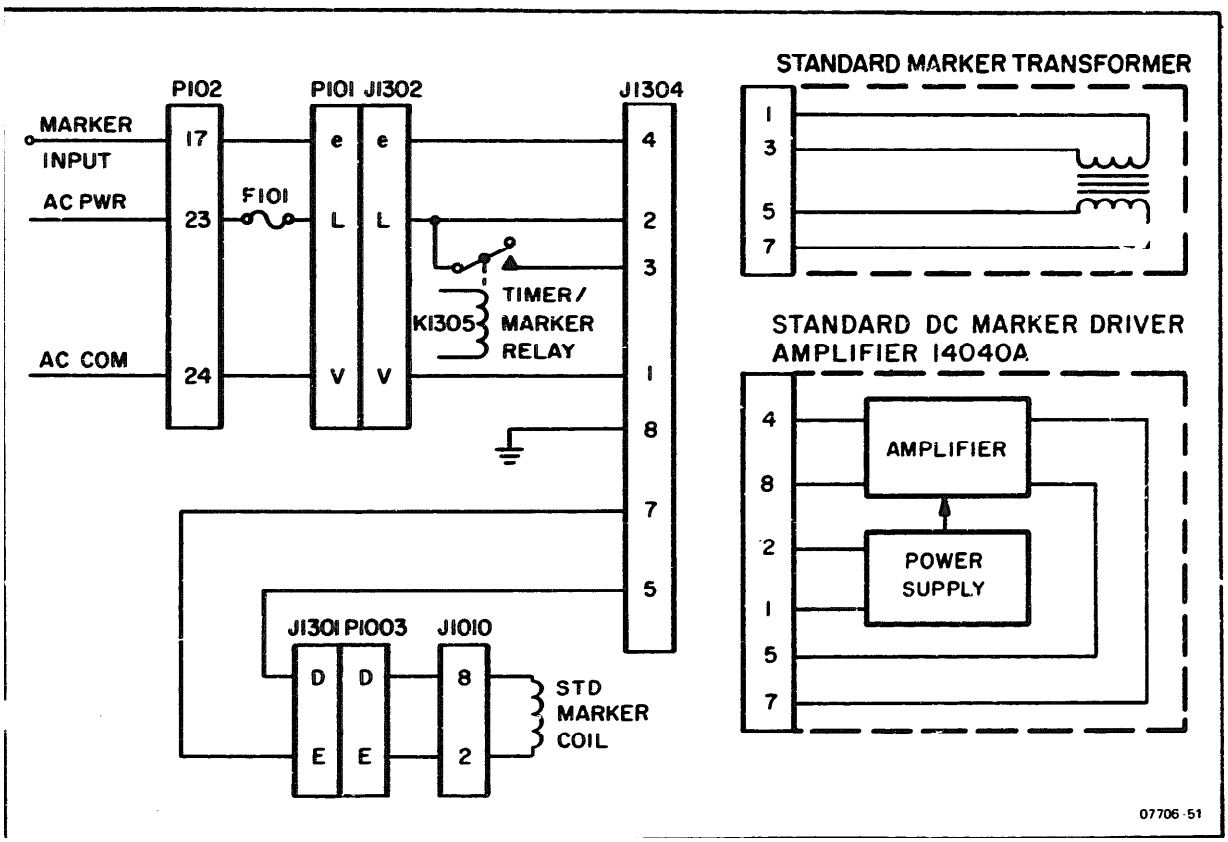


Figure 4-25. Modifications of Standard Marker

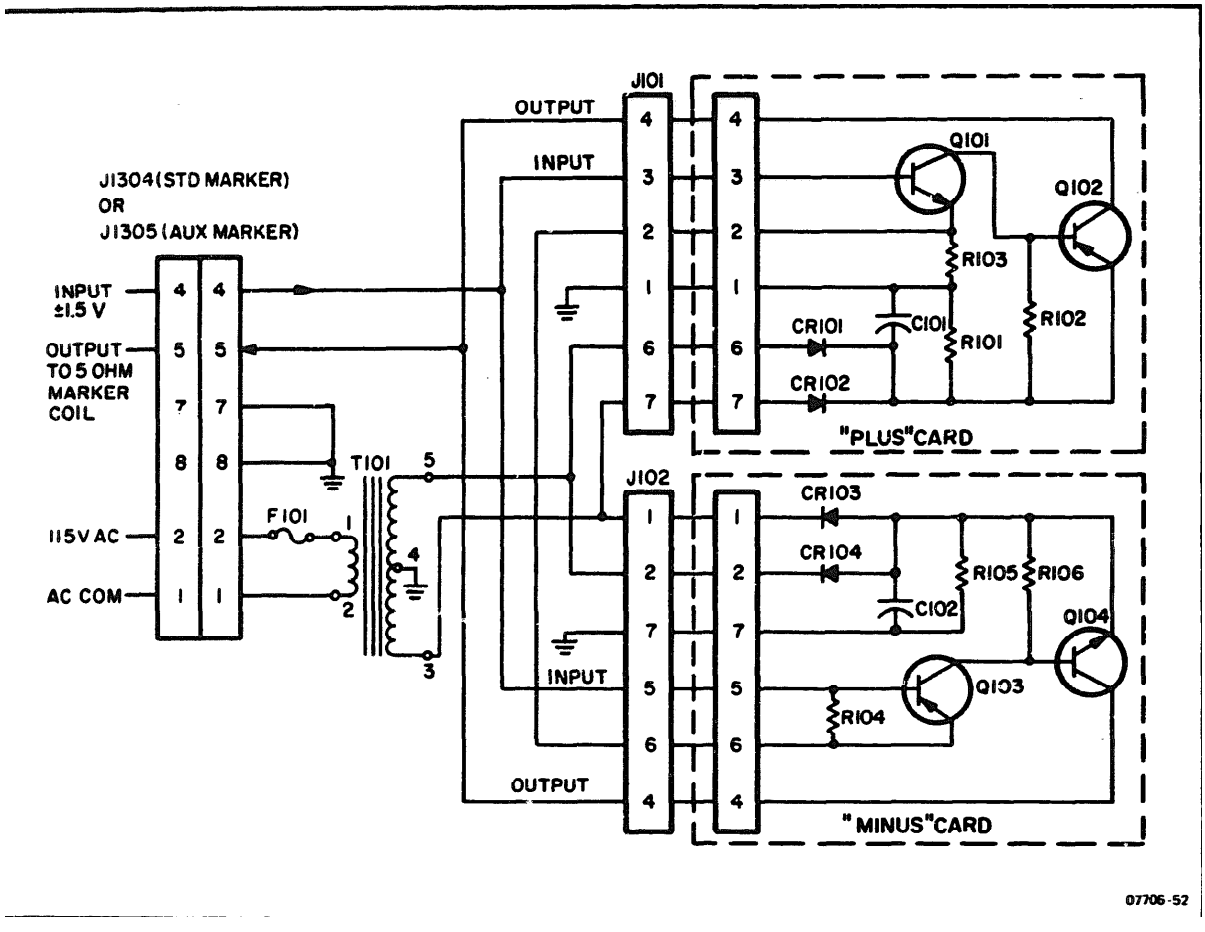


Figure 4-26. + DC Marker Driver Amplifier 14040A

4-109 The ± DC Marker Driver Amplifier Model 14040A is shown in Figure 4-26. The amplifier plugs into J1304 (standard marker) or J1305 (auxiliary marker). With no input signal, there is no output current supplied to the marker coil by output transistor Q102 or Q104. A positive input signal produces a change in the collector current through Q101, and allows Q102 to deliver an output current to the marker coil which gives an upscale (to the left) marker deflection which continues as long as the signal is applied. The common circuit element R103 in the "plus" card provides an interlocking feature which insures that Q103 will not turn on its output transistor, Q104.

4-110 A negative input signal produces a change in the collector current through Q103, and allows Q104 to deliver an output current to the marker coil for a down-scale marker deflection, which continues as long as the signal is applied. Once again, the common circuit element R103 in the "plus" card provides an interlocking feature.

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 This section provides maintenance and service information for the 6- and 8-channel 350-Series Recorders. Information includes performance checks (Paragraph 5-5) which can be used as incoming quality control checks or as a performance check after repair; preventive maintenance (5-10); corrective maintenance (5-56); and troubleshooting and repair (5-136). A separate section on maintaining the Model 7700-02B Driver Amplifier starts at Paragraph 5-120. Figures 5-31 through 5-34 contain schematic diagrams for the recorders.

5-3 TEST EQUIPMENT AND LUBRICANTS

5-4 Recommended test equipment for performance checking, troubleshooting, repair, and for making adjustments is listed in Table 5-1A together with the performance characteristics required. Other test equipment can be used if their specifications equal or exceed those listed. To ensure satisfactory equipment performance, use only the lubricants specified in Table 5-1B Lubrication intervals are described in Paragraph 5-20.

5-5 PERFORMANCE CHECKS

5-6 The Performance Checks (Table 5-2) and Performance Check Test Card (to be filled out during incoming inspection) are designed to verify specifications and to provide a permanent record of the performance of the system. These checks verify proper operation of all circuits in the system and can be used:

a. as part of an incoming inspection check of the component specifications;

b. periodically, where maximum reliability is paramount;

c. as part of a troubleshooting process to locate malfunctioning circuits; and

d. after any repairs or adjustments, before returning the system (or components) to regular service.

5-7 To facilitate checking the 7700-02B Driver Amplifiers and their power supply, the test cable shown in Figure 5-1 should be fabricated using 12-conductor cable with No. 22 awg (or larger) in-

Table 5-1(A). Recommended Test Equipment

INSTRUMENT TYPE	REQUIRED CHARACTERISTICS	USE	NOMENCLATURE
Adjustable Autotransformer	115 or 230 volt; 0-130 Vac 5 amp 0-260 Vac 2.5 amp	General Test Variable Voltage	CN-16/U
DC VTVM	1 mV to 1000 V full-scale 1 mA to 1 amp	Performance Test and Troubleshooting	ME-186/U
Oscilloscope	dc to 450 kHz 10 mV/cm to 10 V/cm	Performance Test and Troubleshooting	AN/USM-281A
Power Supply	Stable to within 1/10% output greater than 1.5 volts	Signal Source	HP 808A, or equivalent power source
Voltage Divider	Accurate to 0.05% less than 1.5 K ohms	Performance Checks	
Differential VTVM	±10 V/5-digit resolution	Monitor	ME-202A/U
Function Generator	Sine Square Oscillator to 150 Hz	Signal Source	SG-321/U
AC/DC VTVM	300 V full-scale	Performance Testing	ME-26B/U
Wattmeter	550 watts 50/60 Hz	Adjustment	TS-430A/U
Stylus Pressure Tester	0-4 grams	Adjustment	HP 14015A, or equivalent
Frequency Counter	to 40 kHz	Performance Checks	AN/USM-207
Test Cable	See Figure 5-1	Performance Checks	

Table 5-1(B). Lubrication Required

LUBRICANT TYPE	USE	HP PART NO.
Machine Oil, No. 10	Oilite Bearings Mini Clutch (mm/min motor, D, DW models only) Mini Clutches (gearbox, all models)	6040-0220, or equivalent
Penetrating Oil	Pre-lubrication of gearbox oilite bearings	Commercial, such as Marvel Mystery Oil, or equivalent
Gear Grease	Paper Takeup and Brake Roll cork discs Gearbox gears Idler gears Paper takeup shaft	6040-0222, or equivalent
Chain Grease	Motor Chains and Sprockets	6040-0223, or equivalent

sulated, flexible wire. This cable should contain a 12-post terminal strip to permit access to the connections between the driver amplifier and power supply. Label the posts from 1 to 12 as shown, and make the cable any convenient length to run from the system to a nearby support for the driver amplifier.

5-8. VARIABLE LINE VOLTAGE

5 - 9 During the following procedures, the system (or component) should be connected to the power source through an adjustable autotransformer so that line voltage can be changed ±10% from nominal (115 or 230 Vac) to assure proper operation of the system under varying supply conditions.

CAUTION

AVOID DAMAGE BY REMOVING POWER FROM THE SYSTEM PRIOR TO REMOVAL OR REPLACEMENT OF ASSEMBLIES OR COMPONENTS.

Table 5-2(A). Performance Checks, Preamplifier Power Supply 8848A

1. POWER SUPPLY REGULATION.

CAUTION

REMOVE POWER FROM SYSTEM EACH TIME TEST PROBE IS CHANGED.

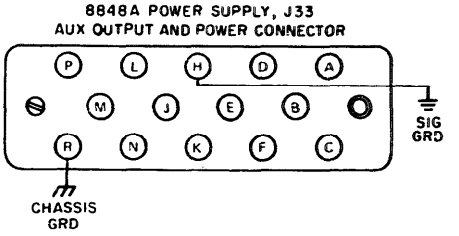
a. Install 6 or 8 typical 8800-Series Preamplifiers into Power Supply.

b. Connect cabinet power cable to ac power line through Variac and connect ac voltmeter to monitor input power to system. Be sure power is OFF at cabinet.

c. Adjust output of Variac to 115 volts ac.

d. Connect differential voltmeter (DVM) to J33-B (see illustration) and J33-H at power supply rear.

e. Turn system power ON at cabinet. Reading should be +12V, ±20 mVdc. (Adjust R4 in power supply if necessary, and lock into position.)



f. Increase line voltage from Variac to 127 Vac. Reading should be +12V ±140 mVdc.

Table 5-2(A) Performance Check, Preamplifier Power Supply 8848A (Cont'd)

g. Decrease line voltage to 103 Vac. Reading should be +12V ±140 mVdc.

h. Remove ac power from system, at cabinet circuit breaker.

i. Connect DVM probe to J33-D.

j. Turn system power ON at cabinet. Reading should be -12V ±140 mV.

k. Increase line voltage at Variac to 115Vac. Reading should be -12V ±140 mV.

l. Increase line voltage at Variac to 127Vac. Reading should be -12V ±140 mV.

m. Return line voltage to 115Vac, and disconnect DVM.

2. POWER SUPPLY RIPPLE.

a. Turn system power OFF at cabinet circuit breaker.

b. Connect oscilloscope to J33-B (+12Vdc).

c. Turn system power ON at cabinet circuit breaker.

d. Ripple on oscilloscope should be not more than 10 mV peak-to-peak.

e. Turn system power OFF at cabinet circuit breaker.

f. Connect oscilloscope to J33-D (-12Vdc).

g. Turn system power ON at cabinet circuit breaker.

h. Ripple on oscilloscope should be not more than 10 mV peak-to-peak.

i. Turn system power OFF at cabinet circuit breaker.

3. OSCILLATORS.

a. Connect oscilloscope and frequency counter to J33-L.

b. Turn system power ON at cabinet circuit breaker.

c. Readings should be not less than 14 Volts peak-to-peak on oscilloscope and between 431.2 and 448.8 Hz on counter.

d. Turn system power OFF at cabinet circuit breaker.

e. Connect oscilloscope and frequency counter to J33-M.

f. Turn system power ON at cabinet circuit breaker.

g. Readings should be not less than 14 Volts peak-to-peak on oscilloscope and between 2352 and 2448 Hz on counter.

h. Turn system power OFF at cabinet circuit breaker.

i. Connect oscilloscope and frequency counter to J33-P.

j. Readings should be not less than 14 Volts peak-to-peak on oscilloscope and between 2352 and 2448 Hz on counter.

k. Turn system power OFF at cabinet circuit breaker.

Table 5-2(B). Performance Checks,Driver Amplifier Power Supply 356-400BW, 358-400B

1. **POWER SUPPLY REGULATION.**

   a. Remove driver amplifier from Channel 1.

   b. Connect test cable described in Paragraph 5-7 (Figure 5-1) between driver amplifier and empty receptacle.

   c. Turn system power ON at cabinet circuit breaker.

   d. Adjust ac line voltage at J413 of Power Supply to 115 Vac with Variac.

   e. Remove preamplifiers from 8248A Power Supply rack.

   f. Connect one differential voltmeter (DVM) lead and one oscilloscope lead to the Power Supply chassis.

   g. First touch the other DVM lead and then the other oscilloscope lead to the terminals on strip E1 of the test cable, and observe the readings given in the following table under TEST 1.

Test Point	FOR ALL DRIVER AMPLIFIERS		FOR UPPER 4 or 6 DRIVERS (358-400B-C2 PC Board Supplies)		FOR LOWEST PAIR OF DRIVERS (358-400B-C5 PC Board Supply)	
	TEST 1 Measurements with 115Vac Power Input		TEST 2 With 103Vac	TEST 3 With 127Vac	TEST 4 With 103Vac	TEST 5 With 127 Vac
	Differential Voltmeter	Oscilloscope	Differential Voltmeter	Differential Voltmeter	Differential Voltmeter	Differential Voltmeter
E1-1	+20.2V ±2.8Vdc	Less than 100mV pk-pk	+18.2V ±2.8Vdc	+22.2V ±2.8Vdc	+18.2V ±2.8Vdc	+22.2V ±2.8Vdc
E1-5	-20.2V ±2.8Vdc	Less than 100mV pk-pk	-18.2V ±2.8Vdc	-22.2V ±2.8Vdc	-18.2V ±2.8Vdc	-22.2V ±2.8Vdc
E1-6	+12V ±0.6Vdc	Less than 100mV pk-pk	+12V ±0.7Vdc	+12V ±0.7Vdc	+12V ±0.6Vdc	+12V ±0.6Vdc
E1-7	-12V ±0.6Vdc	Less than 100mV pk-pk	-12V ±0.7Vdc	-12V ±0.7Vdc	-12V ±0.6Vdc	-12V ±0.6Vdc

   h. With Variac, decrease line voltage to 103 Vac.

   i. Touch DVM lead to terminals given in table, and observe readings in column TEST 2. For lowermost side-by-side pair of driver amplifiers (356-400BW channels 5 and 6 or 358-400B channels 7 and 8), use readings given under TEST 4.

   j. With Variac, increase line voltage to 127 Vac.

   k. Touch DVM lead to terminals given in table, and observe readings in column TEST 3. For lowermost side-by-side pair of driver amplifiers use readings given under TEST 5.

   l. Repeat steps a through j for each remaining driver amplifier location.

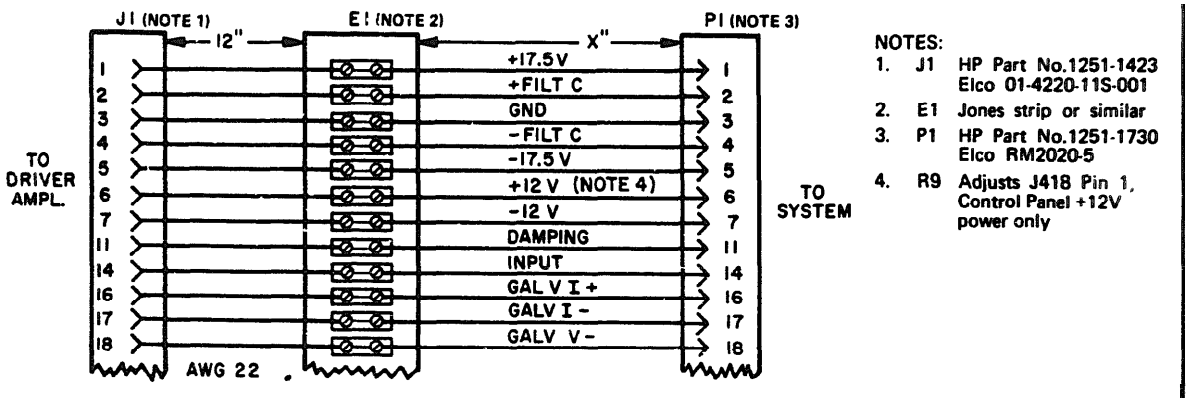


Figure 5-1. Test Cable Schematic Diagram

Table 5-2 (C). Performance Checks, System Signal Circuits

1. RECORDER STYLUS MECHANICAL CENTER.

   a. **Remove fuses F401, F402, F403 and F404 from Driver Amplifier Power Supply**

   b. **Apply ac line power to system through system power cord and cabinet switch/circuit-breaker.**

   c. **Run recorder at 2.5 mm/sec chart speed.**

   d. **Stylus in each channel should be within ±0.5 divisions of mechanical center. If not, see paragraph 5-50 to adjust stylus mechanical center.**

   e. **Replace fuses F401, F402, F403, and F404.**

2. VOLTAGE AND RIPPLE (Preamplifier Power Supply).

   Perform procedure given in Table 5-2(A), parts 1 and 2.

3. VOLTAGE AND RIPPLE (Driver Amplifier Power Supply).

   Perform procedure given in Table 5-2(B).

4. SYSTEM LINEARITY.

   a. Connect precision power supply (see Table 5-1) to pins A and B of preamplifier power supply signal input connector for Channel 1

   b. Connect either : (1) Voltage divider in parallel with signal input (Table 5-1),
      (2) or differential VTVM in parallel (Table 5-1).

   d. **Set preamplifier attenuator control to appropriate scale for 25 divisions deflection at maximum power supply voltage.**

   e. **PERFORM STEPS UNDER EITHER METHOD 1 OR METHOD 2:**

      NOTE

      Method 1 checks for maximum accuracy at +20 divisions, and Method 2 checks for maximum accuracy at full up or full down scale. Use Method 2 for channels with 8807A or 8808A Preamplifiers, and Method 1 for other channels.

   Method 1:
   (1) Set power supply (external signal source) at lowest output.
   (2) Set stylus for channel under test to chart center with preamplifier position control.
   (3) Set signal source and preamplifier sensitivity control to deflect stylus for channel under test +20 divisions.
   (4) Run Recorder at 10 mm/sec chart speed or higher to avoid excessive hysteresis.
   (5) Considering +20 division point as 100% value for linearity check, reduce signal strength of input in steps of 25%, starting at 25 divisions upscale (+125%). Note stylus position at each point.
   (6) When stylus has reached center scale (0%), reverse power supply (signal source) polarity and repeat step 5 from -125% to 0%. Note stylus positions.
   (7) Turn off recorder and signal source.
   (8) Stylus deflections should coincide with heavy lines on chart at ±20 division marks, and should be within 0.25 division of heavy lines at other 5 division intervals.

Table 5-2 (C). Performance Checks, System Signal Circuits (Cont.)

Method 2:
(1) Set power supply (external signal source) to lowest output.
(2) Set stylus for channel under test to chart center with preamplifier position control.
(3) Set input signal level and preamplifier sensitivity control to deflect stylus for channel under test for exact full upscale reading.
(4) Run recorder at 10 mm/sec chart speed or higher to avoid excessive hysteresis.
(5) Reduce signal strength of input to 0% in steps of 25%, and note stylus position at each point.
(6) Reverse input signal polarity and set to deflect stylus fully downscale.
(7) Reduce signal strength of input to 0% in steps of 25%, and note stylus position at each point.
(8) Turn off recorder and signal source.
(9) Stylus deflections should coincide with heavy lines on chart at full upscale and downscale positions, and should be within 0.5 division of heavy lines at other 5 division intervals.

f. Repeat steps a through e for each remaining channel.

5. SYSTEM FREQUENCY RESPONSE.

NOTE

For the frequency response check, a Model 8801A, 8802A, or 8803A Preamplifier is recommended for the channel under test. System frequency response should be within 3 dB from DC to the upper limit (depending on system and preamplifier) as follows:

PREAMPLIFIER	7706B			7708B		
	Frequency	Rise Time	Overshoot	Frequency	Rise Time	Overshoot
8801A	125 Hz	5 msec	0.5 div.	150 Hz	4 msec	0.4 div.
8802A	125 Hz	5 msec	0.5 div.	150 Hz	4 msec	0.4 div.
8803A	100 Hz	7 msec	0.6 div.	110 Hz	6.4 msec	0.6 div.

a. Connect Function Generator (oscillator, see Table 5-l) to pins A and B of preamplifier input connector at rear of preamplifier power supply for channel under test. Monitor amplitude of oscillator output with VTVM.

b. Center recording stylus of channel under test with preamplifier position control.

C. Run recorder at 25 mm/sec chart speed.

d. Set recorder stylus heat to maximum for channel under test.

e. Set Function Generator to 10 Hz signal.

f. Set preamplifier attenuator (range switch) to most sensitive position.

g. Adjust Function Generator amplitude for 10 divisions deflection centered on center scale of recording channel.

h. Note amplitude of Function Generator output.

i. Increase Function Generator frequency to maximum (see Note) without changing amplitude of signal.

j. Adjust COMP control on driver amplifier for 7 ±0.2 divisions recording.

Table 5-2(c). Performance Checks, System Signal Circuits (Cont.)

k. Lower Function Generator frequency to 55 Hz without changing amplitude.

l. Adjust damping control (inside front of recorder next to galvanometer connectors, R1002-R1016 in 358-100 or RlOOl-R1006 in 356-100) for 10 ± 0.5 divisions recording.

m. Set Function Generator frequency to maximum specified in Note.

n. Amplitude of recording should **be** 10 divisions ±3 dB. If not, repeat steps e through n.

0. Return stylus heat control for **channel** under test to normal range.

p. Perform steps e through o for remaining channels.

q. Turn recorder CHART DRIVE switch to OFF.

6. SYSTEM TRANSIENT RESPONSE.

a. **Connect** Function Generator (see Table 5-l) to preamplifier input at rear of preamplifier power supply.

b. Set **Function** Generator to provide square wave output of frequency noted at start of Check 5 (System Frequency Response) for combination of system and preamplifier.

C. Set Function Generator amplitude to provide 10 division deflection for channel under test.

d. Run recorder at maximum speed, briefly.

e. Inspect recording. Rise time should be 4 milliseconds or less (5 msec for 8803A), and leading edge of square wave should show no more than 0.4 division overshoot (0.6 div. for 8803A).

7. SYSTEM DRIFT.

a. Connect system power cord to Variac (Table 5-l) output, and monitor system input voltage. Connect power supply (signal source) to preamplifier input.

b. Allow system to warm up for 30 minutes.

c. Perform Check 4 **(System** Linearity).

d. Set attenuator of preamplifier in channel under test to most sensitive position.

e. Set output of Variac to exactly 115 volts ac. Run recorder at 25 mm/sec.

f. Set output of signal source to convenient calibration point.

g. Set output of Variac to 103 volts ac. Note position of recorder stylus.

h. Set output of Variac to 127 volts ac. Note position of recorder stylus.

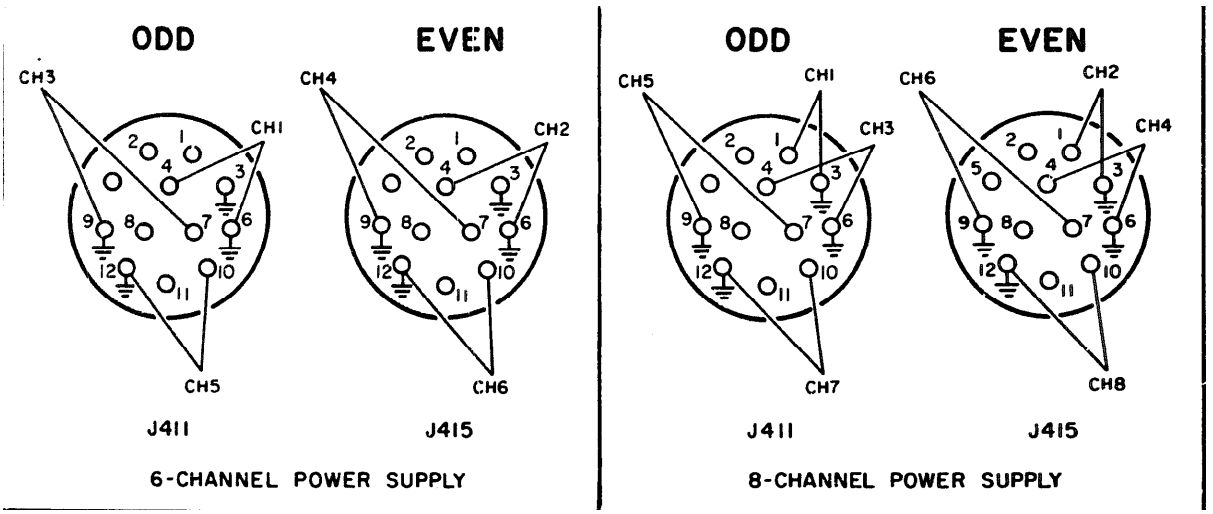
i. At either extreme, stylus position should not vary from original position by more than 0,1 division.

Table 5-2 (C). Performance Checks, System Signal Circuits (Cont.)

8 SYSTEM INHERENT NOISE (Less Preamplifier Noise).

a. Remove signal cable 07727-60010 from driver amplifier power supply input connectors. Note which power supply jack each cable connector goes to, for later replacement.

b' With a jumper wire (single female pin each end) or jumper plug, short input of driver amplifier under test to ground, as shown in following diagrams:



C. Run recorder briefly, at 25 mm/sec chart speed.

d. Noise observed on recording should not exceed 0.1 division peak-to-peak.

e. Repeat steps a through c for each channel.

NOTE

All channels can be tested simultaneously by using several jumper wires, or by permanently wiring jumper plugs for J411 and J415. Do not jump monitor connector P4 of the cable as this may damage preamplifiers. Mating connector for mating jumper plugs is HP Part No. 1251-1663.

9. STYLUS LIMIT ADJUSTMENTS.

The upscale and downscale limit adjustments restrict the positive and negative excursions of the stylus from within 10 divisions of chart edge to 3 millimeters beyond chart edge. These adjustments are made by first driving the recorder to its upscale stop and adjusting R25 (+LIM, Figure 5-27) for the desired limit, and then driving the recorder to its downscale stop and adjusting R26 (-LIM, Figure 5-27) for the desired limit.

Table 5-2(D). Performance Check Test Card

DESCRIPTION	CHECK	
1. STYLUS MECHANICAL CENTER: Each channel - within ±0.5 division. Remove fuses to zero stylus.	CH. 1 CH. 2 CH. 3 CH. 4 CH. 5 CH. 6 CH. 7 CH. 8	±0.5 division
2. VOLTAGE & RIPPLE (358-400B or 356-400BW):	+12 volts -12 volts	
	+I2 volts Ripple, peak-to-peak, -12 volts 100 mV max,	
3. VOLTAGE & RIPPLE (8848A): -12 volts adjustable to ±l40 mV through R4 on the top rear of Preamplifier Power Supply.	+12 volts, ±20 mV -12 volts, Adjustable	
	+12 volts Ripple, peak-to-peak, -12 volts 10 mV max.	
4. LINEARITY: within 0.25 division Total system. Precise voltages applied to Preamplifier input. Monitor voltage with differential VTVM.	CH. 1 CH. 2 CH. 3 CH. 4 CH. 5 CH. 6 CH. 7 CH. 8	0.25 division (0.5% of 50 div chart)
6. FREQUENCY RESPONSE: Including Transient Response and Rise Time. 10 divisions peak-to-peak amplitude at chart center.	CH. 1 CH. 2 CH. 3 CH. 4 CH. 5 CH. 6 CH. 7 CH. 8	Basic Response: 7708B: 0 to 150 Hz within 3 dB 7706B: 0 to 125 Hz within 3 dB
7. DRIFT: 0.1 div Short term drift for Pine voltage variation from 103-i27 volts after 30 min. warmup.	CH. 1 CH. 2 CH. 3 CH. 4 CH. 5 CH. 6 CH. 7 CH. 8	0.1 division (0.2% of 50 div. chart)
8. NOISE: Max. 0.1 div. peak-to-peak Observed as inherent system noise.	CH. 1 CH. 2 CH. 3 CH. 4 CH. 5 CH. 6 CH. 7 CH. 8	0.1 division (0.2% of 50 div. chart)

Table 5-3. Recorder Troubleshooting Guide

PARTS CHECKED	DEFECTS NOTED	REQUIRED REPAIRS	REFER TO
1. Stylus	1. Bent or twisted. 2. Broken side wire support. 3. Broken welds. 4. Broken connection. 5. Side wires twisted out of parallel. 6. Nicked. 7. Carboned (blackened). 8. Mounting contact corroded. 9. Mounting adapter corroded.	Defects 1 through 6 - Replace stylus 7. Clean with cleaning fluid such as Chlorothene, or equivalent. 8. Clean with fine sandpaper; do not remove contact plating. 9. Clean with fine sandpaper; do not remove contact plating.	Fig. 5-8 Fig. 5-4
2. Platen (knife edge)	1. Carbon buildup. 2. Slight nicks or burrs. 3. Deep dents, nicks, burrs.	1. Clean with Chlorothene, reduce stylus heat level to prevent carbon deposit. 2. Use fine emery stone to remove sharp edges. 3. Replace platen (remove 2 mounting screws on platen upper edge and pull platen upper edge and pull platen from table).	
3. Chart Table	1. Carbon or other contamination. 2. Dents, nicks, burrs. 3. Burrs or nicks on radius at bottom of table plate	1. Clean with Chlorothene. 2. Remove sharp edges with fine emery stone. 3. Remove sharp edges with fine emery stone. Replace table if one end of table bottom has large amount of wear.	
4. Pressure Roll	1. Seized. 2. Slight burrs or nicks.	1. Clean bearings with Chlorothene and oil sparingly. 2. Remove sharp edges with emery stone.	
5. Drive Roll Guide	1. Squeaking or chattering.	1. Check drive roll guide edge clearance near pressure roll. Adjust to about 1/16 inches (1, 6 mm) by loosening mounting screws and moving Drive Roll Guide to or from Drive Roll. Tighten mounting screws. screws. **CAUTION** DO NOT RUN RECORDER WITH LOOSE DRIVE ROLL GUIDE OR WITHOUT PROPER CLEARANCE OVER WHOLE RADIUS OF GUIDE SURFACE.	
6. Drive Roll	1. Cracks or cuts. 2. Slick or dirty.	1. Replace Drive Roll. 2. a. Remove Permapaper. b. Remove paper guide from table: Pull down at one end of guide and release paper guide leaf spring with slight push of small screwdriver on spring.	Fig 3-4

Table 5-3. Recorder Troubleshooting Guide Continued (Cont.)

PARTS CHECKED	DEFECTS NOTED	REQUIRED REPAIRS	REFER TO
		c. Run recorder at highest speed. d. Clean surface of drive roll with Chlorothene dampened cloth. **CAUTION** DO NOT SATURATE DRIVE ROLL WITH CHLOROTHENE AND BE CAREFUL THAT CLOTH DOES NOT GET CAUGHT IN DRIVE ROLL. e. Wait until drive roll is completely dry. f. Stop recorder. g. Install Permapaper.	Fig. 3-4
7. Brake Roll	1. Cracks. 2. Dirty or Slick. 3. Sticking or jamming.	1. Replace Brake Roll. 2. Clean with Chlorothene while turning by hand. 3. With proper brake adjustment, Brake Roll should turn smoothly. Four possible defects can cause brake roll jamming: Bent brake roll studs. Replace Brake Roll. Side plate bearings dirty or too tight. Brake disc washer not lubricated. Brake Roll adjustment too tight.	Fig. 5-2 5 - 5 Para. 5-26
8. Steel Idler Gears	1. Gear teeth badly worn.	1. Replace defective gears. Replace gear box output shaft gear if adjacent idler is worn.	Fig. 5-5 Fig. 5-18
9. Paper Take-Up	1. Paper too loose or tight on spindle.	1. a. Run recorder at 25 mm/sec. Stop recorder. Adjust take-up clutch screw until slight finger pressure depresses paper between drive roll and take up spindle. b. Run recorder at highest speed and adjust paper tension. c. Repeat adjustments at slow speeds. d. Check operation at high, medium and slow speeds. **NOTE** Take-up may operate erratically at slow speeds if clutch screw is not locked. e. Tighten clutch lock (CCW rotation) after each adjustment.	Fig. 5-24

5-10. PREVENTATIVE MAINTENANCE

5-11. **Preventive maintenance is recommended every 1000 hours of operation or every six months, depending upon the operation conditions.** Table 5-3 **is recommended as a check chart for preventive maintenance as well as an aid for minor repairs, adjustments and troubleshooting.**

5-12. MECHANICAL CHECKS

5-13. Refer to Operation Section III, (Figure 3-3) **and check for proper operation** before continuing.

5-14. Switch power to the system OFF. Inspect the Symptoms of mechanical or electrical overload. Check for dents, **rust, corrosion, or** othcr evidence of mechanical or electrical abuse. Check that ail system components **are securely** mounted, including the cable **connectors. Check the** cables for strain, breaks, frayed insulation **(particularly** at bends), and that the **cables are** free **when the** recorder is moved in and out.

5-15. The following steps will **check the** recorder mechanical operation:

a. Recorder Slides. Check **that the recorder** slides in and out smoothly and **locks in the normal (closed)** position (see Figure 5-2).

b. Paper Take-Up. Hold **the paper take-up shaft** and check for a small amount of play in take-up shaft

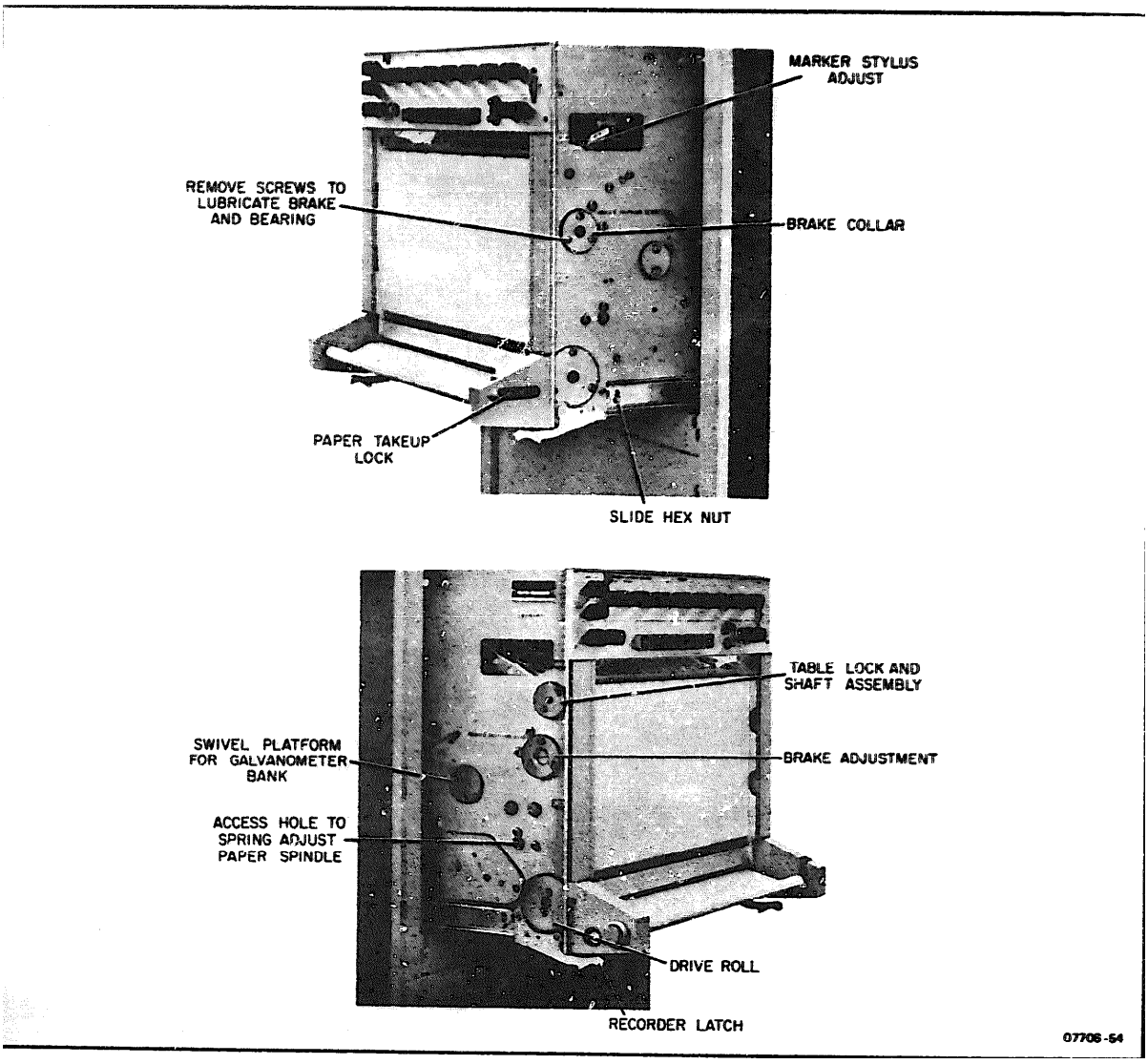


Figure 5-2. Recorder on Slide Assembly

rotation. (If the ten nsion is too tight or loose, refer to paragraph 5-103 for adjustment.)

c. Paper Loading. Refer to Figure 3-4 and load Permapaper into the recorder. Apply power and run ten feet of paper at the highest paper drive s-peed to correct any mistracking resulting from paper loading. Approximately 3/32 in. of the platen table surface should be visible to the right of the chart. Check that paper take-up is working properly.

d. Paper Tension. Inspect paper travel over the writing edge at the highest MM/SEC speed. The paper should remain tight against the edge during travel, not curve over it. Adjust the brake screw to tighten paper (see paragraph 5-25).

e. Paper Tracking. Run approximately 5 feet of chart at the 5 mm speed with one channel stylus centered. Remove the recording and measure the distance between the trace and the edge of the channel. The measurement should not vary more than 0. 5 mm from center. Repeat procedure at the highest speed. The same specifications apply. If paper weave exceeds the limit, check paper loading techniques and paper tension. Check Table 5-3.

f. Paper Parallax. Check parallax with paper drive motor OFF and Permapaper tight against the platen writing edge. Carefully mark the two outer recording channels, along the knife edge of the platen, with a pencil and inspect the lines. The lines must lie on the same time line, within 0. 25 division. If not, check paper loading technique and chart tension (paragraph 5-25).

g. Writing Styli. Remove each stylus by loosening clamping screw (see Figure 5-4, lift writing arm straight up. Inspect the writing surface. It should be clean and straight. If the stylus is bent, it sometimes can be straightened with tweezers; if not, replace it. If the stylus is burred or twisted, replace it. Insert good stylus in galvanometer clamp and secure in place. The flexible stylus heater leads should form parallel loops with each other. Tighten the stylus heat lead screws (Figure 5-8). Now check the overhang of each stylus over the writing platen edge (see Figure 5-4). The writing element should overhang 2/3 of its length (the middle 1/ 3 of the element provides the most uniform heat).

NOTE

improper overhang can result in poor trace definition across the channel, an erroneaous indication of system non-linearity.

1. Stylus Pressure. When pressure is too light the trace will be faint and not clearly defined. When pressure is too high, friction will cause noticeable hysteresis and non-linearity. Refer to paragraph 5-39 for adjustment procedure.

2. Marker Styli. Inspect each marker for cleanliness and good mechanical condition. Run a few feet of recording at highest chart speed with the marker held for continuous oneration. Inspect the recording. If unsatisfactory, replace the stylus. To adjust - marker amplitude, refer to paragraph 5-41.

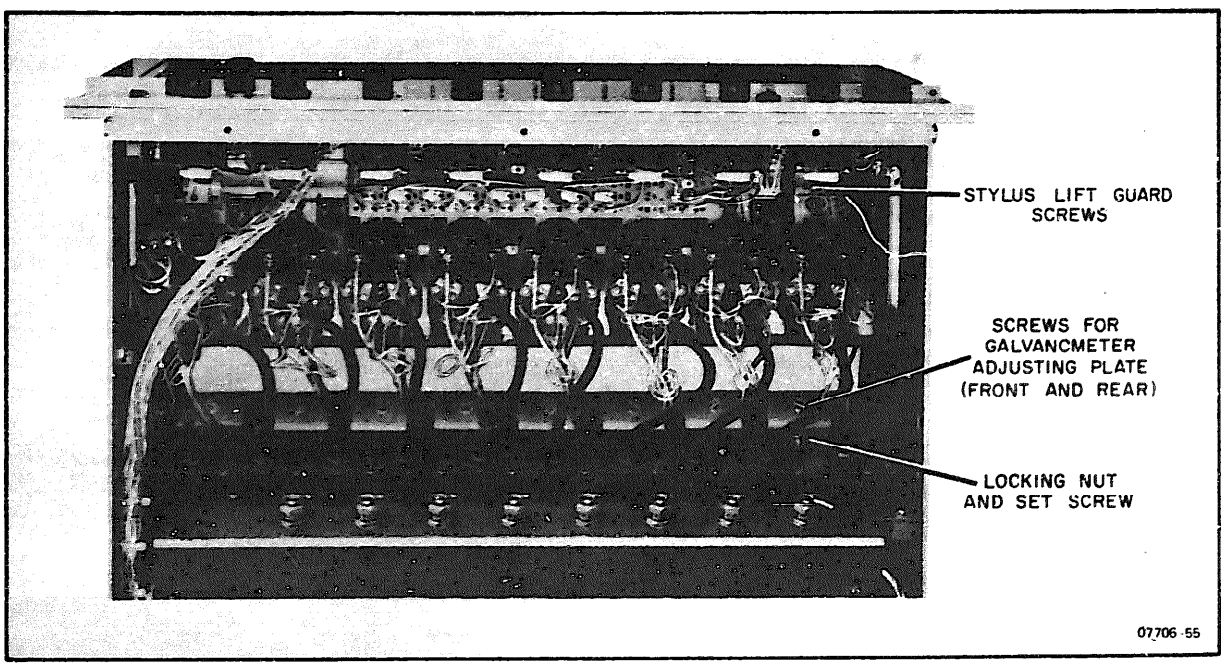


Figure 5-3. Looking Down on Galvanometer Bank

3. Stylus Heat. Apply power to system; set paper drive to 25 mm/sec, and adjust each Stylus Heat control for best trace. Rotate each POSITION control on the Control Panel from one extreme position to the other and observe the corresponding channel record-ins. Trace definition should be the same over the entire channel width. In case of a sudden change in definition at one point, inspect the writing surface (beneath the paper) for a nick or burr at that point. If the change in difinition extends over some portion of a channel's width, check for a defective or improp-erly inserted stylus. Check Table 5-3.

4. . Stylus Deflection. With the Preamplifier POSITION controls set alternately to the extreme rotation points, check the stylus deflection. The mechanical stops on the galvanometers should limit deflection to not more than 2 mm beyond the edge of the recording channel (or 1 mm when writing arm motion is toward an adjacent marker arm) (Figure 5-8).

5-16. ELECTRICAL CHECKS.

5-17. The electrical checks to be made are included in the Performance Checks given in Table 5-2.

5-18. CLEANING.

5-19. Cleaning may be required at much shorter intervals than specified in paragraph 5-11, depending upon the particular environmental conditions.

a. Remove power from the system, open rear door to the system and remove any dust or dirt accumulation with a vacuum hose.

b. Clean all front panels, controls, viewing win-dow, etc., with a clean, lint-free cloth, or with a wax impregnated polishing cloth.

Remove Permapaper and clean deposits from the" writing edge of the recorder ten with a cleaning fluid, such as Chlorothene. Clean drive roll and the paper brake roll (see Figure Figure 5-5) With Chlorothene. Use it sparingly and let roll s dry thoroughly after cleaning.

d. Clean each stylus with Chlorothene. Do not use steel wool or any cleaner containing abrasive metal particles.

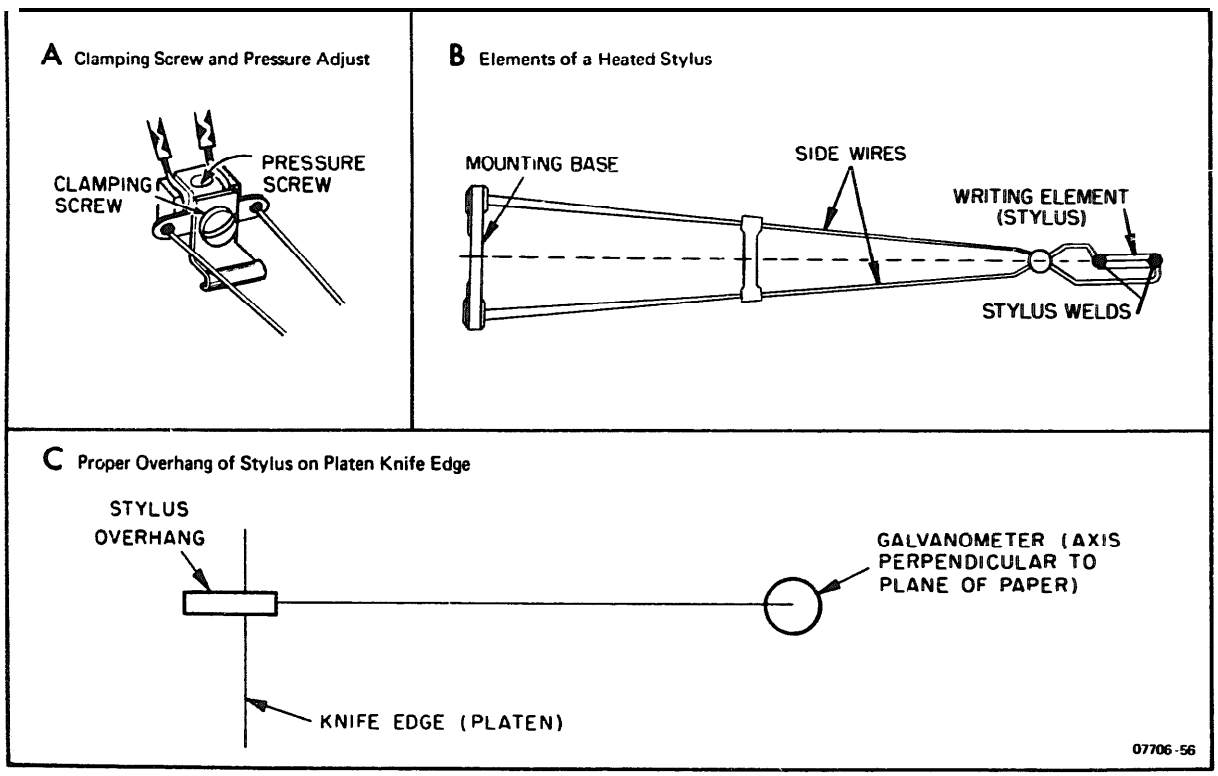


Figure 5-4. Stylus Check and Replacement

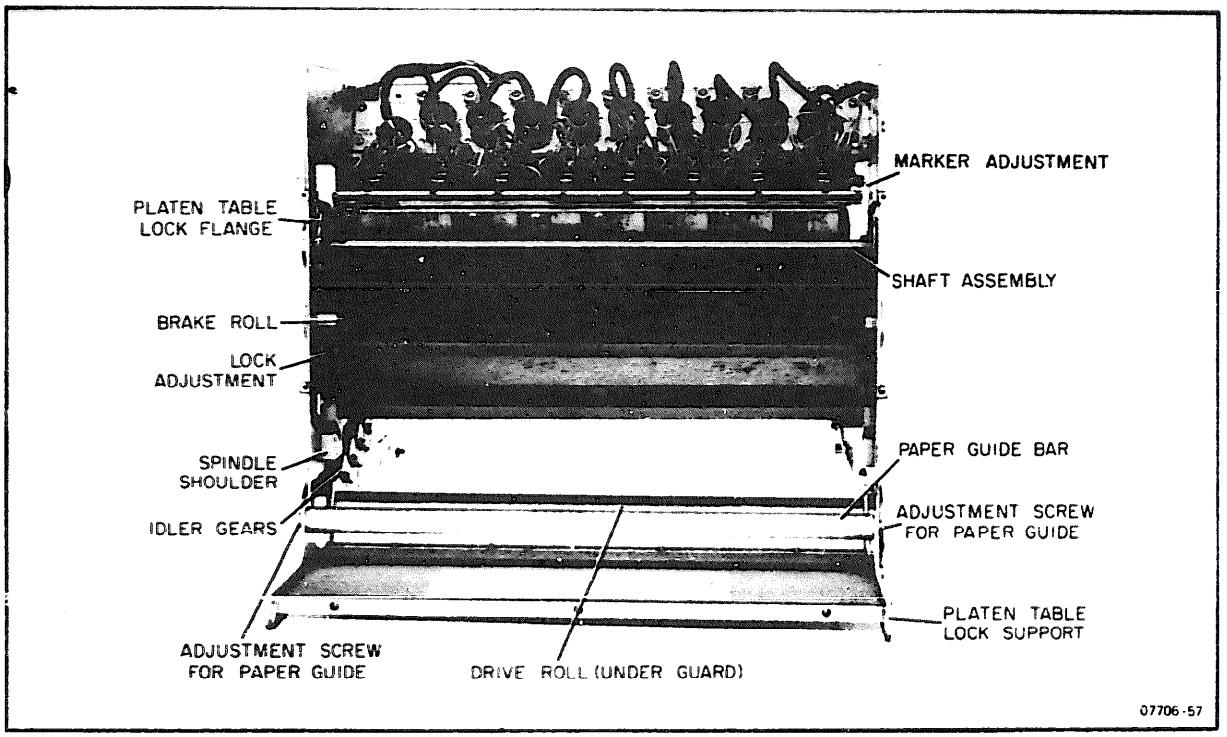


Figure 5-5. Recorder Check Points

5-20. LUBRICATION.
(Gear Box Lubrication. see paragraph 5-70)

5-21. Major lubrication is performed during each recorder overhaul. Minor lubrication should be performed during other maintenance check points such as periodic preventive maintenance and after minor repairs and adjustments (see Table 5-3). The guide to proper lubrication depends on recorder usage. Recorders operating for long periods in the upper half of the speed range probably will require lubrication only every 2000 hours because the gear box is practically free running, i.e., most of the clutches are disengaged. If the recorder is run at the slower speeds for extended periods, more frequent lubrication is required. Futher whenever an extended recording period is anticipated (on-line for 30/60/90 days) lubrication and overhaul prior to the recording period will help to assure uninterrupted service. For a list of required lubricants see Table 5-1B.

5-22. ADJUSTMENTS AND REPAIRS

5-23. ADJUSTMENTS FOR PROPER PAPER FEED.

5-24. The paper drive and brake rolls feed and guide the paper through the recorder and require special Attention to keep the paper speed and tracking aligned.

5-25. Brake Roll Adjustments and Repairs.

5-26. Install Permapaper in recorder. See Operation, Section III, loading procedures for paper Run

the recorder at 25 mm/sec speed: stop recorder when paper has settled on platen. Use a screwdriver and turn the Brake Adjusting screw (Figure 5-2) about five turns counterclockwise. Set the recorder to run and slowly turn the Brake Roll Adjusting screw clockwise while watching the paper as it travels over the platen. Stop adjusting the Brake Roll tension when the paper has settled snugly on the platen clearly showing the platen knife edge.

a. Set the Mark-Time switch to Time. Check the recorder timing at 25 mm/sec chart speed with a millimeter scale for accuracy. If the adjustment is correct, the timing marks should be 25 mm apart. Make fine adjustments with l/4 turns of the Brake Roll Adjusting screw. Check timing again and make fine adjustments at both 100 mm/sec and 5 mm/sec chart speeds.

b. Under certain humid conditions, with the Brake Roll adjusted too tight at the lowest chart speeds, the paper stretches as it passes between the platen and the drive roll resulting in false paper timing because the paper contracts after passing the drive roll. Check

the accuracy of the paper speed timing again with a millimeter scale.

5-27 If any of the following symptoms are evident in the recorder, it is probable that it could be cause by Brake Roll or Drive Roll malfunction:

a. Paper not tracking properly, i. e., paper moves to one side or the other. See Paragraph 5-28.

b. Paper weaving, i. e., moves side-to-side in regular pattern.See Paragraph 5-29.

c. Chattering noise, i. e., uneven tension caused by dry cork disc or bad bearing. See Paragraph 5-30.

d. Irregular paper speed, i. e., speed range drops or paper-stalls. See Paragraph 5-31.

e. Uneven paper tension over platen, i. e., paper on one end of platen is tight, loose on other end. See Paragraph 5-32.

5-28. PAPER NOT TRACKING PROPERLY. The surface of the Drive or Brake Roll becomes slick from paper residue after long usage, preventing proper traction. A worn roll can be determined by inspection and touch after it is cleaned with Chlorothene.

NOTE

New rolls have a rippled surface that disappears shortly after use. Loss of ripple does not indicate a bad roll.

Other indications theat the roll is deteriorating are minute surface cracks or inability to maintain proper speed. Correct fault by replacing defective roll.

5-29. PAPER WEAVING. If the rolls are not worn (see above paragraph), weaving is caused by dirt or other foreign matter on the rolls. Clean with Chlorothene.

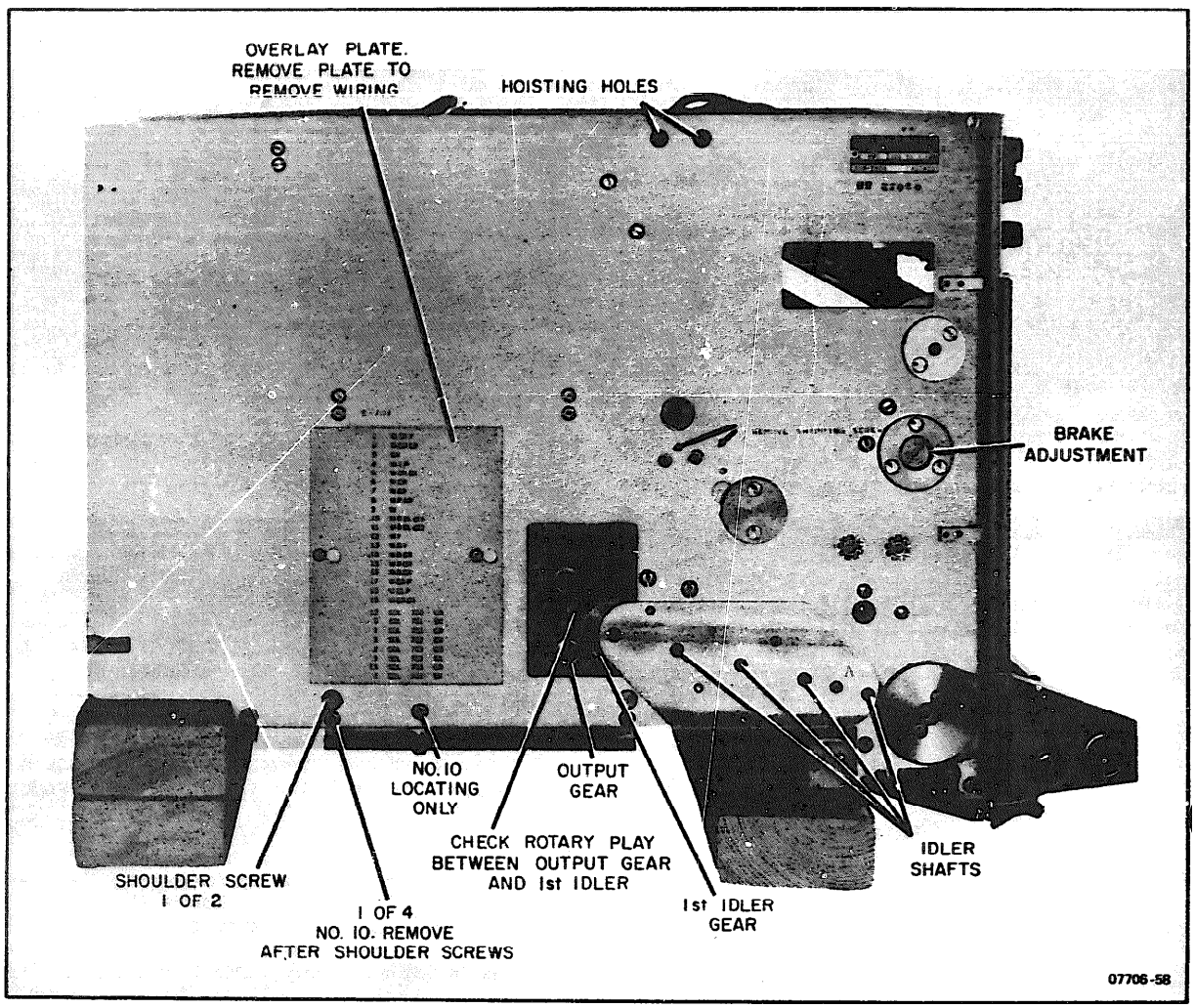


Figure 5-6. Recorder Removed from Cabinet, Prepared for Gear Box Removal

5-30. CHATTERING. This is usually caused by lack of lubrication on the brake roll cork disc, which causes positive traction instead of the slipping clutch action desired; or a defective brake roll bearing (s). Remove the right brake roll support (three #8 oval head screws) (see Figure 5-2). Clean cork disc with Chlorothene. Allow it to dry. Then lubricate with grease, HP Part No. 6040-0222.

CAUTION

DO NOT ALLOW GREASE TO CONTAMINATE RUBBER ROLLS.

Check the bearings for out-of-roundness, too tight fit of roll stud and bearing, presence of burrs or foreign matter. Brush wash with Chlorothene (do not submerge bearing in fluid); remove burrs; check for out-of -roundness. Replace if defective. Lubricate with machine oil (#IO) before replacing bearings in recorder side plates.

5-31. IRREGULAR PAPER SPEEDS. Most problem that cause irregular speeds can be attributed to drive and/or brake roll trouble: rolls need cleaning, disc needs lubricating, etc. , see preceding paragraphs.

5-32. UNEVEN PAPER TENSION. The brake roll causes this uneven pulling on the paper. When the cork disc is dry (no lubricant), there is no slipping action and the brake roll tension becomes constant at the disc end, pulling the paper taut over the platen edge. Follow brake roll removal and disc lubricating prodedures in paragraph 5-30. Incomplete adjustment of the Brake Adjusting screw can cause uneven tension; see paragraph 5-26.

5-33. Other Causes of Improper Paper Feed

5-34. Play in the paper spindle support from the left spindle support spring can cause paper weave. To increase the spring pressure, simply remove the spindle (and paper from the spindle) and gently push the spring inward from the access bole (see Figures 5-2 and 5-5) on the recorder side plate. Do not extend spring beyond spindle support inner surface. Too much spring action can cause spindle hub wear.

5-35. Uneven wear on paper guide bar (see Figure 5-5) or along the bottom radius of the table can cause improper tracking. If the guide bar is worn unevenly, it can be rotated to a new position by loosening screws at either end. If the radius of the plate is uneven, it should be replaced.

5-36. Damage to the recorder side plates and/or platen table locks can cause improper paper tracking. The recorder side plates can be damaged during shipping. If the side plates have been bent, it is sometimes possible to repair the damage. Loosen all support bar screws on' the front panel and chassis, being careful not to loosen or remove screws attaching parts to only one side plate. Relieve some weight At the recorder front end; the side plates will tend to correct themselves. Tighten all screws that were loosened and check the side plates with a straight edge for twists or bends. The straight edge should be as long as the side plates. Imperfections should be less than l/32 inch. If the bend does not straighten, the side plate should be replaced since the side plates support the paper spindle and can cause poor paper feed if the bend is severe enough.

5-37. Damaged platen table locks. The lock support shaft assembly may be damaged so that the table locks out of square. Check this with the table assembly down. Inspect the table lock flanges for enlarged slots causing uneven locking. Check the table lock support for damage and wear; the platform link for loose shoulder SC screws.

5-38. STYLUS AND GALVANOMETER ADJUSTMENTS AND REPAIRS.

5-39. Stylus Pressure.

5-40. Check stylus pressure with the calibrated pressure gage 14015A (see Figure 5-7). Lift the stylus at the center of the heating element support wire. Lift as close to 90° as possible. The stylus setting should be 2 grams. Run the recorder at 5 mm/sec speed. Lift the stylus with the gage until the stylus stops writing on the paper; the gage should read 2 grams. If the pressure is not correct, adjust the stylus pressure screw (Figure 5-8). Turn clockwise for less pressure and counterclockwise for more pressure. The adjustment should be made l/4 turn at a time. Check that the stylus remains level with the paper for correct definition.

5-41. Marker Amplitude.

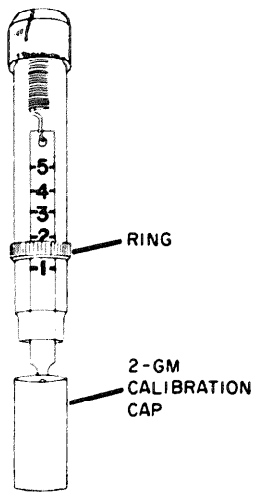
5-42. Run the recorder at high speed with the marker held for continuous operation. If the marker trace amplitude is insufficient, the amplitude can be adjusted approximately 3 mm. Use a No. 10 Allen wrench and adjust the setscrew located at the side of the marker (Figure 5-8). Adjust through the coil opening. Access is through the recorder side plates (recorder extended) for right or left marker.

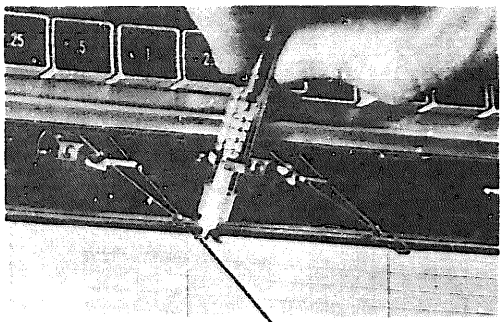
5-43. Stylus Mechanical Stop.

5-44. The mechanical stops prevent the stylus excursions from exceeding 2 mm beyond the channel edge or 1 mm toward an adjacent marker arm. Set these limits by loosening the stylus Travel Adjustment screw with a screwdriver, setting the stops and tightening the screw. Refer to Figure 5-8 for screw location.

5-45. Stylus Overhang.

5-46. The proper position for the stylus heating ribbon on the platen is shown in Figure 5-4. In the center of the channel, the ribbon overhang is approximately two-thirds of its length, which is required for a constant density trace when the stylus moves to its positive and negative maximum positions. The center





a. **Calibrate stylus pressure tester by holding vertically at eye level, with 2-gm calibration cap on hook, slide knurled ring to read 2 gms.**

b. **Measure stylus pressure by hooking tester under writing arm side rod above the stylus (gage perpendicular to writing arm). Read gage just as stylus loses contact with paper.**

c. **Adjust stylus pressure to 2-3/4 gms with stylus pressure screw.**

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Figure 5-7. Calibrating and Measuring Stylus Writing Pressure

one-third of the ribbon provides the most even heat gradient. Improper stylus overhang can be suspected when the trace density is uneven and the stylus appears otherwise in good condition, i. e., the ribbon is not bent or twisted, etc. To adjust for overhang error, refer to Figure 5-8. The callouts refer to Channel 1 adjustments, which are typical for all channels.

a. Loosen all stylus lift guard screws.

b. Loosen the galvanometer adjust plate screws in front and rear of the galvanometer magnet.

C. Loosen the locking nut on the adjusting plate.

d. The adjusting setscrew will move the magnet to the rear of the recorder when turned clockwise. Loosen setscrew and push the magnet to slide assembly forward. All adjustments are not complete until the galvanometer adjusting plate screws are tightened. Tightening these screws tends to upset the adjustment, therefore, the adjustments may have to be repeated until the stylus overhang is accurately two-thirds of the ribbon length.

e. Check all screws and nuts for tightness before completing operation.

5-47. Galvanometer Sensitivity.

5-48. The galvanometer sensitivity is governed by the gauss strength of the magnet, which is adjustable by the magnet shunt attached to the left side of the magnet pole pieces (Figure 5-9). The shunt is adjusted by a hex-head at the front of the shunt. Lower the paper tracking table to gain access to the adjustment.

a. Turn hex nut clockwise for less sensitivity or counterclockwise to increase sensitivity. Sensitivity is 160 mA for 10 divisions (see Figure 5-22).

b. Check the adjustment by running the recorder and letting the paper track properly before making another Sensitivity check. Repeat-the above if necessary, making small changes each time until the proper setting is reached.

NOTE

The maximum adjustment of the shunt cannot exceed 5/8" beyond the shunt housing. If this does not correct the linearity problem, the magnet strength must be restored.

5-49. Stylus Mechanical Center (Zero).

5-50. The Permapaper must be feeding through the recorder correctly with no weaving or sliding to one side.

a. Unplug the galvanometer cable.

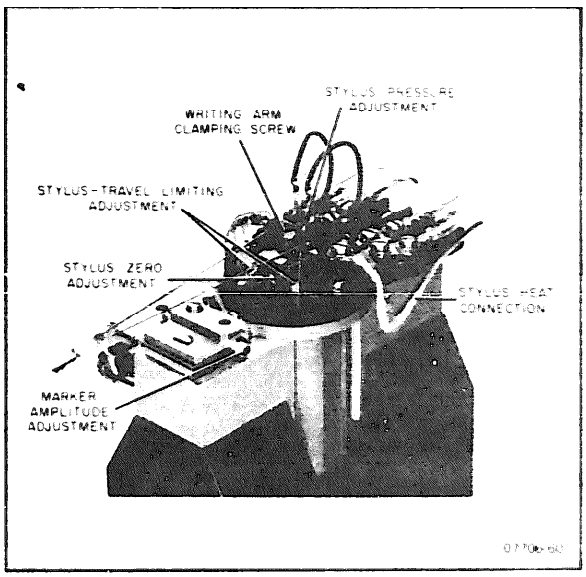


Figure 5-8. Stylus Adjustments and Limits

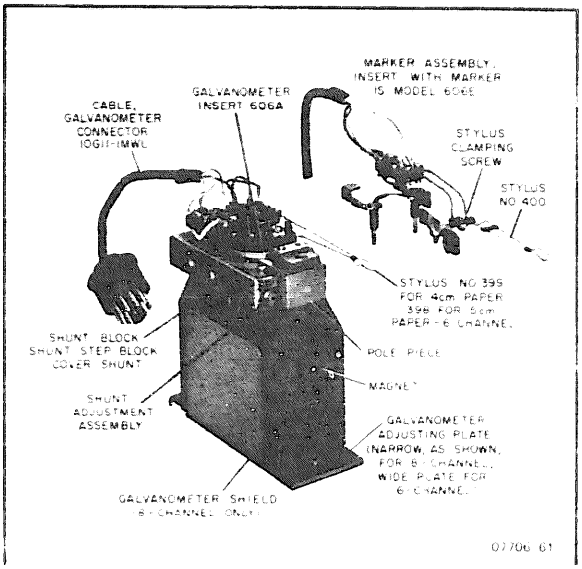


Figure 5-9. Typical Galvanometer Assembly With Marker

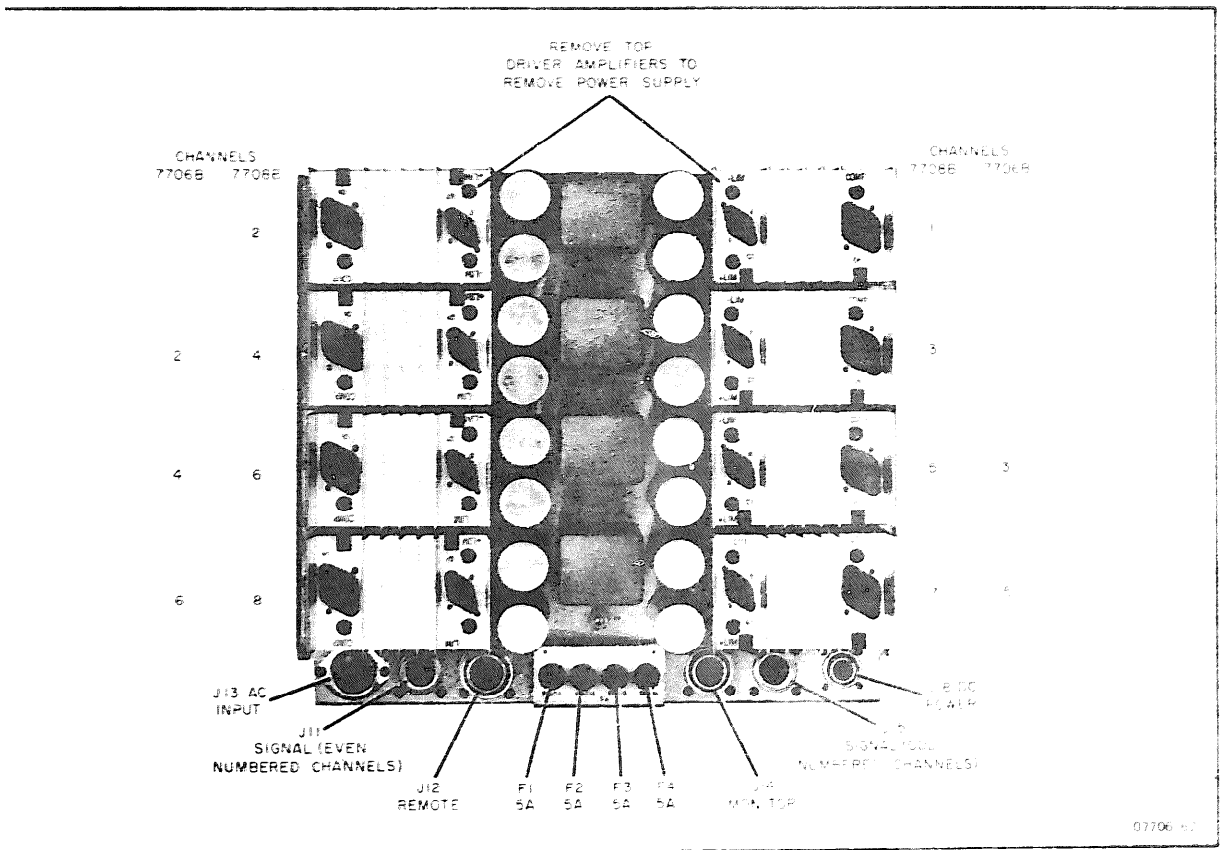


Figure 5-10. Model 358-400B Power Supply With Model 7700-02B Amplifiers

Loosen the setscrew at the bottom of the stylus adapter slightly (Figure 5-8) with the spline wrench supplied; see Accessories in Section I.

c. Mechanically swing the stylus adapter with the spline wrench to the desired position and tighten the setscrew. This adjustment may have to be done repeatedly as tightening the setscrew may move the setting. The final cheek of the stylus center position is made with the recorder running.

d. Adjust the stylus pressure as described in paragraph 5- 39. Stylus pressure must be corrected ior proper sensittviry and dampmg.

5-51. PAPER TAKE-UP ADJUST'MENTS.

5-52. The paper take-up should keep the paper snug on the take-up roll after data has been recorded. If the paper is too loose or tight, it can be adjusted by turning the knurled clutch adjustment on the left side of the paper take-up (see Figure 5-24, item 5).

5-53. Adjust the take-up when any of the following are observed: paper loose, paper tight, take-up erratic particularly at low speeds, take-up chatters.

a. Loosen the clutch lock nut (see Figure 5-24, item 6) by turning counterclockwise.

b. Run through the paper loading procedures in Section III Operation. Start recorder and run paper until it has settled evenly over platen table.

C. Install paper core on paper take-up spindle by inserting spindle with square hole mating square left support bolt.

d. Compress spring by pushing slightly on washer allowing take-up spindle end to slip into paper take-up right support slot (see Figure 5-24, item 4).

e. Lock spindle in place by sliding spindle retainer forward.

f. Check paper loading instructions for paper positioning on take-up spindle (see Section III).

5-54. Paper Take-Up Clutch.

5-55. The clutch should be adjusted when the recorder is running.

a. Run the recorder at 25 mm/sec for a preliminary check to see that the paper is snug between the drive roll and the take-up spindle.

b. Adjusting clutch screw clockwise will tighten paper tension; counterclockwise loosens paper tension.

C. Paper tension is proper when it will depress slightly with light finger pressure.

d. Run recorder at maximum speed and make minor adjustments on the clutch screw until paper tension is proper.

e. Repeat step d at the lowest speed making adjustments for proper tension as indicated.

NOTE

Paper take-up may be erratic particularly at low speeds) if the clutch screw has not been tightened. If correct performance cannot be achieved by adjustment, see paragraph 5-26 and Figure 5-24 for disassembly and repair procedures.

f. Make a final check to see that The tension proper for low, medium and high speeds, the clutch screw in place (Clockwise).

5-56. CORRECTIVE MAINTENANCE

5-57. DISASSEMBLY OF SYSTEM COMPONENTS.

NOTE

Driver Amplifiers and Driver Amplifiers Power Supply are removed from the rear of the Cabinet.

5-58 Driver Amplifier Removal.

Driver amplifiers are held in place with two screws, one on each side (see Figure 5-10). Loosen screws and pull Driver straight out. Mark each Driver removed so that it will be returned to the same location. This will avoid re-adjustment for frequency response.

5-60. Driver Amplifier Power Supply Removal.

5-61. The Driver Amplifier Power Supply can be handled by one man even with the Drivers installed as it weighs about 27 pounds.

a. Remove all connecting cables along the lower edge of the power supply chassis and remove the top two Drivers to get at the mounting screws for the power supply.

b. Remove the upper screws and lift the power supply to release from the retaining studs. Swing the upper edge of the unit outward. This will be supported at the bottom corners.

C. Reach down-into the inside of the power supply and remove the three cables attaching the supply to the recorder.

d. Hold the top and bottom of the supply and lift free of lower supports. Turn the supply slightly to clear the cabinet door and remove from system.

5-62. Recorder Removal and Repair.

5-63. Remove the recorder only when the repair, overhaul, or modification cannot be performed in cabinet.

WARNING

THE RECORDER WEIGHS APPROXIMATELY 200 POUNDS, MANUAL REMOVAL OF THE RECORDER IS POSSIBLE WITH TWO OR MORE MEN BUT DUE TO THE WEIGHT AND SIZE, A HOIST IS RECOMMENDED. THE HOIST SHOULD BE CAPABLE OF LIFTING THE UNIT FROM THE CABINET AND MOVING IT TO A WORK BENCH. HOLES ARE PROVIDED AT THE UPPER EDGES OF BOTH SIDE PLATES FOR ATTACHING A LIFT BAR.

a. Remove all connecting cables from the rear of the recorder.

b. Release locks and pull the recorder out so that it is extended from the cabinet as far as the slides will allow.

C. Remove the two hex-head screws from each side of the recorder which hold the recorder to the latch slides (see Figure 5-2).

d. See WARNING above and remove the recorder.

Support the recorder on the work bench with pieces of lumber approximately 2 inches (50 mm) x 4 inches (100 mm) x 2 feet (. 6 meter). Place one 2 x 4 flat at the front of the recorder directly behind the latch locks. Do not rest the recorder on these locks. Place the other 2 x 4 on edge at the rear of the recorder at the point where the side plates are cut out (see Figure 5-6).

5-64. Gear Box Removal.

5-65. Prior to removing the Gear Box, remove all wiring behind the overlay plate at the left side of the recorder. Carefully note each wire location, as indicated on overlay plate. This is particularly important if the recorder has both mm/sec and mm/min speeds. Remove the Gear Box as follows:

a. Remove the four mounting screws (2 sems, 2 shoulder locating) at each side of the Gear Box (see Figure 5-6). With these screws removed, the gear box is held in place by the two sems screws located between the removed screws. When these two screws have been removed, the gear box will drop free from the recorder as indicated in Figure 5-11 and the unit can then be removed by sliding out from the rear. To do this, the rear 2 x 4 is placed so that it supports one side of the recorder. After removal, place 2 x 4 support under both side plates.

b. Set the gear box on the work bench and remove the Chain Drive Cover (not shown) by removing the four screws.

C. Remove the four screws at the bottom face of the base plate to remove the gear box from the assembly. Tip the gear box in towards the chain and sprocket assembly to disengage the chain from the yoke sprocket as indicated in Figure 5-12.

5-66. Gear Box Overhaul.

5-67. Lift the gear box from the motor assembly and place on the bench. Remove the four No. 10 sems screws from each solenoid plate (see Figure 5-12) and the cable clamp from the solenoid wires. Remove the solenoid plates (see Figure 5-13). since solenoids 1 and 4 fit snug over the shaft 9, ease the plate off slowly to prevent damaging the solenoid stop hinges. Remove the four shoulder locating screws holding front gear box side plate. (Figure 5-13) Remove the front gear box plate slowly. Jiggle slightly if it dues not clear from the gear box easily.

NOTE

Care should be taken not to upset the gear train shaft locations. Position the gear box on the bench as indicated in Figure 5-14 for further breakdown.

a. A tray to hold gear and shaft assemblies can be made out of a piece of plywood and the separators out of 1/2" (12 mm pieces of pine. This tray not only keeps the gear and shaft assemblies in their correct order for re-assembly, but also keeps these assemblies from being damaged. As indicated in Figure 5-14, the top two mini-clutch and shaft assemblics are removed and placed in the top compartments of the tray in the same order they were removed from the gear box. The next row of shafts (#1 and #2) are removed and placed in the tray in the same manner as the first rows. The next four clutch and shaft assemblies (#4, #3, #8 and #7) are removed together since the gears interlock. Slowly pull shafts from gear box keeping all assemblies intact. As each shaft assembly is removed from its place in the tray, note the compartment and shaft position so there wi11 be no trouble in re-assembly.

b. When all the shafts are placed in the tray in their proper sequence, inspect all bearings (Figure 5-14) for excessive wear. Wash, do not submerge, side plate and bearings in Chlorothene. If the plate and bearings are submerged, the oilite bearings will dry out and wear badly. When the assembly is completely washed, dry with cloth or compressed air. Repeat with other side plate. Oil all gears and both side plate bearings so that the bearings will become saturated while working on rest of gear box. Oil bearings in two steps:

(1) Oil with a penetrating oil such as Marvel Mystery oil.

(2) Before re-assembly of gear shafts to side plates, oil heavily with #10 machine oil.

C. As indicated in Figure 5-15, the mini-clutch shaft assembly is disassembled and ready for inspection of the roller bearings and springs. These mini-

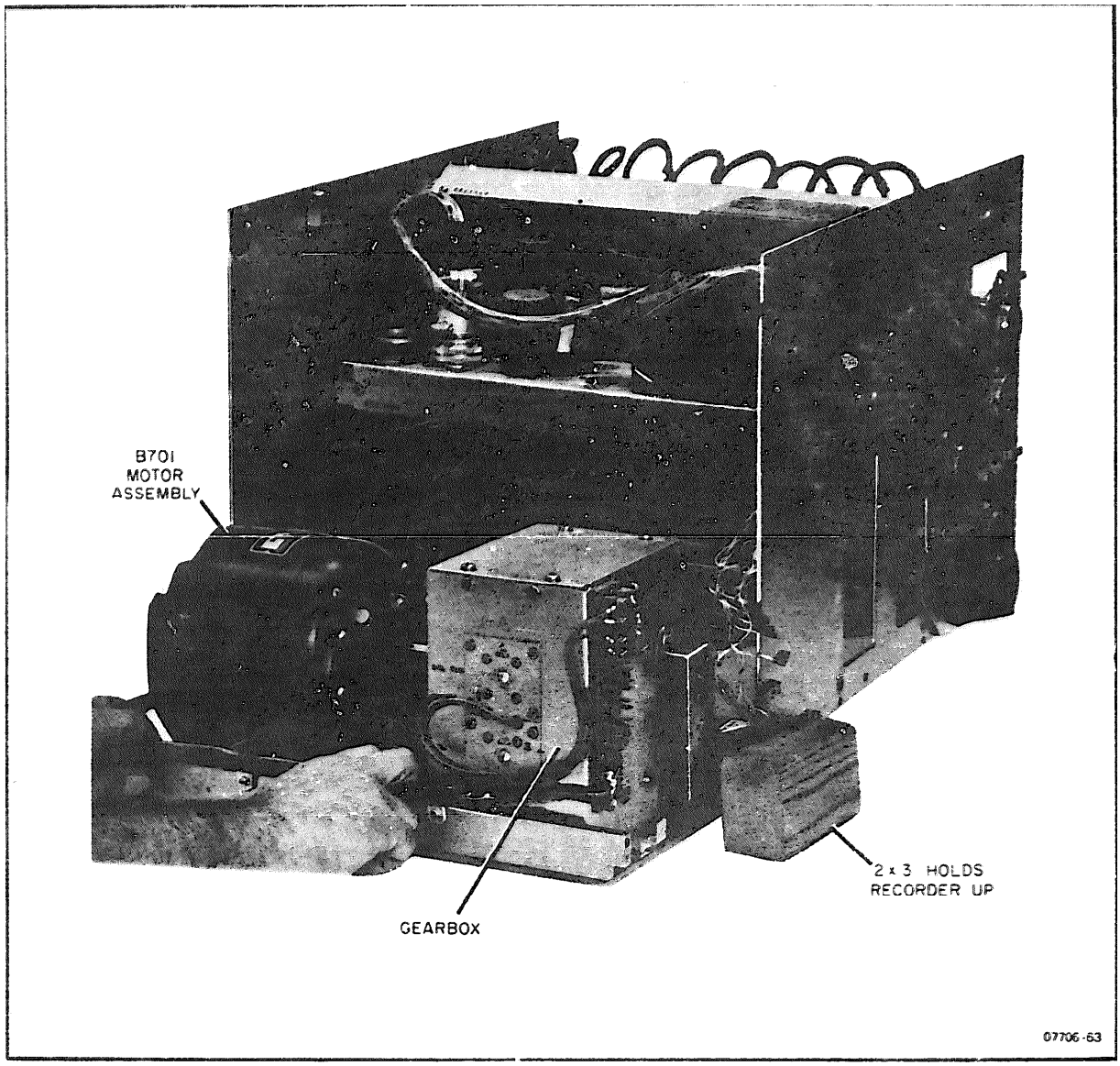


Figure 5-11. Removing Gear Box and Motor From Recorder

clutches normally cause no trouble if they are cleaned properly and all the springs are in place. Do not re-assemble if any of the springs are missing. Check the inner surface of the gear hub for excessive wear (beyond a bright polish). If the inner surface of the gear hub has been scored, it must be replaced.

d. Check the following.areas of the clutch assembly, referred to in Figure 5-15:

When all of these parts are inspected, clean the whole shaft assembly with Chlorothene.

(1) Excessive shaft wear (replace shaft if worn down)

(2) Make sure the two setscrews on the mini-clutch are tight.

(3) See that the rollers are in working condition when spring loaded.

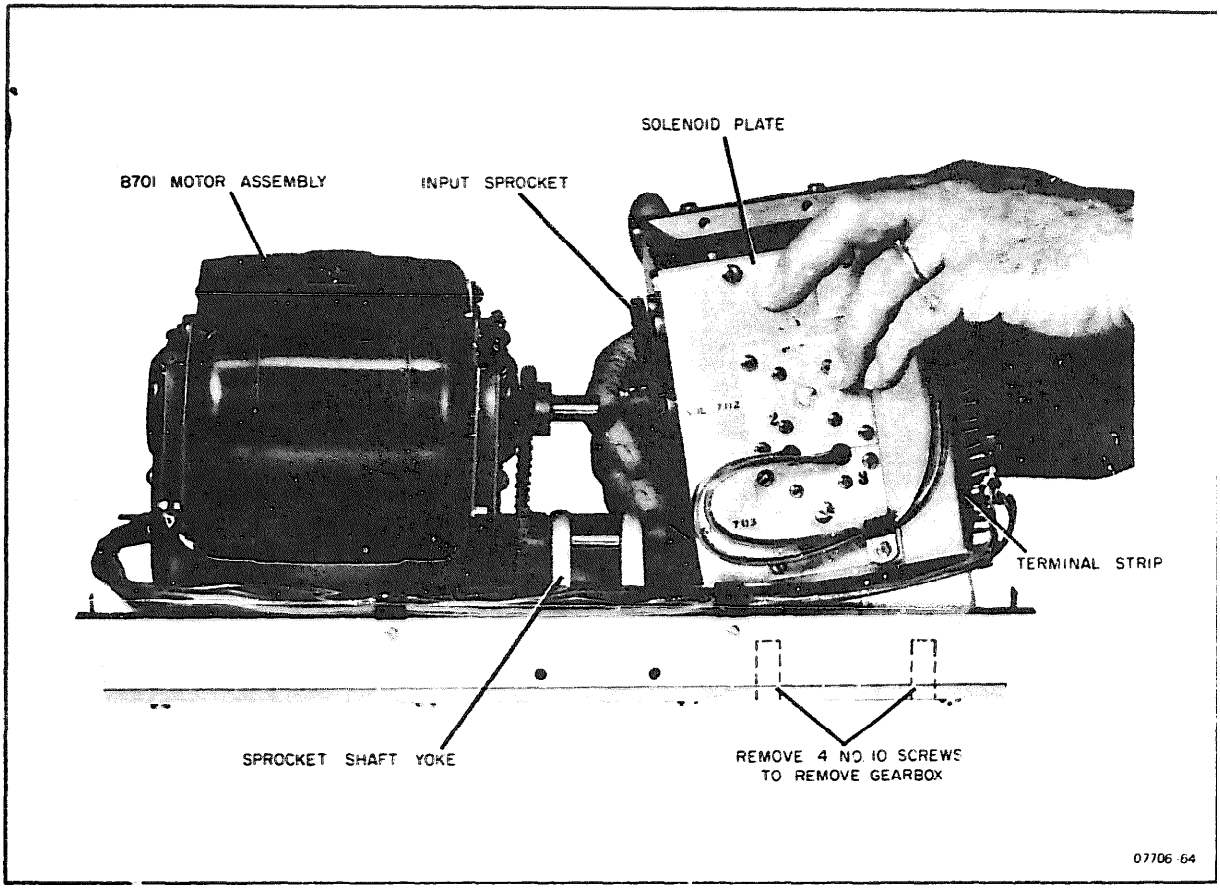


Figure 5-12. Removing Gear Box From Base Plate

5-68. Spring C Butch Assembly.

5-69. Note the position of the shaft before removing from the tray. Disassemble shaft (see Figure 5-16) as shown, and wash each part thoroughly with Chlorothene. Inspect clutch hubs as well as shaft ends for excessive wear (beyond polish). Inspect clutch spring inner surface for wear. Also check gear teeth. Any part worn beyond a polish should be replaced.

a. If a rust color residue was evident before washing clutch with Chlorothene, the clutch probably ran dry of lubricant or the wrong type of lubricant was used in its packing. The only grease to be used in this gear box is HP Part No. 6040-0222. If any nylon gear in the box is stripped, make sure no shavings from the stripped gear are imbedded in any other gear of the box. Nylon shavings are bard to locate, so it is necessary to wash out *all gears with* a stiff bristle brush. Clean and re-assemble these gear shafts. When installing the mini-clutch gear, be sure that the springs do not fly out when depressing the rollers.

NOTE

Do not grease any gears. It is more convenient after the gear box is assembled.

b. Figure 5-17 illustrates excessive wear of the clutch and hub assemblies. These parts will wear when the gear box has been run for long periods of time without a maintenance check, wrong methods of packing the clutches, or if the wrong grease is used. Trouble will also be evident if the recording paper is allowed to double around the drive roll of the recorder and jam the drive roll and gear box to a sudden stop. If paper jamming is corrected but the gear box tends to run roughly or chatters, turn the power off and locate the damaged part immediately. Damaged clutch sleeves result when there is not enough clearance between the clutch sleeve and the solenoid stop (see Figure 5-18). Clearance procedures are given in paragraph 5 - 85.

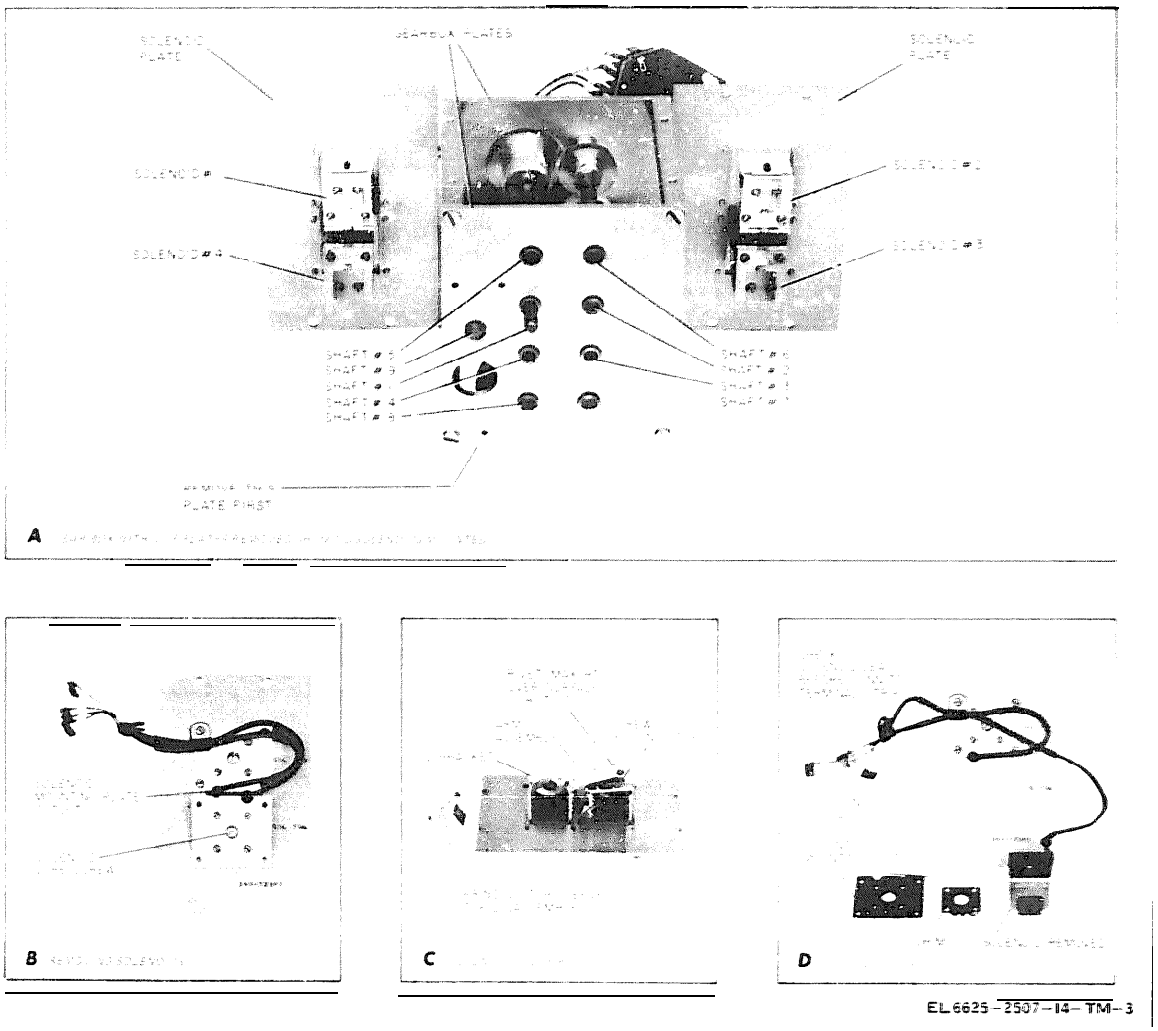


Figure 5-13. Solenoid gear box plates.

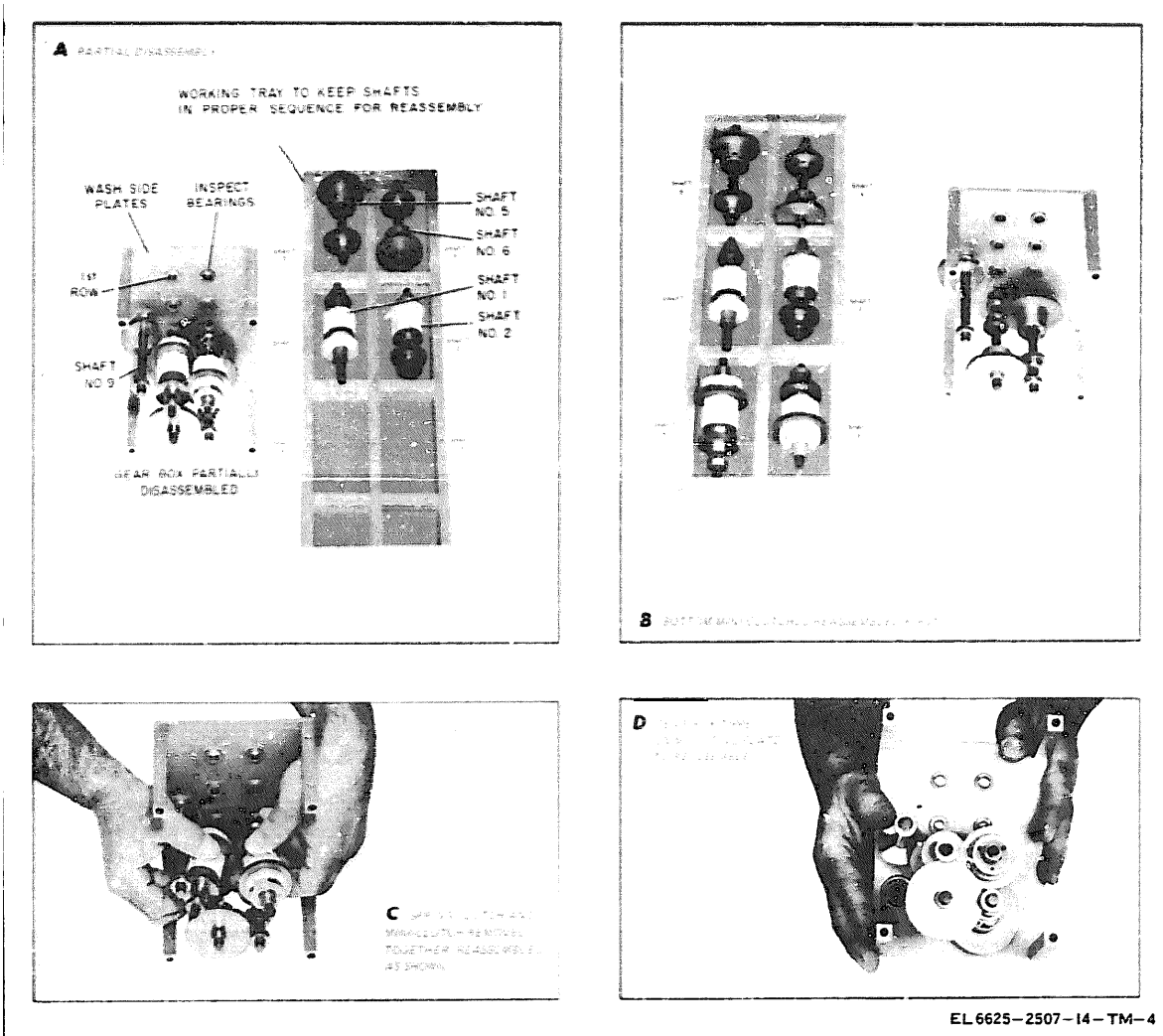


Figure 5-14. Gear box, disassembly and reassembly.

5-70. Gear Box Lubrication

5-71. When the whole gear box is clean and all defective parts replaced, the gear box is ready to be lubricated (see Figure 5-19).

a. Grease the shaft adapter working surface liberally with grease, HP Part No. 6040-0222, as shown in Figure 5-19 (a).

b. Liberally coat the inner surface of the chutch spring with Figure 5-19 (b), and install it with a twist with the key stud facing the shaft adapter.

c. When the clutch spring is seated properly on the shaft adapter, Figure 5-19 (c) completely fill the remaining cavity so that there is no air pocket. Coat the outer surface of the clutch spring with grease. Coat the inner working surface of the clutch sleeve, Figure 5-19 (d) with a heavy surface grease and install over clutch spring, which is already on the shaft adapter.

CAUTION

SPRING KEY STUD AND NOTCH ON SLEEVE MUST MATE FOR SHAFT TO FIT PROPERLY. CHECK THAT THESE TWO PARTS ARE PROPERLY ENGAGED.

Fill any air pockets with grease after the clutch sleeve is installed. Coat the working surface of the clutch hub and gear assembly as indicated in Figure 5-19(e), and install on shaft only up to its clutch.

d. At the shaft adapter there is a hole that must be plugged before the assembly is forced together. Do not force the clutch hub and gear together until the hole is plugged to prevent the grease from escaping (Figure 5-19 (I)).

NOTE

If the adapters do not have this hole, they are usable since this was added as a modification.

As the clutch hub and gear is forced into the clutch spring in a twisting manner, note the darkening of the clutch sleeve indicating that the grease forced into the spring cavity earlier is now being forced throughout the clutch assembly leaving no air pocket.

NOTE

This lubrication procedure must be followed for proper endurance of the gear box.

Check that the clutch hub and gear hits bottom on the shaft adapter. This check is to be made with hole open. There must be a bottoming effect in this assembly. Lubricate the four spring clutches in this manner, but: Do not grease the four mini-clutches. Oil mini-clutches liberally through oil hole. Rotate the mini-clutch gear to ensure complete spreading of oil on working surfaces.

5-72. Shaft and Clutch Re-Assembly.

5-73. Since the lower four shaft assemblies of the gear box are interlocked, they must be installed using the following procedure:

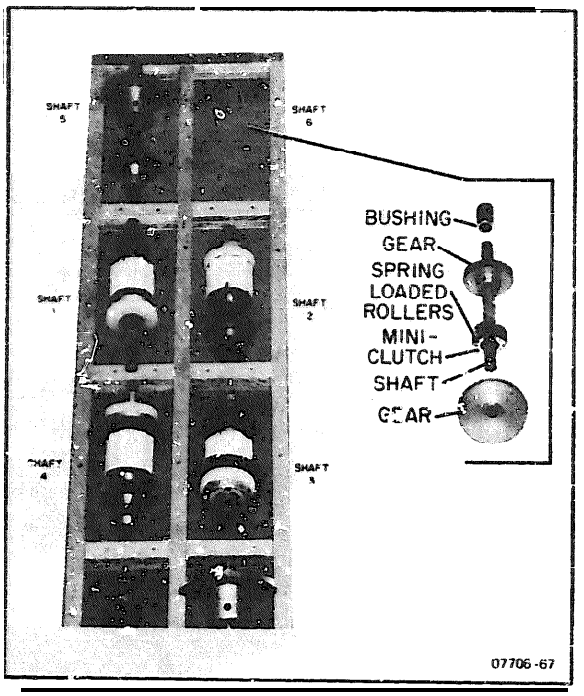


Figure 5-15. Mini-Clutch Assembly, Components

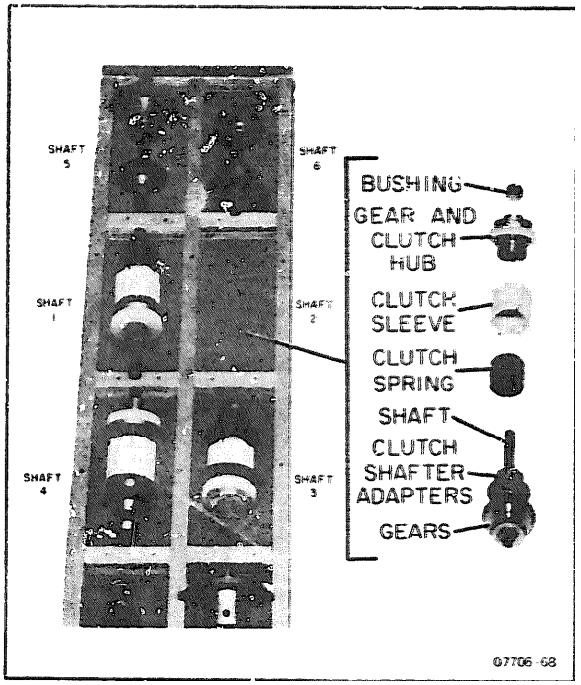


Figure 5-16. Spring Clutch Assembly, Components

a. Install the mini-clutches as indicated in Figure 5-14 (b), with the shaft end just inside the bearing enough to hold the assemblies in place. Keep these two shafts out of the side plate bearings as much as possible until the next two shafts are installed. Slip the next row of clutch shafts into the bearings as indicated in Figure 5-14 (c) just enough to mesh all mating gears. Tip the gear box side plate on its back slowly: see Figure 5-14 (d). If the shaft assemblies are in their proper places, they will fall into the side plate bearings under their own weight with a little juggling of the assembly. If the gears do not mesh properly, DO NOT force them; this can result in gear damage. In proper sequence, install the shaft assemblies that remain. Install the top row mini-clutches last, see Figure 5-14 (a). The upper four shafts can be installed in pairs without jamming as in the lower four shafts.

b. Install the front bearing plate on the shafts to complete the gear box assembly. Then to ensure that the shafts are positioned correctly, rest the gear box on a flat surface before tightening the four shoulder screws. Rotate the upper mini-clutch gears manually. Tightness or difficulty in rotating gears indicates a lack of end play of one or more shaft assemblies. End play should be at least 0.004 inch. Recheck cleaning, lubricating procedures and inspect bearing and shaft for out-of roundness. If the gears rotate freely except for one or two positions in a full turn, check the gear teeth.

CAUTION

IF A NYLON GEAR IS STRIPPED, CHECK SURROUNDING CLUTCH MECHANISMS WITH MAGNIFYING GLASS TO SEE THAT NO STRIPPED PIECES ARE EMBEDDED IN THEM OR ASSOCIATED GEARS. NYLON FIBRES CAN DAMAGE GEAR TEETH AND CLUTCHES

c. Install the large sprocket on the input shaft and test the complete gear box by manually turning the sprocket, checking for smooth, free operation of the complete gear train from simple finger pressure.

d. Output gears on the outer side of the gear box plate should be inspected for damage (see Figure 5-18). The output gear should be replaced if worn since it drives the drive roll through five idlers. A damaged output gear can result in damaged idler gears, drive roll gear and/or the gear box itself.

5-74. Idler and Drove Roll Gears.

5-75. Remove the five idler gears held in place with retaining rings (see 5-5). Clean the gears with Chlorothene; look them over closely for flaws; grease gears and oil bearing. Replace gears.

5-76. **Testing Gear Box Components.**

5-77. The gear box should be given a running check before the solenoid plates are assembled. Install the gear box on the motor mounting plate using the four No. 10 screws (see Figure 5-12) and the procedures in Paragraph 5-86. Apply 115 Vac to the motor leads at the terminal strip. If the input sprocket is properly aligned and planes parallel, the gear box should run smoothly. If it chatters or runs irregularly, it usually is caused by misalignment of the yoke and sprockets.

5-78. Greasing the Gears.

5-79. When the gear box runs smoothly, store the motor and brush grease HP Part No. 6040-0222 on all gear teeth, using liberal amounts. Rotate sprocket by hand to make sure all gears are fully greased. Run motor to run off any excess grease.

WARNING

DO NOT ATTEMPT TO CLEAN EXCESS GREASE FROM GEAR BOX WHILE: MOTOR IS RUNNING. STOP MOTOR AND TURN INPUT SPROCKET BY HAND WHILE CLEANING GREASE FROM GEAR I. WHEN GEAR BOX HAS BEEN CLEANED RUN MOTOR FOR l/2 HOUR BREAK-IN PERIOD.

5-80. Checking Solenoid Operation.

5-81. The solenoids mounted on the side plates (Figure 5-13) must be checked for proper operation. The solenoid is mounted in a steel U-bracket, Figure 5-13 (c). The arm assembly is also steel. When the solenoid is actuated, and the brass rivet heads are peened flush with the surface of the arm; through usage, the arm becomes magnetized to the H-bracket when the solenoid is energized. This prevents proper selection of paper speeds.

5-82. REPLACING RIVET. The rivets should be replaced if the rivet head is flush with surface of the arm. Remove the two screws holding the solenoid stop to the arm. The arm will spring back revealing the brass rivets. Remove the old rivets with a sharp edged tool. Push the rivet shank out with a drift punch. Insert new rivet (Part No. 0361-0363) and flange the hollow rivet shank with center punch. Usually the flanging will flatten the rivet head a little but the 0.008 to 0.010 inch maximum extension of the rivet over the arm assembly plate, see Figure 5-13 (c), will require slight tapping with a light hammer. The rivet head provides the air gap necessary to keep the arm assembly from being magnetized.

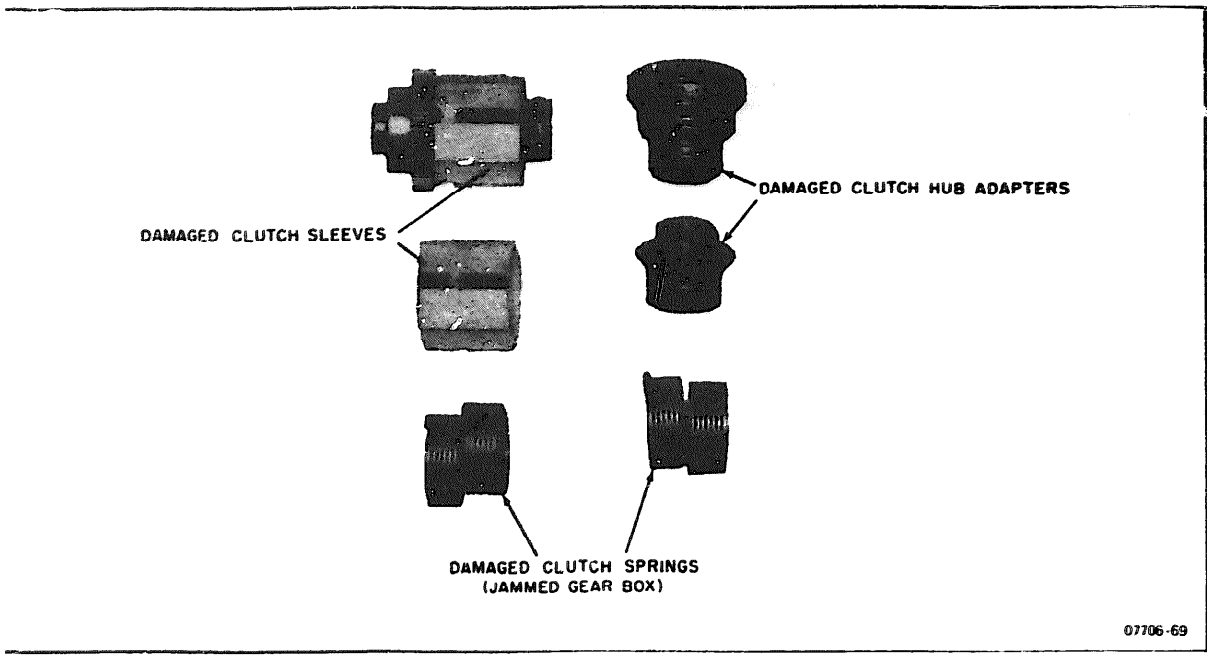


Figure 5-17. Excessive Wear on Clutch and Hub Assembly

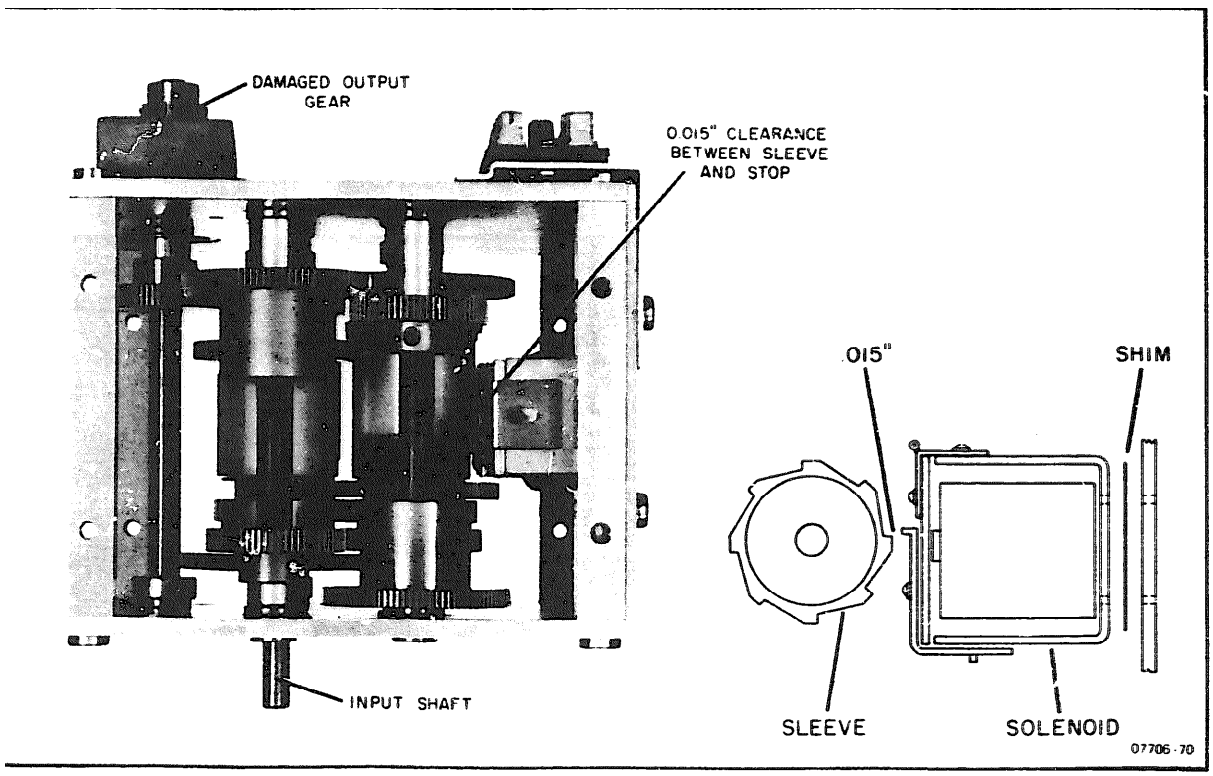


Figure 5-18. Gear Box Assembled, Clearance Between Solenoid And Clutch Sleeve Indicated

5-83. After installing the rivet, assemble the spring clutch sleeve stop and check the solenoid operation by connecting a 24-volt battery and switch in series with the solenoid winding; green (+), black (-). If the solenoid does not release the arm when the switch is opened, the rivet is not providing a proper air gap and should be replaced. Normal care in this operation should bring desired results. Check each of the solenoids for proper operation and air gap.

5-84. ASSEMBLING SOLENOID PLATES TO GEAR BOX. Remove the gear box using procedures described in paragraph 5-64. Install one solenoid plate to gear box first by attaching plate with four No. 10 sems screws. Attach leads to 24-volt source and check for 0.015 in. clearance between solenoid stop and clutch sleeve crease (see Figure 5-18). If the clearance is insufficient, shims are available on order in three sizes (0.003, 0.005 and 0.010 in.) to correctly adjust the stop distance to the sleeve, see Figure 5-13(d). Both solenoids must be checked. Use the same procedure to install and check the other solenoid plate and solenoids.

NOTE

Each solenoid must be located in its proper place for correct recorder paper speeds. It is possible to erroneously locate solenoid lead wires through the wrong cutout in mounting plates and result in wrong terminal connections, see Figure 5-13 (b). Each solenoid side plate must be mounted to proper side of gear box or recorder will run at improper speeds.

5-85. Reassemble the gear box to the mounting plate with the four No. 10 screws (see Figure 5-12). Plug-in motor to drive the gear box. Energize each solenoid to test the clearance between stop and spring clutch sleeve by pushing on solenoid core screw, see Figure 5-13(b). Average finger pressure will change the clearance between stop and sleeve and indicate whether clearance is sufficient.

5-86. Gear Box Installation.

5-87. Install the gear box on the mounting plate as indicated in Figure 5-12. Place chain on input sprocket and tip. the bottom of the gear box away from the motor so that the sprocket chain can be looped under the sprocket on the yoke. When the chain is in, the proper position, fasten gear box to the mounting plate.

a. Check for proper alignment of the input sprocket with its mating sprocket on the yoke with a straight edge, as indicated in Figure 5-20. When properly aligned, the chains and sprocket will not chatter or cause a heavy chain noise. If adjustment is needed, adjust the sprocket on the gear box, not the yoke sprocket.

b. To adjust the proper tension in the chains, the yoke must be moved on the gear box baseplate. The motor is moved to adjust the chain from motor sprocket to yoke. Check the proper alignment between motor sprocket and yoke sprocket as the other two sprockets were checked with a straight edge. The proper tension of the chains is about 3/ 16" depression of the chain between the sprockets the chain is mounted on. When all chain adjustments are made, the chains must be lubricated with chain grease HP Part No. 6040-0223. Check for loose screws or set screws. Run the motor with the clip leads and actuate one solenoid at a time to check the proper clearance of the solenoid stop to the clutch sleeve. As the gear box is running, press solenoid mounting screw when the solenoid is actuated. This check ensures the proper clearance of solenoid stop, if when pressing on this screw, there is no ticking of the stop to clutch sleeve. If there is a ticking, depending on how hard, remove the proper shim from the solenoid mounting plate. When this last check is made, the gear box cover and chain cover are installed, the solenoid leads are installed on the terminal strip and the motor oiled.

C. The gear box and motor assembly is now installed in the recorder by reversing the disassembly procedures. Check the play between the small output stud gear and its meshing idler gear (see Figure 5-6). If there is no play after all mounting screws are tight, loosen the eight screws fastening the motor and gear box mounting plate to the two support bars of the mounting plate. The eight screws on the bottom surface of the mounting plate allow the gear box stud gear to move away from the first idler gear allowing slight play between these two gears.

d. Check this play again after the eight screws have been tightened. With all proper alignments and adjustments made and the gear box terminal strip wired up, taking care for proper placement of wires, apply power for a complete check of the gear box and paper speeds before installing recorder back in the cabinet. Temporarily reconnect driver amplifier power supply to rear of recorder and connect ac line cord to power source. Check recorder speeds as outlined in paragraph 5-25. If speeds do not correspond with speed selected, check solenoid leads for improper terminal connections.

5-88. Galvanometer Disassembly

5-89. The individual galvanometers for all channels are alike except for the marker channel, usually channel 8 (see Figure 5-21). These conventional D'Arsonval moving coil galvanometers have the coil snugly housed in the air gap between the poles of the large U-shaped Alnico 5 magnets.

5-90. The platen table locking mechanism and galvanometer bank are linked together so the writing styli move up, out of the way of the table. This helps prevent styli damage during paper loading. However, a large paper loop over the platen will damage the styli if the styli are dropped heavily on the paper.

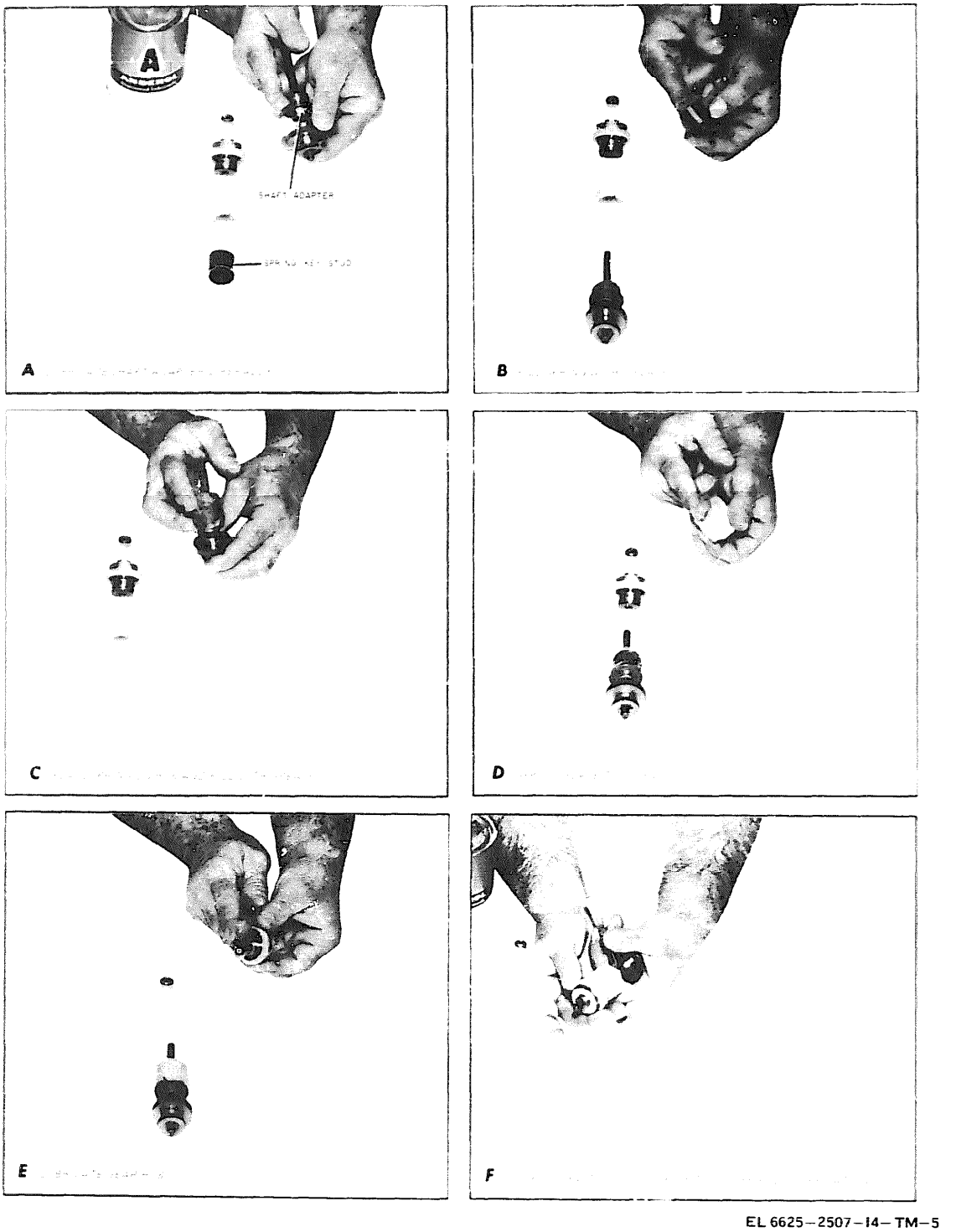


Figure 5-19. Lubrication procedures for gear box clutch assemblies

5-91 The galvanometer inserts can be removed and repaired or overhauled without removing the magnet from the bank. However, if the magnet becomes badly damaged or loses its magnetic strength (rated at 8000 gauss) it can be easily replaced by removing the top styli guard and the screws holding the magnet plate (see Figure 5-3

5-92. REMOVING COIL ASSEMBLY. The coil is rigidly suspended on torsion wires inside a coil housing which is mounted in the air gap of the magnet. Both torsion wires are rigidly clamped to hold the coil so that the stylus will maintain a zero-signal position at the center of the recording chart. The torsion wires thus function not only to suspend the coil, but also, like the spring in a meter movement, to provide restoring torque to return the stylus to zero when no signal information current passes through the coil, and to determine the position of the stylus when signal currents pass through the coil.

5-93 Each galvanometer has an adjustable magnet shunt permanently mounted to the side at the pole pieces. The magnet shunt has two functions, (1) to adjust sensitivity of the galvanometer, and (2) when fully pulled in, to maintain the magnet gauss at full strength so that the galvanometer can be removed from the magnet. When the shunt is fully pulled in, it can be seen in the hole of the shunt housing (see Figure 5-9)

CAUTION

ONLY WHEN THE SHUNT IS VISIBLE IS IT SAFE TO REMOVE THE COIL FROM THE MAGNET WITHOUT LOSING THE MAGNET STRENGTH.

5-94 Disassemble the galvanometer as follows:

a. Remove the stylus from the galvanometer by loosening the clamping screw (see Figure 5-8)

b. Remove the screws attaching galvanometer insert to the block (see Figure 5-23

c. Unplug the galvanometer cable, remove the cabling from the galvanometer cap and gently pull the galvanometer insert from the magnet (see Figure 5-23

d. Use masking tape to remove all foreign matter from the magnet gap. The magnet must be clean of filings or chips.

e. Gently lower the new coil into the magnet and attach the mounting screws. Firmly push the galvanometer coil to the front of the magnet and tighten the mounting screws. If there is no mechanical rubbing when the stylus holder is moved from side to side, the galvanometer is mounted correctly. If the galvanometer does touch the sides, the mounting screws

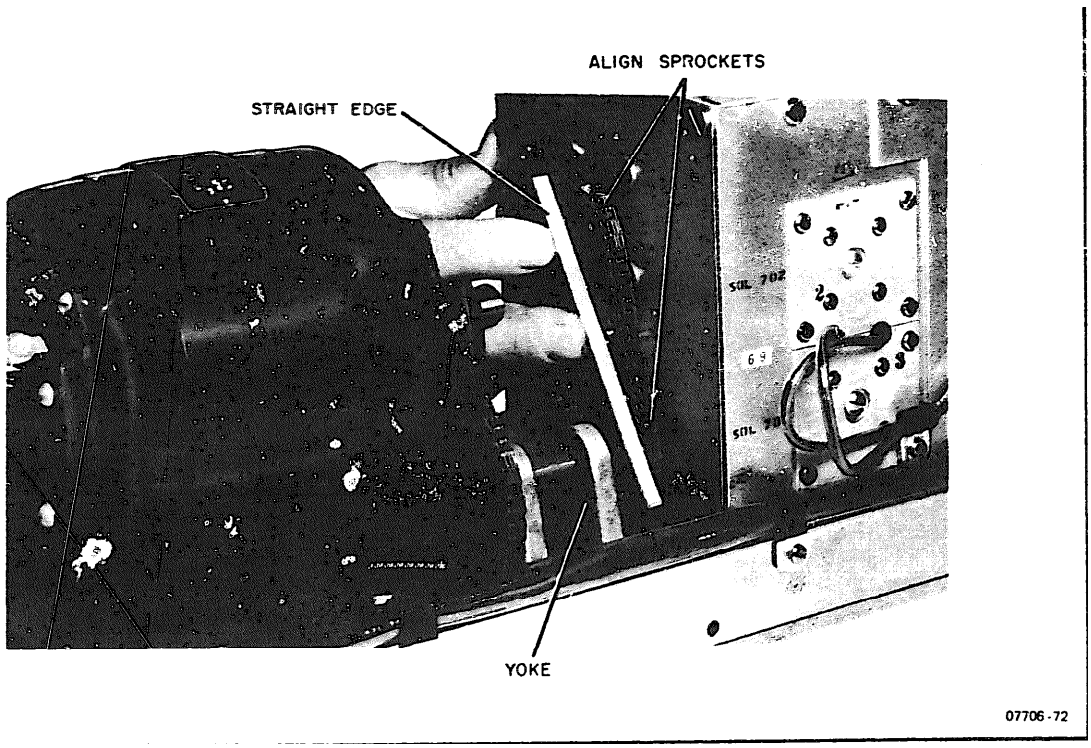


Figure 5-20. Alignment Sprockets

must be loosened and the galvanometer recentered in the magnet gap. The galvanometer must be properly set for correct performance.

f. Connect all wiring removed from the defective coil to the new coil.

g. Turn the shunt adjusting nut counterclockwise until the shunt is flush with the rear of the shunt housing.

h. Check the galvanometer coil with the circuit in the following figure (Figure 5-22

i. Make final adjustments of the shunt (either clockwise or counterclockwise) until the 10 divisions deflection for 160 mA current is correct.

j. All newly installed galvanometers must have the stylus mechanically centered and the stylus stops adjusted (see paragraph 5-43

5-95. Paper Take-Up Disassembly.

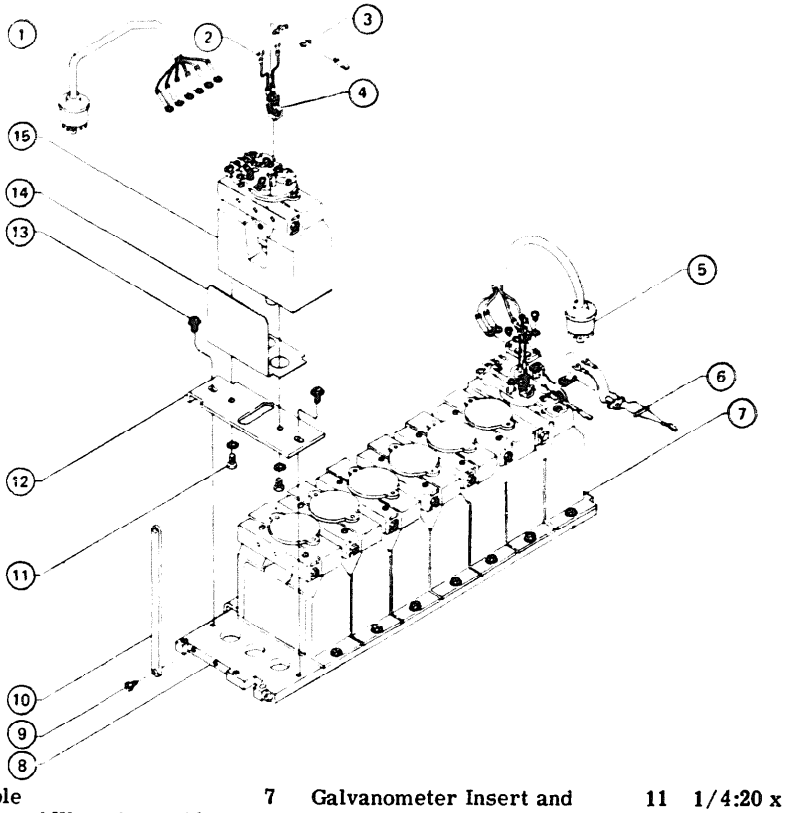
5-96 The paper take-up is driven by a rayon belt from the drive roll (see Figure 5-24). The pulley, cord and pressure discs assembly acts as a slip clutch keeping the tension constant across take-up spindle, when the cork discs have proper lubrication.

5-97 If the paper take-up is performing badly or an overhaul is scheduled, disassemble the take-up as follows (see Figure 5-24

a. Remove paper take-up spindle (1) by releasing spindle lock (2).

b. Remove two 6-32 x 5/8 in. sems screws (3).

c. Remove right bearing and retainer assembly (4), attached to front panel by two screws (4a).



1	Cable	7	Galvanometer Insert and Magnet Assembly	11	1/4:20 x 3/8" Long Binding Head Screw
2	Lug and Wire Assembly	8	Galvanometer Mounting Plate	12	Galvanometer Adjusting Plate
3	Stylus	9	Platform Link Pin	13	10:32 Hex Head Screw
4	Stylus Mounting Adapter Assembly	10	Platform Link	14	Galvanometer Shield
5	Cable			15	Galvanometer Insert and Magnet Assembly
6	Marker Stylus				

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Figure 5-21. Bank of Galvanometers for 8-Channel Recorder

d. Remove paper take-up adjust (5) and lock (6) holding the square end of paper take-up shaft (7).

e. Slip the pulley belt (8) from pulley (9).

f. Remove carefully the pulley and friction clutch assembly (7) (8) (9) (11) (12) (13) (14) (15) from the bearing and retainer assembly (10).

5-98. CLEANING AND LUBRICATING PAPER TAKE-UP Wash all take-up parts with a grease solvent such as Chlorothene. The groove in the pulley may need brush cleaning to remove all foreign matter.

5-90. When thoroughly dry, lubricate the face of the cork discs (12) (13) used on both sides of the pulley (9) with grease HP Part No. 6040-0222. Oil all oilite bearings with machine oil HP Part No. 6040-0220. Coat the end of the take-up shaft (7) with grease HP Part No. 6040-0222.

5-100 Assembly of Paper Take-up.

5-101 Reassemble the pulley and clutch assembly as shown in Figure 5-24

NOTE

The spring (15) must be oriented with the turned-in-end facing the take-up adjusting knob (5). This end of the spring mates with the slot in the pulley shaft. The spring is compressed and released by the paper take-up adjust (5) for paper tension adjustments.

a. Install pulley and clutch assembly (7) - (15) on bearing and retainer assembly (10).

b. Slip pulley take-up belt (8) on pulley (9).

c. Install paper take-up adjust (5) and lock (6) to hold pulley and clutch assembly (7) - (15) in place.

d. Slide take-up belt (8) lower loop on (16) with (19) adjusted to minimum belt tension position.

e. Install the other half of the bearing and retainer assembly (20) with the two 6/32 sems screws (3).

f. Attach the right (4) and left (10) bearing and retainer assemblies to the recorder front panel with (4a) and (10a) screws.

g. Adjust the take-up spindle adjust knob (5) for proper paper tension after loading paper in recorder (see Section III).

5-102 ADJUSTING PAPER TAKE-UP PRESSURE PULLEY The pressure pulley (16) is adjusted by the offset shaft on (19). Changing the position of the offset shaft lessens or increases the belt tension. This control should be adjusted during overhaul and when it appears that the paper is not being taken up properly on the take-up spindle (paper not taut, or unevenly taken up). The above indicates the belt has stretched but may perform properly if the slack can be taken up by the pressure pulley adjustment (19).

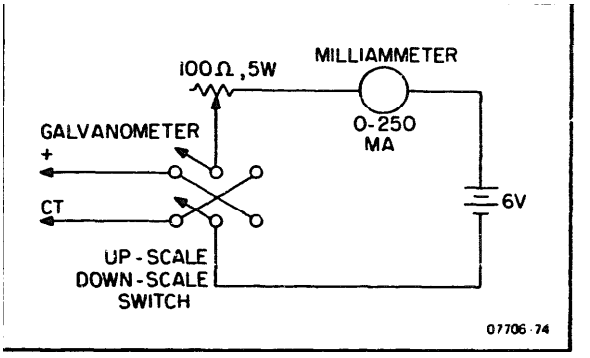


Figure 5-22. Checking Galvanometer Sensitivity

5-103 The following adjustment is made with a few turns of paper on the paper take-up spindle. Since the load increases as the roll of paper on the spindle increases, it is advisable to check paper tension with a half roll or more on the spindle also.

a. Loosen the 10/32 setscrew (21) with a 3/32 Allen wrench.

b. Turn pressure pulley (19) with 1/2" spin-tight wrench until the paper on the spindle tightens.

c. When paper is taut and evenly snug on spindle, lock the pressure pulley with setscrew (21).

d. If pressure pulley adjustment does not take up slack in pulley belt, replace belt.

5-104 MM/MIN Speed Option.

5-105 When systems are supplied with both millimeter/second and millimeter/minute speeds ("D" and "DW" models), the assembly shown in Figure 5-25 is attached to the gear box mounting plate.

5-106. DISASSEMBLING SPEED REDUCTION ASSEMBLY Refer to paragraph 5-64 for procedures to remove the gear box. After the gear box is removed, remove the chain drives from the assembly by loosening the four screws holding each sprocket gear shaft support.

5-107 Inspect the MM/MIN mechanism as follows:

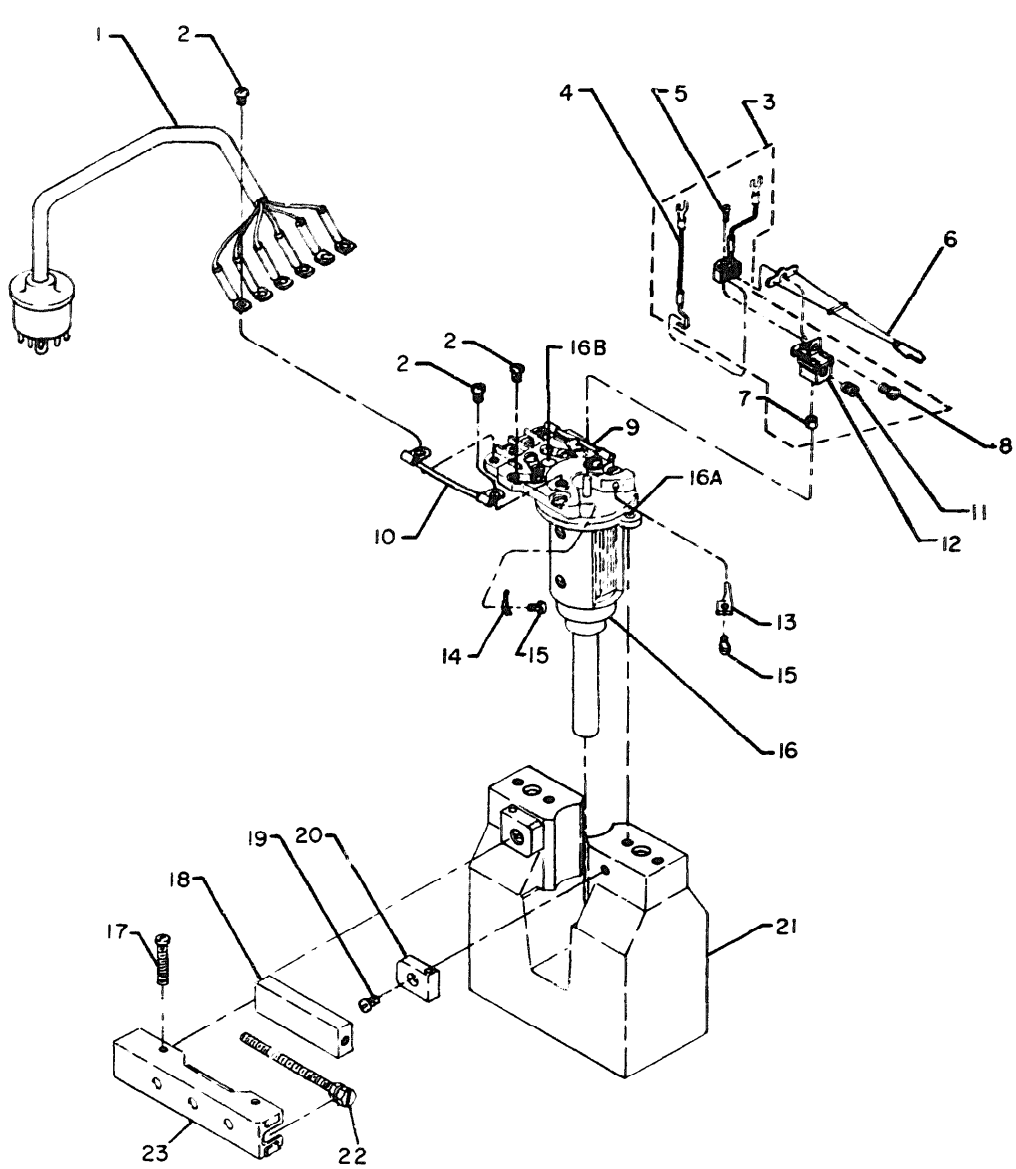
a. Loosen the setscrews on the sprockets, remove sprockets, chain drives, and mini-clutch.

b. Examine the sprocket teeth and chain drives for defects, i.e., missing teeth, damaged chain link, etc.

c. Brush clean the chains and sprockets with Chlorothene.

d. Disassemble the mini-clutch and clean with Chlorothene. Do not soak in fluid. Reassemble.

5-108. REASSEMBLING SPEED REDUCTION ASSEMBLY The gear box should be removed from the mounting plate before reassembly of the chains and sprockets.



1	Galvanometer Cable	9	Stylus Heat Jumper } older	16A	Insert Screw
2	Machine Screw	10	Stylus Heat Jumper } models only	16B	Insert Screw
3	Stylus Mtg. Adapter Assy.	11	Setscrew	17	Sems
4	Pigtail	12	Adapter Base Assembly	18	Shunt Block
5	Adj. Screw (Stylus Pressure)	13	Stylus Stop	19	Sems
6	Writing Arm	14	Stylus Stop	20	Shunt Step Block
7	Split Sleeve	15	Machine Screw	21	Magnet
8	Screw (Stylus Holdown)	16	Galvanometer Insert Assembly	22	Shunt Adjustment Assy.
				23	Shunt Cover

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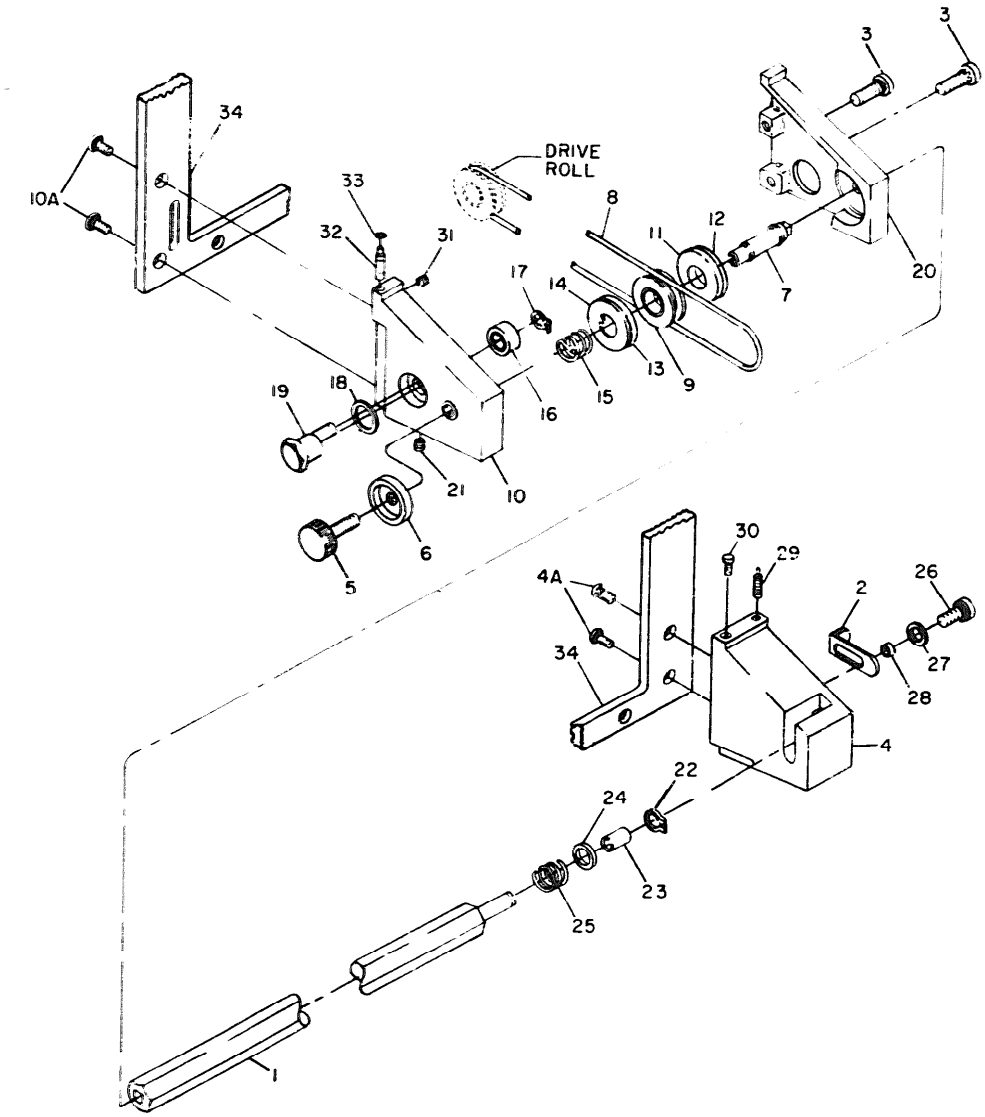
Figure 5-23. Exploded View of Galvanometer Assembly



1	Spindle, Paper Assembly	11	Cork Friction Disc	23	Bearing, Bronze
2	Latch	12	Pressure Disc	24	Washer, Flat
3	Screw	13	Cork Friction Disc	25	Spring
4	Spindle, Retainer PTU (R. H.)	14	Pressure Disc	26	Sems
4A	Screw	15	Spring	27	Spacer
5	Clutch, Screw	16	Pressure Pulley & Bearing	28	Washer Spacer
6	Clutch, Lock Nut	17	Ring, Retainer	29	Plunger, Spring
7	Shaft, Paper Take-Up	18	Washer	30	Nylon Screw
8	Belt	19	Stud	31	Setscrew
9	Pulley & Bearing Assembly	20	Retainer, Spindle (L. H.) Inner	32	Pivot Pin
10	PTU Bracket Assembly	21	Setscrew	33	Nylon Washer
10A	Sems	22	Ring, Retainer	34	Front Panel

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Figure 5-24. Exploded View of Paper Take-up Assembly

5-109. Install "Y" sprocket shaft support to the mounting plate with four #10 screws, see Figure 5-25

5-110 Assemble the three sprockets on "Y" shaft with the 2-3/4" diameter sprocket next to the motor, the 2" diameter sprocket in the middle of the support with its associated chain and the 1-1/4" sprocket to drive the gear box input shaft.

5-111 Install the chain from the motor to the 2-3/4" diameter sprocket, using a feeler gage to adjust for 0.004" end play on shaft "Y". This should be done with the middle sprocket free and the end sprocket tightened flush on the end of the shaft.

5-112 Install "X" sprocket shaft support to the support plate, see Figure 5-25

NOTE

The cut-out on the plate and the offset angle of the sprocket shaft support should be aligned on the right side to assure proper end play and chain adjustment.

5-113 Install chain on sprocket in the middle of "X" support arbor, inserting sprocket shaft through both sprocket and support assembly, see Figure 5-26 Install washers between same sprocket and support assembly at the side nearest to the mini-clutch. Be sure that the shaft is inserted in such a manner that its flattened sections are not mounted on the bushings

5-114 Install chain on mini-clutch sprocket and place sprocket on shaft. Insert the mini-clutch into the hub with the setscrews aligned with the flattened parts of the shaft. The right-angle cutouts on the mini-clutch should be as shown in Figure 5-25. Tighten the mini-clutch setscrews through the openings in the sprocket hub. The shaft end should be almost flush with the mini-clutch sprocket hub. Adjust the shaft for 0.004" end play by using feeler gage between washers and the center sprocket. Tighten setscrews on center sprocket. Recheck end play.

5-115 Install "X" support assembly with its attached mounting support plate to mounting base (see Figure 5-25) using retainer plate on the other side of the base. The middle sprocket on "Y" assembly, which was left free, can now be aligned with center sprocket on "X" assembly and the setscrews tightened. Adjust for proper chain tension (1/16" to 1/8" slack) and parallelism of shafts. Tighten the support assembly to the base plate.

NOTE

If equipment is not to be completely overhauled, cleaning and lubricating can be performed without disassembly of sprockets and chains.

5-116 MN/MIN MOTOR ASSEMBLY

Loop the chain over the mini-clutch sprocket and the sprocket attached to the motor shaft and make the following adjustments:

a. Align motor over the four holes; insert screws and adjust chain slack for approximately 1/8" and alignment with mini-clutch gear (see Figure 5-26). Tighten screws and check complete assembly for proper operation.

b. Manually turn the main drive motor shaft clockwise. The mini-clutch sprocket should not turn, but the clutch inside will turn clockwise.

c. Manually turn the main motor shaft counterclockwise (more effort will be required to rotate it in this direction); the mini-clutch will engage turning all sprocket and chain assemblies.

d. Manually turn the MM/MIN motor shaft counter clockwise; all chain and sprocket assemblies will turn clockwise.

5-117 After all parts are in complete alignment and all chains have the proper slack, the assembly can be lubricated. Oil all oilite bearings and mini-clutch with oil HP Part No. 6040-0220 through the oil hole in the hub. Lubricate all chains and sprockets with grease HP Part No. 6040-0223.

a. Apply power to the large drive motor and observe that the 60:1 motor shaft does not turn. Apply power to the 60:1 motor black and blue leads: all the chains and sprockets should turn in the clockwise direction.

CAUTION

LARGE MOTOR MUST RUN CLOCKWISE LOOKING AT SHAFT FROM FRONT. IF THIS MOTOR IS RUNNING IN COUNTERCLOCKWISE DIRECTION, DAMAGE TO 60:1 MOTOR WILL OCCUR. SMALL MOTOR MUST NOT BE OVERLOADED.

b. Remove the power to both motors.

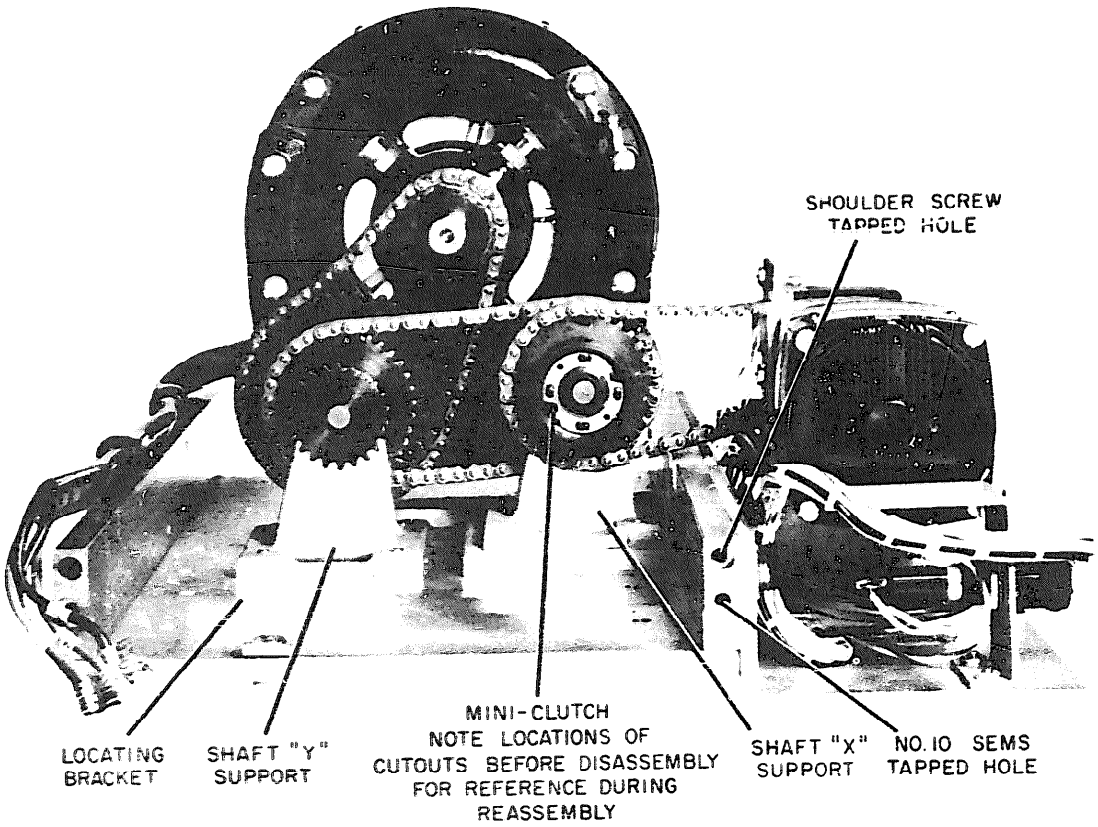


Figure 5-25. MN/MIN Speed Motor Assembly

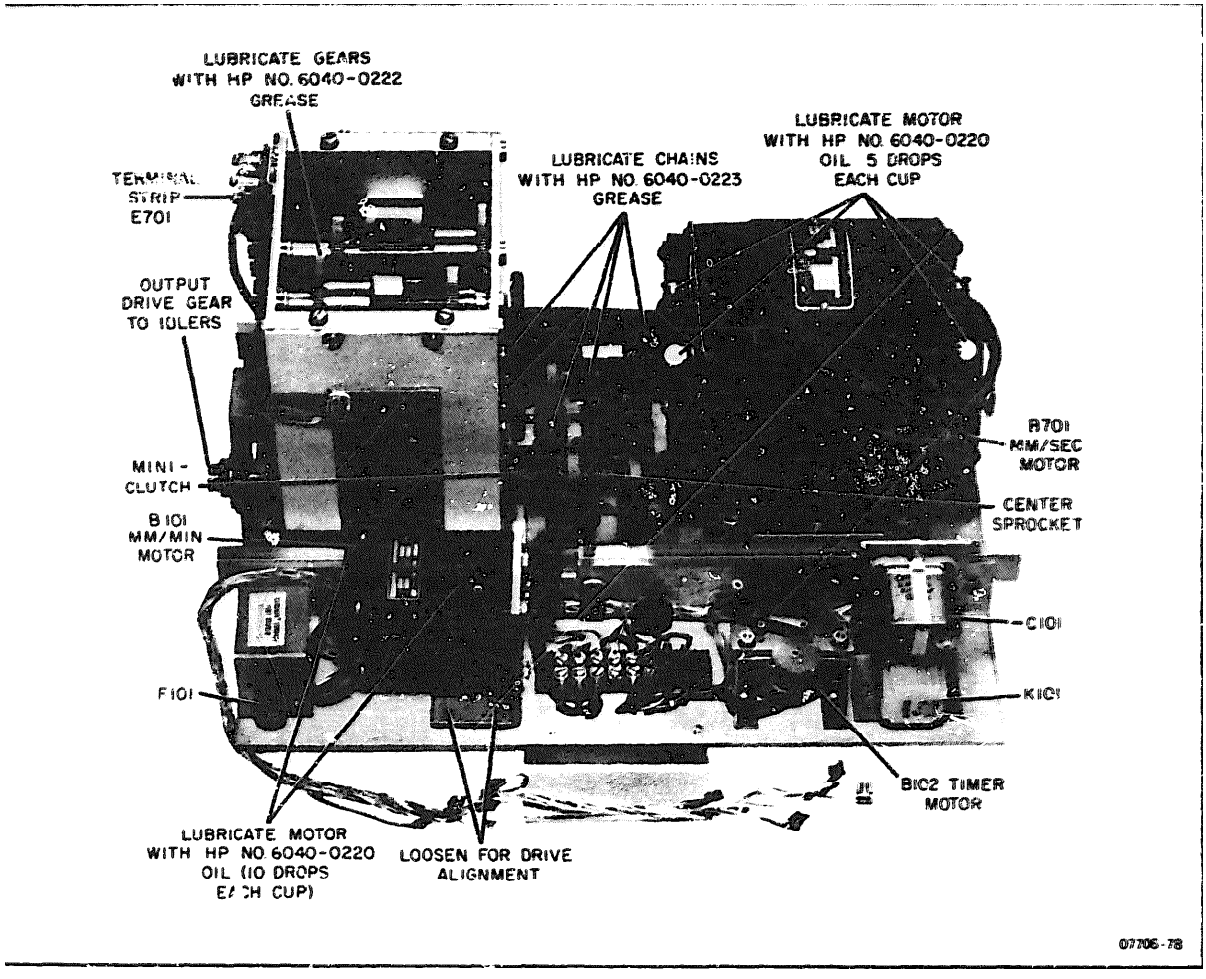


Figure 5-26. Lubrication and Points and Componentfor Speed Drivers, "DW", Records

5-118. MM/MIN GEAR BOX INSTALLATION

Attach chain to gear box sprocket and tip the top of the gear box towards the large motor and while looping the chain on the mounting sprocket. Check that both sprockets are in alignment to minimize chain noise. Attach the gear box to the base plate with the four mounting screws.

a. Attach cable from the kit drive motor assembly bracket to terminal board E-701 and attach the solenoid wires as follows:

(1) Black wire to E701-3

(2) SOL 1 White and Yellow wire to E701-12

(3) SOL 3 White, Orange, Yellow wire to E701-1

(4) SOL 3 White, Orange, Green wire to E701-2

(5) SOL 4 White, Red Yellow wire to E701-13

b. Repiace chain cover.

c. Install entire unit in recorder chassis and reconnect recorder cable to terminal board E701. Install the recorder in the cabinet, as well as the power supply and drivers. Reverse the procedures of paragraphs 5-57 through 5-63.

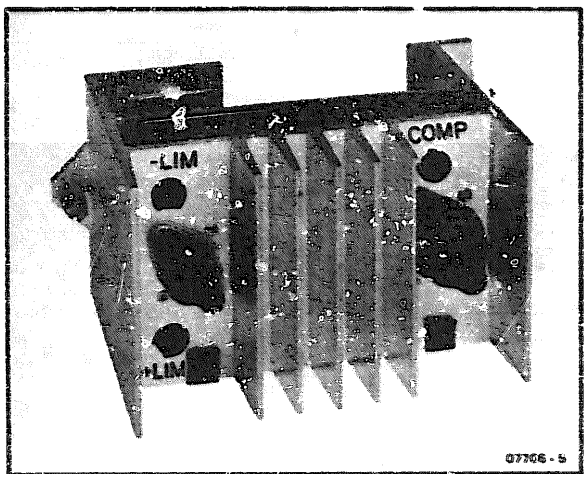


Figure 5-27. Driver Amplifier Limit and Compensation Controls

5-119 MAINTENANCE OF 7700-02B DRIVER AMPLIFIER

5-120. INTRODUCTION

5-121. This section contains instructions for the maintenance of Driver Amplifier 7700-02B. These instructions include troubleshooting, replacement and repair of components, and adjustments after repair.

5-122. PERFORMANCE CHECKOUT

5-123 Make the performance checkout given in the applicable Recording System manual to ensure that a new or repaired Driver Amplifier meets system specifications.

5-124 TEST EQUIPMENT

5-125 Required test equipment is listed in Table 5-4. The test cable shown in Figure 5-1 must be fabricated locally.

5-126 TROUBLESHOOTING

5-127 It is most desirable to check out the Driver Amplifier while directly connected to the Driver Amplifier Power Supply. However, to gain access to all the components on the printed circuit board, it may become necessary to remove the Driver Amplifier from its physical location and reconnect it back to the power supply through the test cable shown in Figure 5-1. The "X" dimension of the cable will vary with the individual set-up. It should be long enough to allow the Amplifier and test equipment to be placed on a bench behind the System Cabinet.

NOTE

Excessive cable length can cause Amplifier to oscillate. Use cable as short as possible; be sure to ground Amplifier case.

5-128 It is assumed that the Driver Amplifier has been localized as a faulty component by direct substitution of a known good unit. To localize trouble within the faulty unit, proceed as follows:

a. Turn off power to Recording System.

b. Remove Driver Amplifier from Driver Amplifier Power Supply.

c. Visually inspect Driver Amplifier for signs of burned components, broken leads, or damaged printed-circuit board.

NOTE

If the symptom of a faulty Driver Amplifier is that it continuously blows the fuse in the Driver Amplifier Power Supply, do not plug in the faulty Driver Amplifier until it has been checked out for a shorted component. One of the causes for a blown fuse could be a defective insulating washer under one of the power transistors (Q6 or Q7). This is indicated by burned-out resistors R22 and R23.

d. If Driver Amplifier checks out visually, place it on bench close to Driver Amplifier Power Supply.

e. Interconnect Driver Amplifier to Driver Amplifier Power Supply with test cable.

f. Set stylus mechanical zero to chart center.

g. Turn on Recording System power.

h. Check voltage across R24 with Recorder stylus centered. Voltage should be zero ± 100 mV.

i. Check voltage across R24 with Recorder stylus upscale (left). Voltage should be + 1 volt ± 10%.

j. Check voltage across R24 with Recorder stylus downscale (right). Voltage should be -1 volt ± 10%.

k. If voltages in steps h, i, or j do not check out, check dc voltages of circuits (see driver amplifier schematic diagram figure 6-4

l. Check for amplifier oscillation (up to 3 Mhz) by placing oscilloscope across R24. There should be no oscillation.

m. If oscillation is detected in step l, use oscilloscope to isolate circuit causing oscillation.

n. To isolate a faulty component within a circuit, turn off Recording System power and disconnect test cable from amplifier. Then, use an ohmmeter and standard test procedures to locate the faulty component.

5-129 REMOVAL OF PRINTED CIRCUIT BOARD

5-130 To remove the circuit board from the chassis of the Driver Amplifier, first remove leads from top and bottom (as applicable) of pins 1 through 10 on the printed circuit board. Then loosen screw and slide out circuit board. When replacing circuit board, secure in place with same screw. Then connect leads to pins 1 through 10, observing the color coding of leads to pins as shown in

5-131 ADJUSTMENTS

5-132 Table 5-4 contains instructions for making frequency compensation and damping adjustments. These adjustments must be made every time a Driver Amplifier is replaced in a Recording System. The frequency compensation control is located in the Driver Amplifier (R5, see Figure 5-27 and the damping control in the Recorder In addition, the limits of stylus travel are adjusted at the Driver Amplifier. The plus and minus limit adjustment controls are shown in Figure 5-27 Adjust using the procedure in Table 5-2(c), step 9.

5-133 The frequency compensation adjustment (step 9 in Table 5-5) is made at a frequency (Hz) dependent upon the Recording System and Preamplifier being used with Driver Amplifier 7700-02B. This frequency may be determined as follows:

Preamps	7706B	7708B
8801A	125 Hz	150 Hz
8802A	125 Hz	150 Hz
8803A	100 Hz	110 Hz

5-134 TROUBLESHOOTING

5-135 GENERAL

5-136 The best approach to troubleshooting the 7706B and 7708B systems is to obtain as much information as possible from the recorder itself and front panel controls. But as in most equipment consisting of sub-systems, troubleshooting can be divided into two categories or levels:

a. System troubleshooting, in which the trouble is identified with a specific function and subassembly of the system.

b. Troubleshooting the section or component isolated by system troubleshooting (see Table 5-3 for recorder).

5-137 When a malfunction is evident or suspected, disconnect the inputs to the System and make the System Performance Checks in Table 5-2 If the System does not check out, refer to the functional diagrams in Figure 5-28 and 5-29 and then to the Troubleshooting Tree in Figure 5-30 If the System is apparently operating properly, check that all inputs are within limits of the specifications. For example, the input signal may be intermittent or have a small signal-to-noise ratio. Damaged connecting cables may be causing noise or intermittent connections.

Table 5-4. Equipment Required for 7700-02B Driver Amplifier

Instrument	Characteristics	Application	Nomenclature
D-C VTVM, zero center	±1 mV to 1000V 1 mA to 1 ampere	Used to measure Amplifier output during troubleshooting	ME-186/U
Oscilloscope	Min. bandwidth of 5MHz 10 mV/cm to 10V/cm.	Used to detect Amplifier os oscillation during troubleshooting.	AN/USM-281A
Test Cable	See text (para. 5-127). See Figure 5-1.	Used as a patch cable to connect Amplifier to its Power Supply; also exposed terminal board in center of cable allows access to Amplifier connections.	Fabricated by user to requirements of system location.
Function Generator	Minimum frequency range of 2 to 150 Hz. Minimum output range of 30 mV rms to 2 V rms. Continuously adjustable.	Used when making frequency compensation adjustment.	SG-321/U

Table 5-5. Frequency Compensation And Damping Adjustments

1.	Turn off Recording System power.
2.	Set stylus mechanical zero to chart center.
3.	Connect Function Generator to preamplifier input.
4.	Set DAMPING control of Recorder galvanometer to center of its travel.
5.	Turn on Recording System and Function Generator.
6.	Center stylus by using preamplifier position control.
7.	Set Function Generator for a 2 Hz sine wave, and adjust its amplitude for a 10 division peak-to-peak recorded signal.
8.	Maintaining same amplitude as in step 7, set Function Generator to required frequency as instructed in paragraph 5-133.
9.	Adjust frequency compensation (COMP) control of Driver Amplifier for a 7 division peak-to-peak recorded signal (3dB down).
10.	Set Function Generator for 2 Hz square-wave, and adjust amplitude for a 10 division peak-to-peak recorded signal.
11.	Run recorder at 25 mm/sec and adjust DAMPING control to obtain 0.4 division overshoot on leading edge of square wave.
12.	Repeat steps 9, 10, and 11 until requirements of steps 9 and 11 are satisfied simultaneously.

5-138. SYSTEM TROUBLESHOOTING

5-139. System troubleshooting consists of observing the indications on the recording chart and relating these indications to the functions of a particular section or circuit. Basically, all channels function independently except for a common power supply for the preamplifiers and power supply for each pair of driver amplifiers. System power is controlled by the circuit breaker switch. Therefore, if the whole system is dead, then check the ac input. If none of the channels respond to the separate CAL and POSITION controls on the preamplifiers, either of the common power supplies could be defective and should be checked. Recorder electrical problems are evidenced by some malfunction of the chart drive, speed selection, or stylus heat control circuits. Mechanical troubleshooting hints are distributed throughout the paragraphs on recorder maintenance, paragraphs 5-11 through 5-118.

5-140. SECTIONAL TROUBLESHOOTING

5-141. Troubleshooting can be greatly simplified if checking is done by substitution in the signal flow path. This is done by interchanging the connecting cables between components. The common output cable from the preamplifier power supply is divided into signal connectors (J411 and J415) at the Driver Amplifier Power Supply chassis: one for even-numbered channels and one for odd-numbered. If an odd-numbered channel is not functioning, interchanging the connectors will aid in identifying the problem area, either within the input circuitry or within the Driver-galvanometer circuits.

5-142. Voltages to the preamplifiers can be checked at the Preamplifier Power Supply chassis, connector J33. Cable interchanging can be carried through to the recorder, isolating Driver Amplifiers, and to the galvanometer bank, if the problem leads to the galvanometers.

5-143. Driver Amplifiers can be easily interchanged at the rear of the System. Mark each amplifier so that it will be returned to the original channel. When an amplifier is suspected, refer to the schematic and theory of the Amplifier to troubleshoot. An extension cable to remove the amplifier for bench work is diagrammed in Figure 5-1. Refer to paragraph 5-127 for recommended troubleshooting procedures for driver amplifiers.

5-144. Operating the Recorder controls can be used to identify electro-mechanical troubles. Use the schematics to check through each function, relay action, indicator light, etc. Refer to the theory of the Recorder in Section IV for an analysis of the electrical and mechanical operation of the Recorder.

CAUTION

DO NOT USE A SHARP METAL OBJECT SUCH AS AN AWL OR TWIST DRILL FOR THIS PURPOSE. SHARP OBJECTS MAY DAMAGE THE PLATED-THROUGH CONDUCTOR. MELT SOLDER BEFORE REMOVING.

5-145 REPAIR

5-146. PRINTED CIRCUIT BOARDS

5-147 The printed circuit boards used in the system are of the plated-through type consisting of metallic conductors bonded to a base board of insulating material. The metallic conductors are extended through the component mounting holes by the plating process. Soldering can be done from either side of the board with equally good results.

6-148 Following are recommendations and precautions pertinent to etched circuit repair work.

a. Avoid unnecessary component substitution; it can result in damage to the circuit board and to adjacent components.

b. Do not use a high-power soldering iron on the circuit boards. Excessive heat may lift a conductor or warp the board. Ten watts is sufficient power for a soldering iron or pencil used for circuit board work.

c. Use a wooden toothpick to remove solder from component mounting holes while solder is melted.

5-149. COMPONENT REPLACEMENT

5-150. Apply heat carefully to avoid damage to the plated-through conductor holes and to the replacement component. The following procedure is recommended:

a. Remove the defective component.

b. Melt solder in component lead holes. Use clean, dry, heated soldering iron to remove excess solder.

c. Bend lead of replacement component to correct shape and insert component into the lead holes. Using heat and solder sparingly, solder leads in place. Heat may be applied to either side of the board. A heat sink (longnose pliers, heat-sink tweezers, etc) should be used on the lead between the component and the point being soldered when replacing transistors and diodes to prevent excessive heat from damaging the component.

d. Through-hole plating breaks are indicated by the separation from the board of the round conductor pad on either side of the board. To repair breaks, press conductor pads against the board and solder replacement component lead to conductor pads on both sides of the board.

e. After soldering a new component into place, remove excess flux from the soldered areas and apply electrical varnish or lacquer to protect against contamination and corrosion.

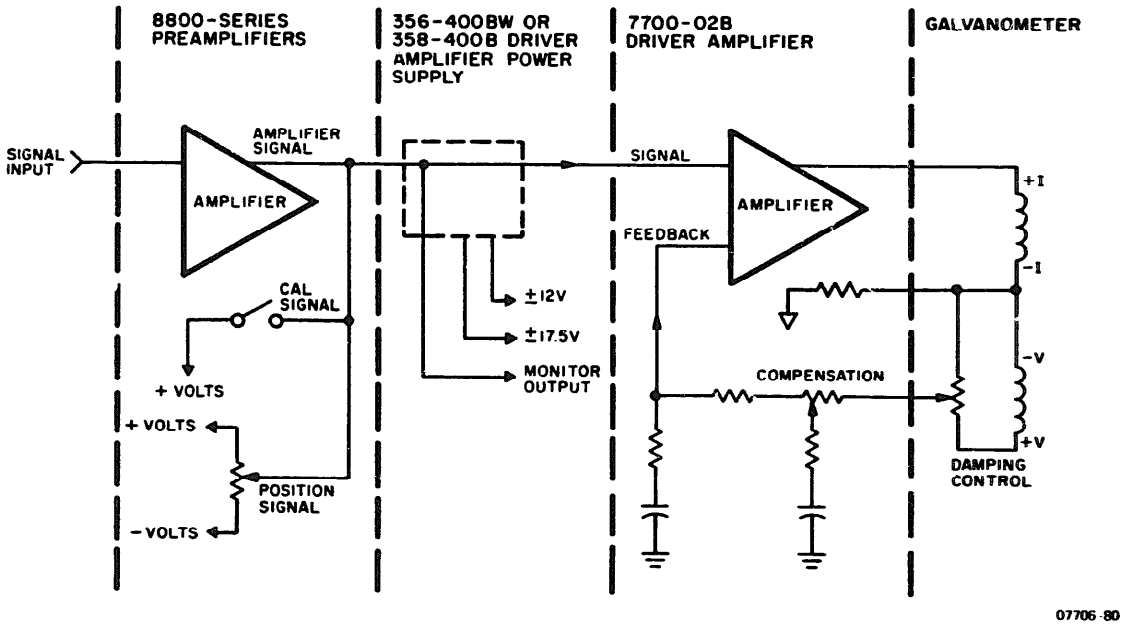


Figure 5-38. System Functional Diagram

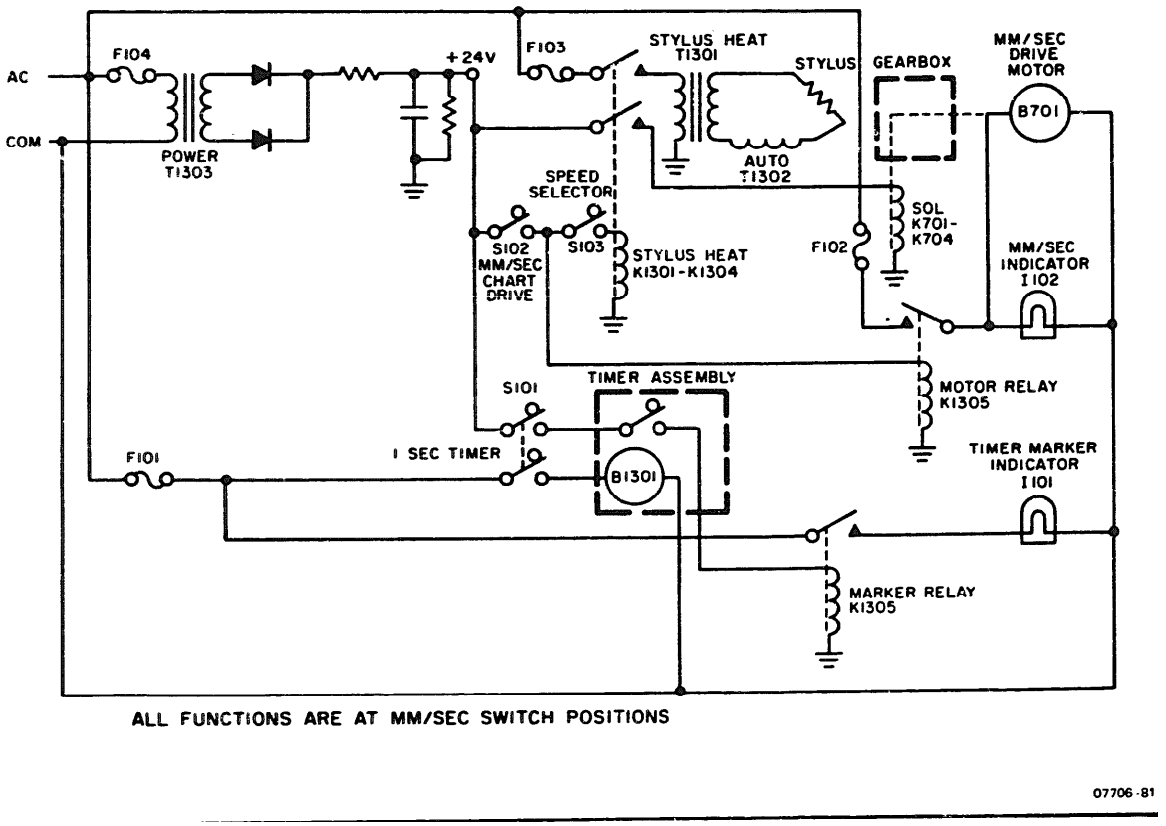


Figure 5-29. Recorder Functional Diagram

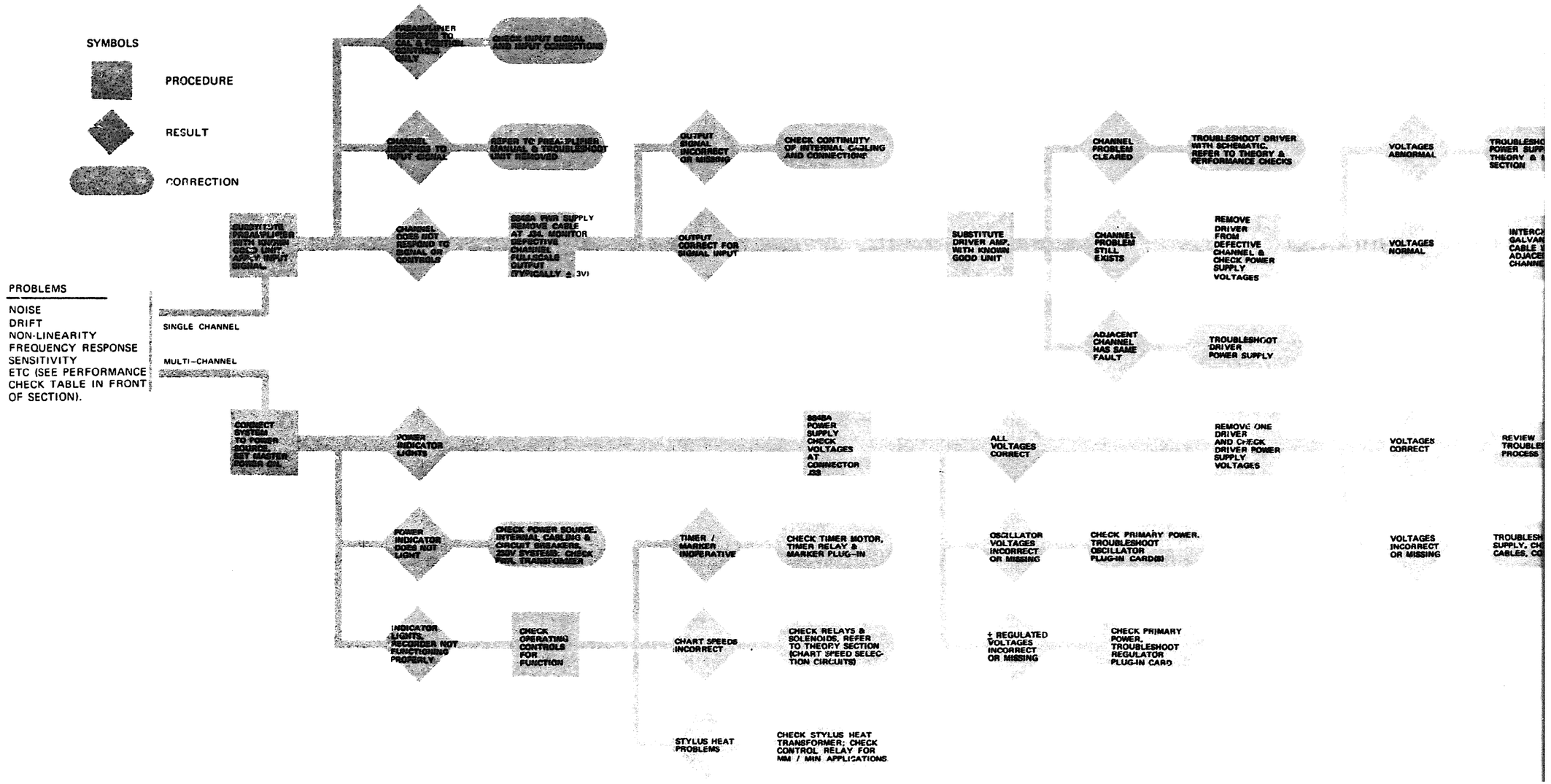

SYMBOLS
PROCEDURE
RESULT
CORRECTION
PROBLEMS
NOISE
DRIFT
NON-LINEARITY
FREQUENCY RESPONSE
SENSITIVITY
ETC (SEE PERFORMANCE CHECK TABLE IN FRONT OF SECTION).
SINGLE CHANNEL
MULTI-CHANNEL
CHECK INPUT SIGNAL AND INPUT CONNECTIONS
REFER TO PREAMPLIFIER MANUAL & TROUBLESHOOT UNIT REMOVED
CHECK CONTINUITY OF INTERNAL CABLING AND CONNECTIONS
SUBSTITUTE DRIVER AMP. WITH KNOWN GOOD UNIT
TROUBLESHOOT DRIVER WITH SCHEMATIC, REFER TO THEORY & PERFORMANCE CHECKS
VOLTAGES ABNORMAL
REMOVE DRIVER FROM DEFECTIVE CHANNEL & CHECK POWER SUPPLY VOLTAGES
VOLTAGES NORMAL
TROUBLESHOOT DRIVER POWER SUPPLY
ADJACENT CHANNEL HAS SAME FAULT
CONNECT SYSTEM TO POWER SOURCE. SET MASTER POWER ON.
POWER INDICATOR LIGHTS
POWER INDICATOR DOES NOT LIGHT
INDICATOR LIGHTS, RECORDER NOT FUNCTIONING PROPERLY
CHECK POWER SOURCE, INTERNAL CABLING & CIRCUIT BREAKERS. 230V SYSTEMS, CHECK FUSE, TRANSFORMER
CHECK OPERATING CONTROLS FOR FUNCTION
TIMER / MARKER INOPERATIVE
CHART SPEEDS INCORRECT
STYLUS HEAT PROBLEMS
CHECK TIMER MOTOR, TIMER RELAY & MARKER PLUG-IN
CHECK RELAYS & SOLENOIDS, REFER TO THEORY SECTION (CHART SPEED SELECTION CIRCUITS)
CHECK STYLUS HEAT TRANSFORMER; CHECK CONTROL RELAY FOR MM / MIN APPLICATIONS
ALL VOLTAGES CORRECT
OSCILLATOR VOLTAGES INCORRECT OR MISSING
± REGULATED VOLTAGES INCORRECT OR MISSING
CHECK PRIMARY POWER, TROUBLESHOOT OSCILLATOR PLUG-IN CARD(S)
CHECK PRIMARY POWER, TROUBLESHOOT REGULATOR PLUG-IN CARD
REMOVE ONE DRIVER AND CHECK DRIVER POWER SUPPLY VOLTAGES
VOLTAGES CORRECT
VOLTAGES INCORRECT OR MISSING
REVIEW TROUBLE PROCESS
TROUBLESH SUPPLY, CH CABLES, CO

Figure 5

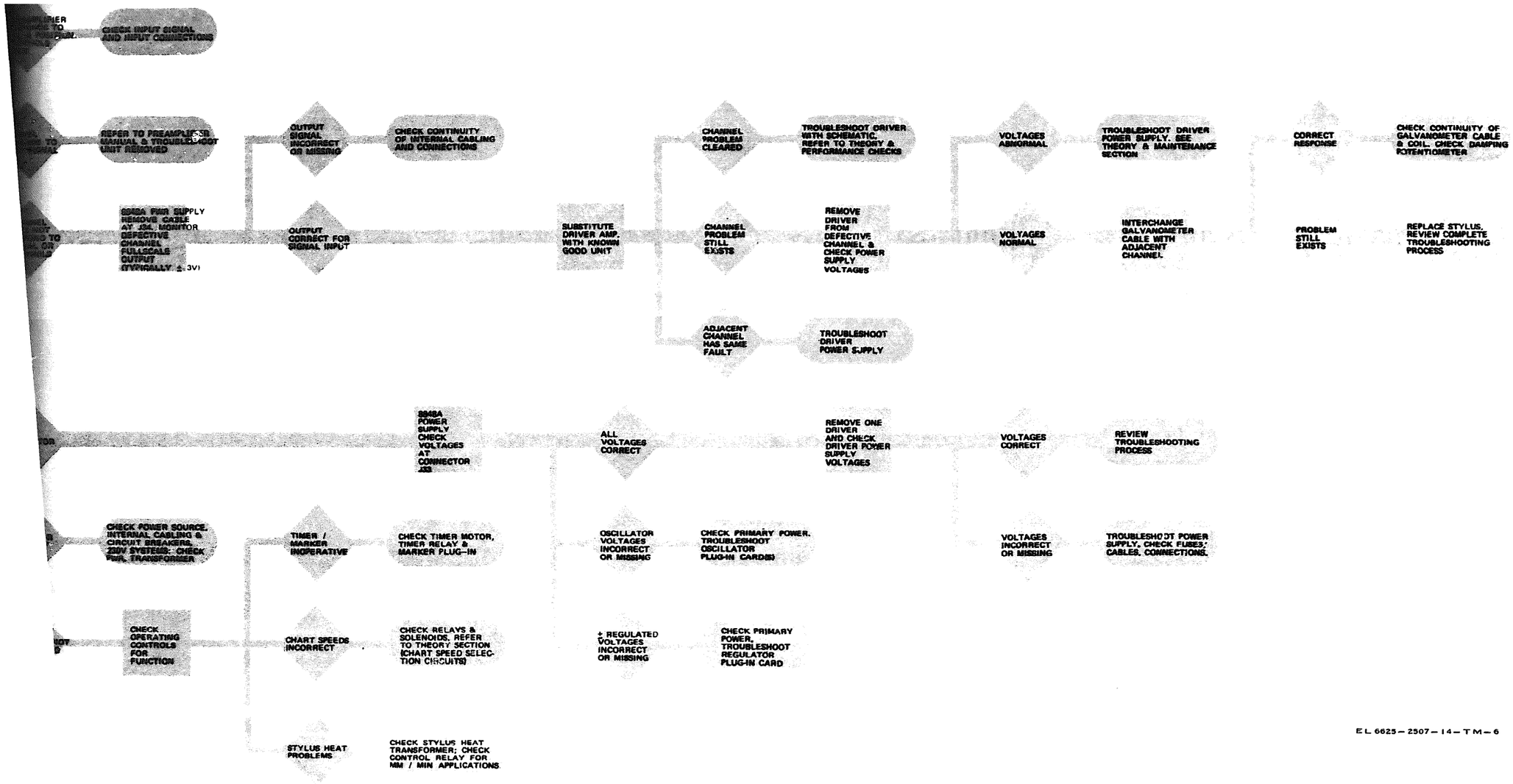
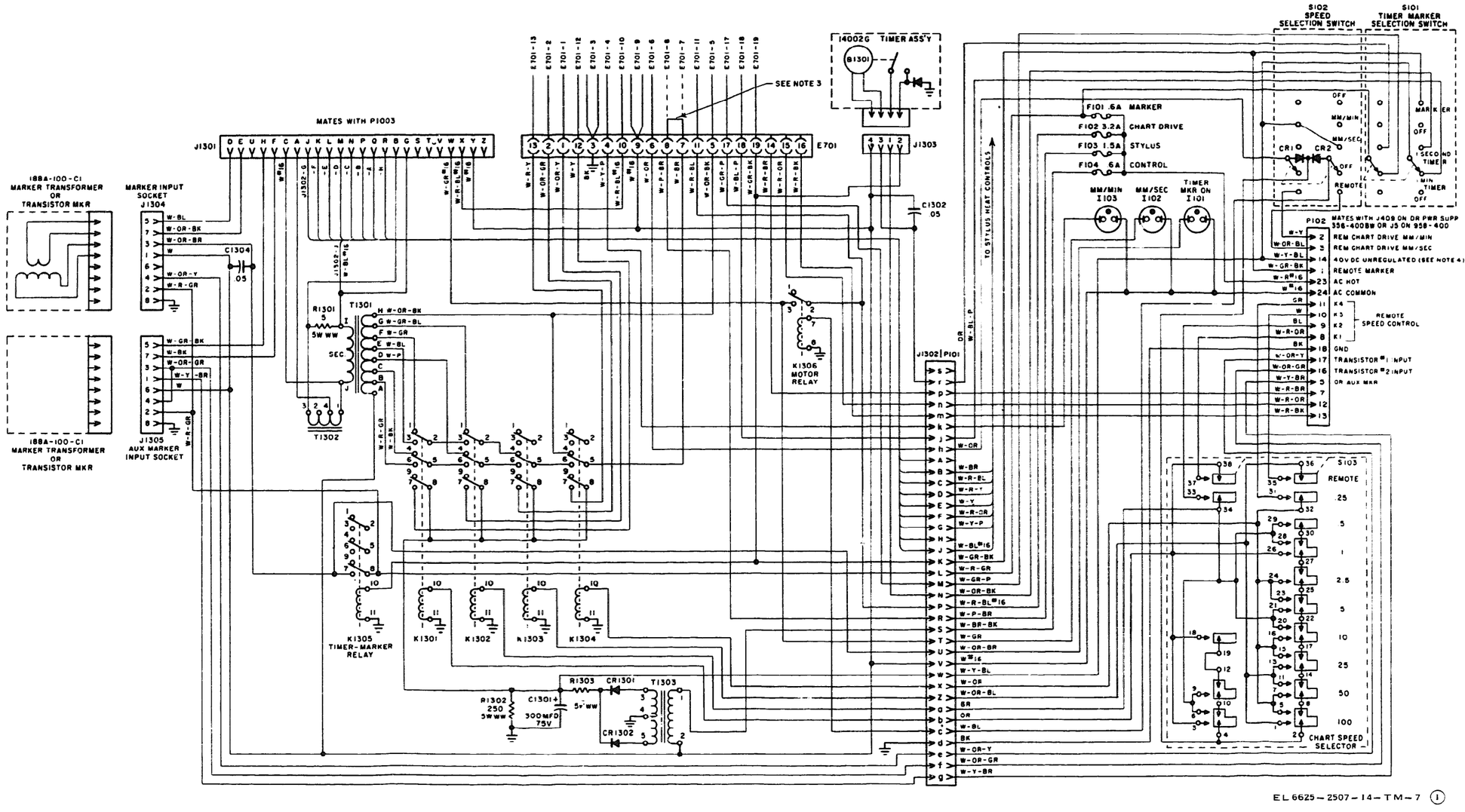


Figure 5-30. System Troubleshooting



EL 6625-2507-14-TM-7 (1)

Figure 5-31 Recorder Schematic Diagram (356-100DW) (sheet 1 of 2).

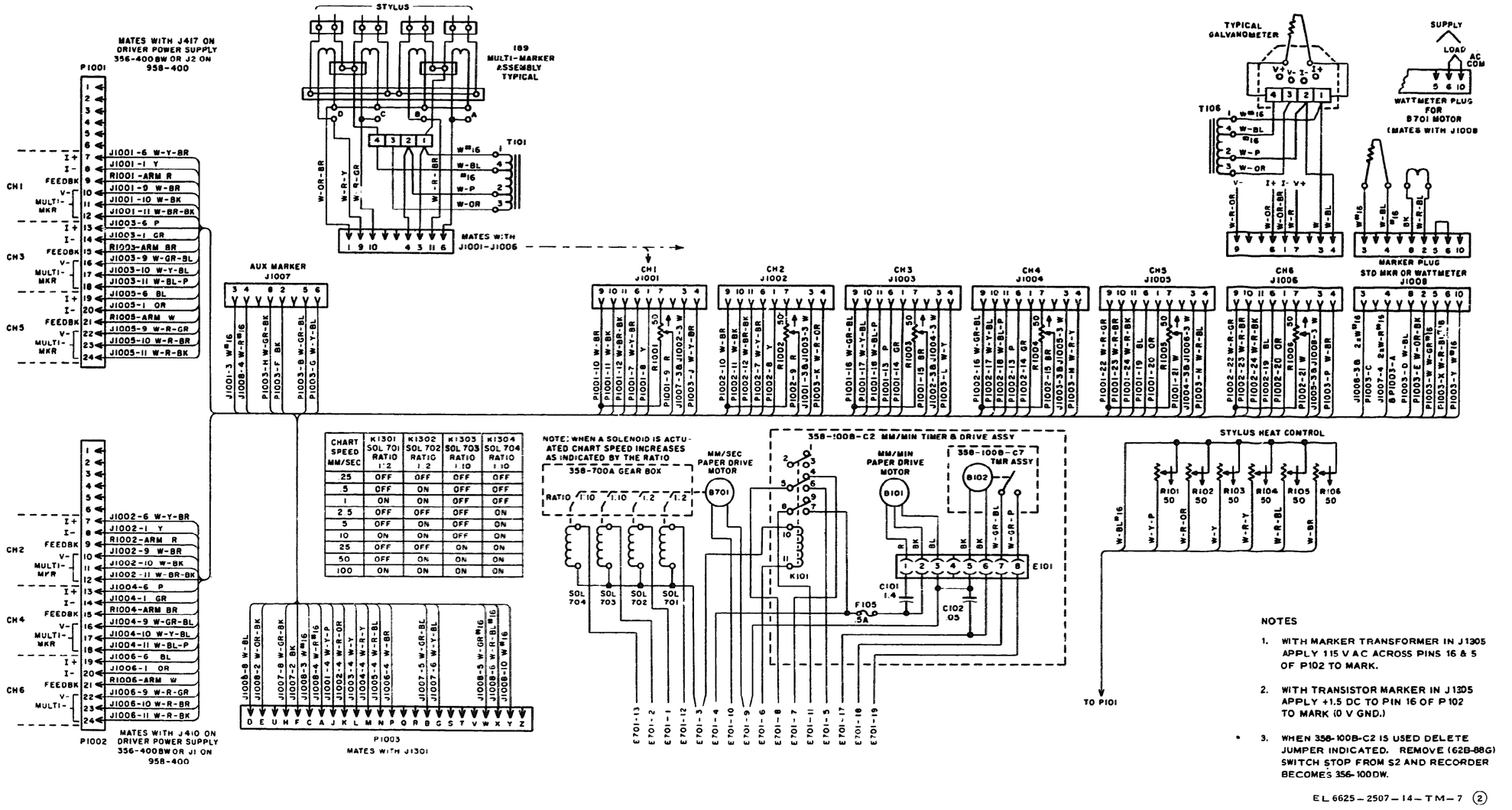
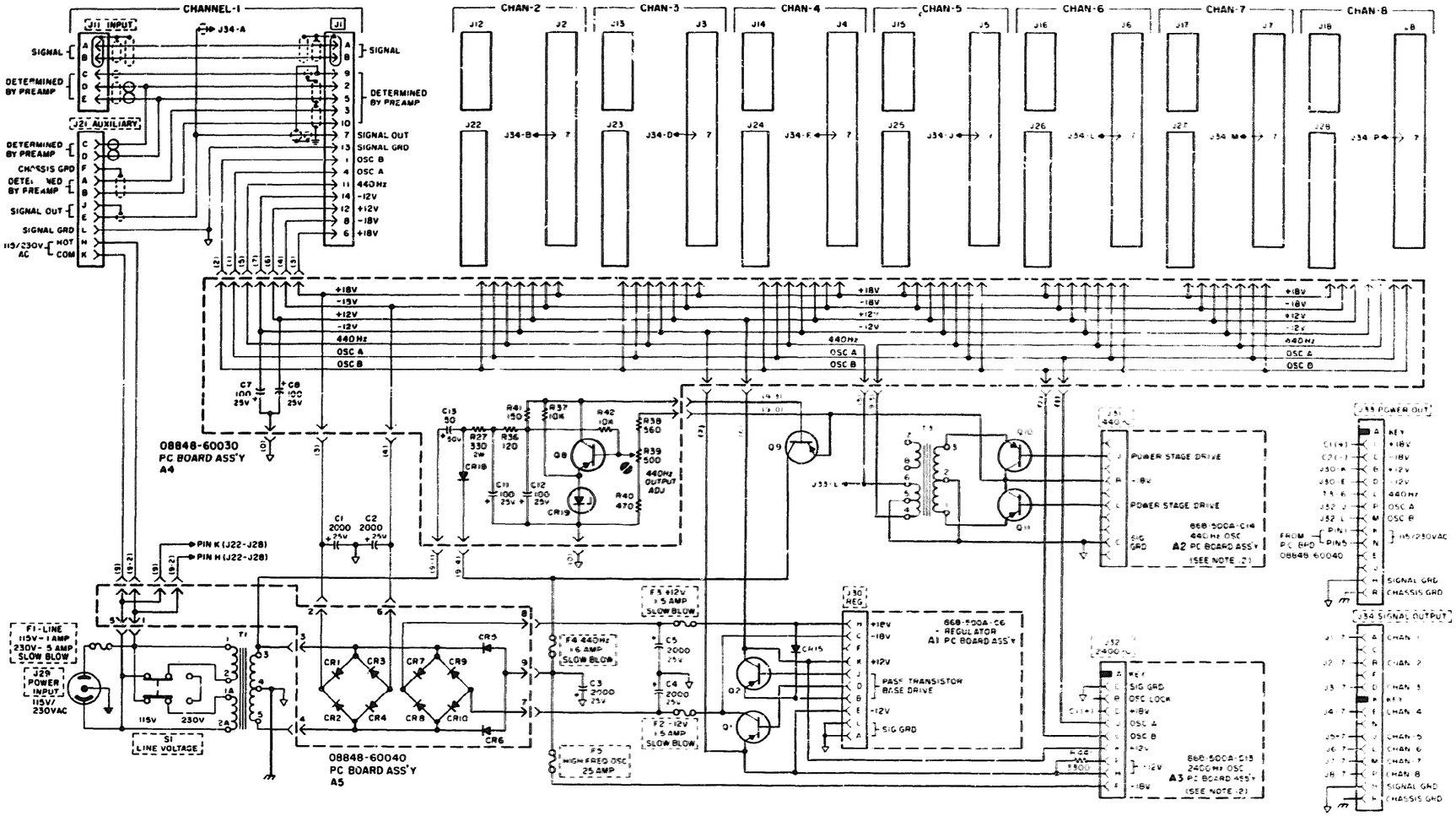


Figure 5-31 Recorder schematic diagram (356-100DW) (sheet 2 of 2)



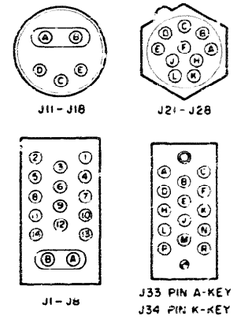
NOTES

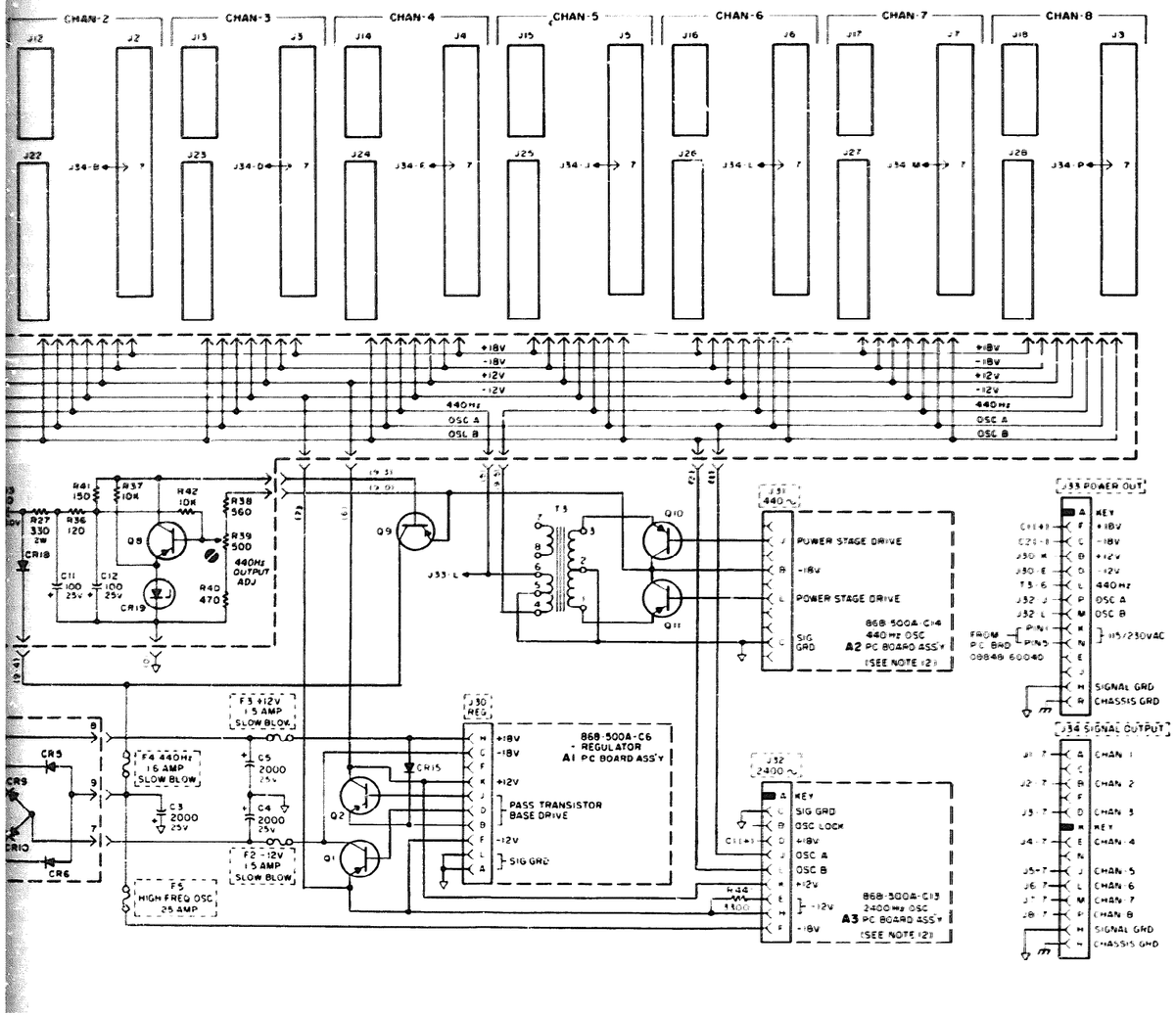
1. RESISTANCE IN OHMS ±10% 1/2W UNLESS OTHERWISE NOTED
2. CAPACITANCE IN μF UNLESS OTHERWISE NOTED.
3. ETCHED CIRCUIT BOARD
4. LOCATED ON FRONT PANEL
5. LOCATED ON REAR PANEL
6. SCREWDRIVER ADJUSTMENT
7. CHASSIS GROUND
8. COMMON CONNECTION
9. BREAKDOWN DIODE, UNIDIRECTIONAL ALSO, BACKWARD DIODE
10. P/O - PART OF
11. WIRE COLORS GIVEN USING STANDARD COLOR CODE
EXAMPLE (9 & 3) = WHITE ORANGE

0 = BLACK	5 = GREEN
1 = BROWN	6 = BLUE
2 = RED	7 = VIOLET
3 = ORANGE	8 = GREY
4 = YELLOW	9 = WHITE

12. POWER SUPPLIES AVAILABLE:
A. 8848A WITH 2400Hz & 440Hz OSCILLATOR CARDS
B. 8848A LESS 2400Hz OSCILLATOR CARD (OPTION 01)
C. 8848A LESS 440Hz OSCILLATOR CARD (OPTION 02)
D. 8848A LESS 2400Hz & 440Hz OSCILLATOR CARDS (OPTIONS 01 & 02)
13. ON BIP-500A CIS P.C. BOARD ASS'Y (1) MAY BE CHOSEN TO MAKE (ANY CIRCUIT PROVIDE 2400Hz ± 2%

CONNECTORS (FRONT VIEW)





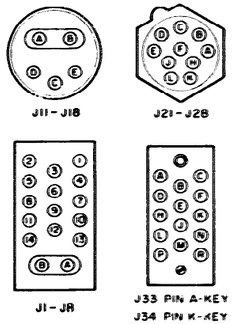
NOTES

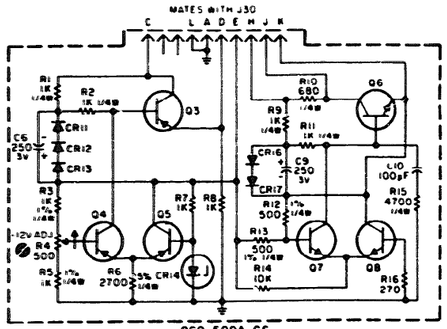
1. RESISTANCE IN OHMS ±10% 1/2W UNLESS OTHERWISE NOTED.
2. CAPACITANCE IN μF UNLESS OTHERWISE NOTED.
3. ETCHED CIRCUIT BOARD
4. LOCATED ON FRONT PANEL
5. LOCATED ON REAR PANEL
6. SCREWDRIVER ADJUSTMENT
7. CHASSIS GROUND
8. COMMON CONNECTION
9. BREAKDOWN DIODE, UNIDIRECTIONAL ALSO BACKWARD DIODE
10. P/O PART OF
11. WIRE COLOR IS GIVEN USING STANDARD COLOR CODE
EXAMPLE: (9, 3) = WHITE, ORANGE

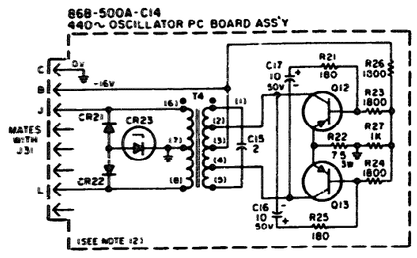
0 = BLACK	5 = GREEN
1 = BROWN	6 = BLUE
2 = RED	7 = VIOLET
3 = ORANGE	8 = GRAY
4 = YELLOW	9 = WHITE

12. POWER SUPPLIES AVAILABLE:
A. 8848A WITH 2400Hz & 440Hz OSCILLATOR CARDS
B. 8848A LESS 2400Hz OSCILLATOR CARD (OPTION 01)
C. 8848A LESS 440Hz OSCILLATOR CARD (OPTION 02)
D. 8848A LESS 2400Hz & 440Hz OSCILLATOR CARDS (OPTIONS 01 & 02)
13. ON A8A1=500A C15 PC BOARD ASS'Y C15 MAY BE CHOSEN TO MAKE TANK CIRCUIT PROVIDE 2400Hz ± 2%

CONNECTORS (FRONT VIEW)







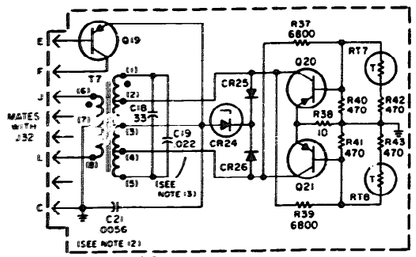


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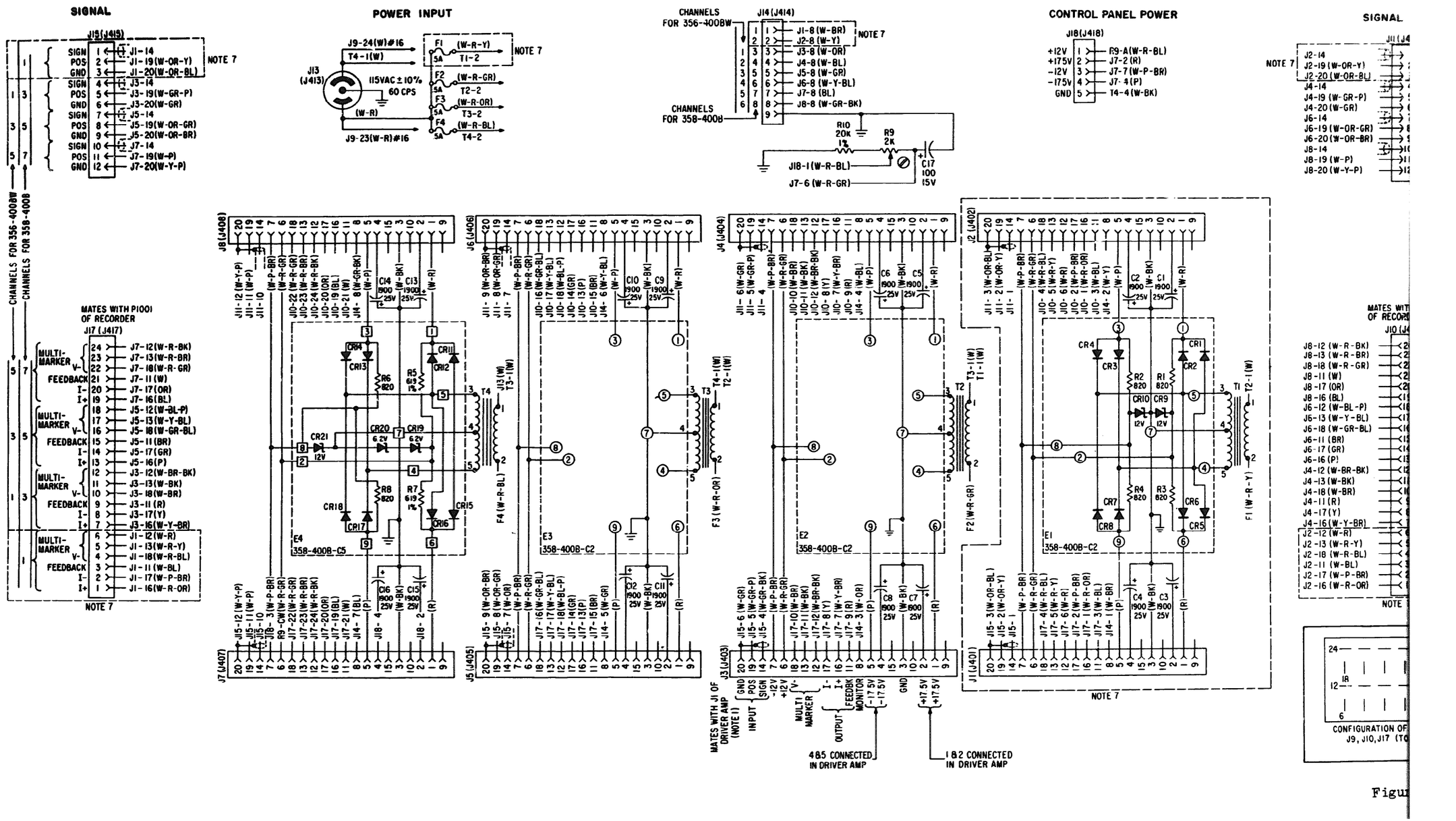
Figure 5-32. Power supply schematic diagram for 8848A.


SIGNAL
POWER INPUT
MONITOR OUTPUT
CONTROL PANEL POWER
SIGNAL
J15(J415)
NOTE 7
SIGN 1 J1-14
POS 2 J1-19(W-OR-Y)
GND 3 J1-20(W-OR-BL)
SIGN 4 J3-14
POS 5 J3-19(W-GR-P)
GND 6 J3-20(W-GR)
SIGN 7 J5-14
POS 8 J5-19(W-OR-GR)
GND 9 J5-20(W-OR-BR)
SIGN 10 J7-14
POS 11 J7-19(W-P)
GND 12 J7-20(W-Y-P)
CHANNELS FOR 356-4008W
CHANNELS FOR 358-4008
J9-24(W)#16
T4-1(W)
J13 (J413)
115VAC ± 10% 60 CPS
(W-R)
J9-23(W-R)#16
F1 5A (W-R-Y) TI-2
F2 5A (W-R-GR) T2-2
F3 5A (W-R-OR) T3-2
F4 5A (W-R-BL) T4-2
CHANNELS FOR 356-4008W
CHANNELS FOR 358-4008
J14(J414)
J1-8(W-BR)
J2-8(W-Y)
J3-8(W-OR)
J4-8(W-BL)
J5-8(W-GR)
J6-8(W-Y-BL)
J7-8(BL)
J8-8(W-GR-BK)
NOTE 7
R10 20K 1%
R9 2K
C17 100 15V
J18-1(W-R-BL)
J7-6(W-R-GR)
J18(J418)
+12V 1 F9-A(W-R-BL)
+175V 2 J7-2(R)
-12V 3 J7-7(W-P-BR)
-175V 4 J7-4(P)
GND 5 T4-4(W-BK)
NOTE 7
J2-14
J2-19(W-OR-Y)
J2-20(W-OR-BL)
J4-14
J4-19(W-GR-P)
J4-20(W-GR)
J6-14
J6-19(W-OR-GR)
J6-20(W-OR-BR)
J8-14
J8-19(W-P)
J8-20(W-Y-P)
MATES WITH P1001 OF RECORDER
J17(J417)
MULTI-MARKER V- 24 J7-12(W-R-BK)
23 J7-13(W-R-BR)
22 J7-18(W-R-GR)
FEEDBACK 21 J7-11(W)
I- 20 J7-17(OR)
I+ 19 J7-16(BL)
MULTI-MARKER V- 18 J5-12(W-BL-P)
17 J5-13(W-Y-BL)
16 J5-18(W-GR-BL)
FEEDBACK 15 J5-11(BR)
I- 14 J5-17(GR)
I+ 13 J5-16(P)
MULTI-MARKER V- 12 J3-12(W-BR-BK)
11 J3-13(W-BK)
10 J3-18(W-BR)
FEEDBACK 9 J3-11(R)
I- 8 J3-17(Y)
I+ 7 J3-16(W-Y-BR)
MULTI-MARKER V- 6 J1-12(W-R)
5 J1-13(W-R-Y)
4 J1-18(W-R-BL)
FEEDBACK 3 J1-11(W-BL)
I- 2 J1-17(W-P-BR)
I+ 1 J1-16(W-R-OR)
NOTE 7
J8(J408)
J6(J406)
J4(J404)
J2(J402)
J7(J407)
J5(J405)
J3(J403)
J1(J401)
C14 1900 (W-BK) 25V
C13 1900 (W-R)
C10 1900 (W-BK) 25V
C9 1900 (W-R)
C6 1900 (W-BK) 25V
C5 1900 (W-R)
C2 1900 (W-BK) 25V
C1 1900 (W-R)
CR4 CR13 CR11 CR12
R6 820
R5 619 1%
CR21 12V
CR20 6.2V
CR19 6.2V
R8 820
R7 619 1%
CR18 CR17 CR16 CR15
T4 T3 T2 T1
J12(W-BL)
T3-1(W)
T4-1(W)
T2-1(W)
T1-1(W)
F4(W-R-BL)
F3(W-R-OR)
F2(W-R-GR)
F1(W-R-Y)
E4 358-4008-C5
E3 358-4008-C2
E2 358-4008-C2
E1 358-4008-C2
C16 1900 (W-BK) 25V
C15 1900 (R)
C12 1900 (W-BK) 25V
C11 (R)
C8 1900 (W-BK) 25V
C7 1900 (R)
C4 1900 (W-BK) 25V
C3 1900 (R)
CR3 CR1 CR2
R2 820
R1 820
CR10 12V
CR9 12V
R4 820
R3 820
CR7 CR8 CR6 CR5
NOTE 7
MATES WITH J1 OF DRIVER AMP (NOTE 1)
GND
POS
SIGN
-12V
+12V
MULTI MARKER V-
I-
I+
FEEDBK MONITOR
-17.5V
-17.5V
GND
+17.5V
+17.5V
INPUT
OUTPUT
485 CONNECTED IN DRIVER AMP
182 CONNECTED IN DRIVER AMP
MATES WITH J1 OF RECORDER
J10(J410)
J8-12(W-R-BK)
J8-13(W-R-BR)
J8-18(W-R-GR)
J8-11(W)
J8-17(OR)
J8-16(BL)
J6-12(W-BL-P)
J6-13(W-Y-BL)
J6-18(W-GR-BL)
J6-11(BR)
J6-17(GR)
J6-16(P)
J4-12(W-BR-BK)
J4-13(W-BK)
J4-18(W-BR)
J4-11(R)
J4-17(Y)
J4-16(W-Y-BR)
J2-12(W-R)
J2-13(W-R-Y)
J2-18(W-R-BL)
J2-11(W-BL)
J2-17(W-P-BR)
J2-16(W-R-OR)
NOTE 7
24
18
12
6
CONFIGURATION OF J9, J10, J17 (TO

Figu

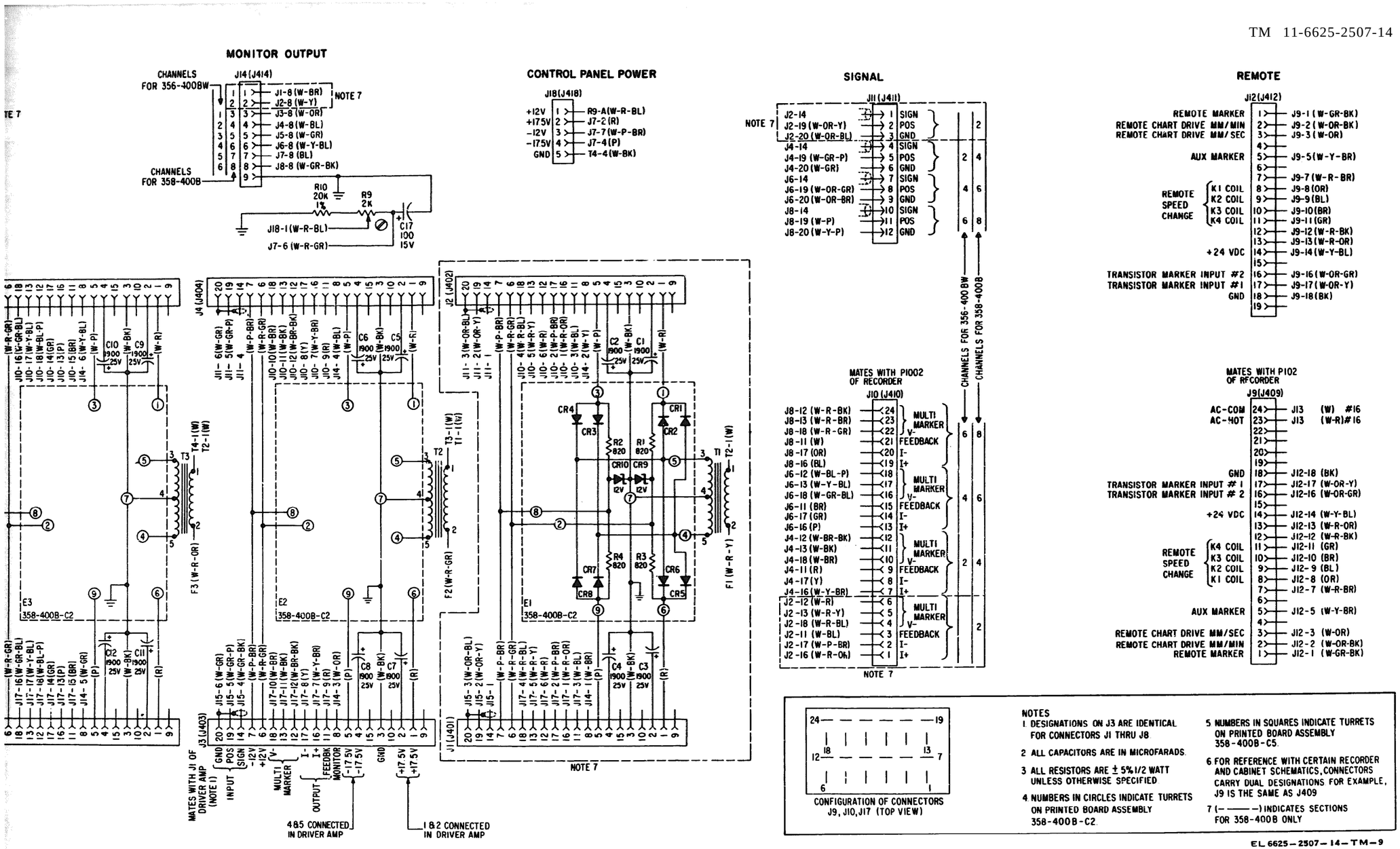


Figure 5-33. Driver amplifier power supply models 356-400BW, 358-400B, 956-400C,and 958-400C, schematic diagram.

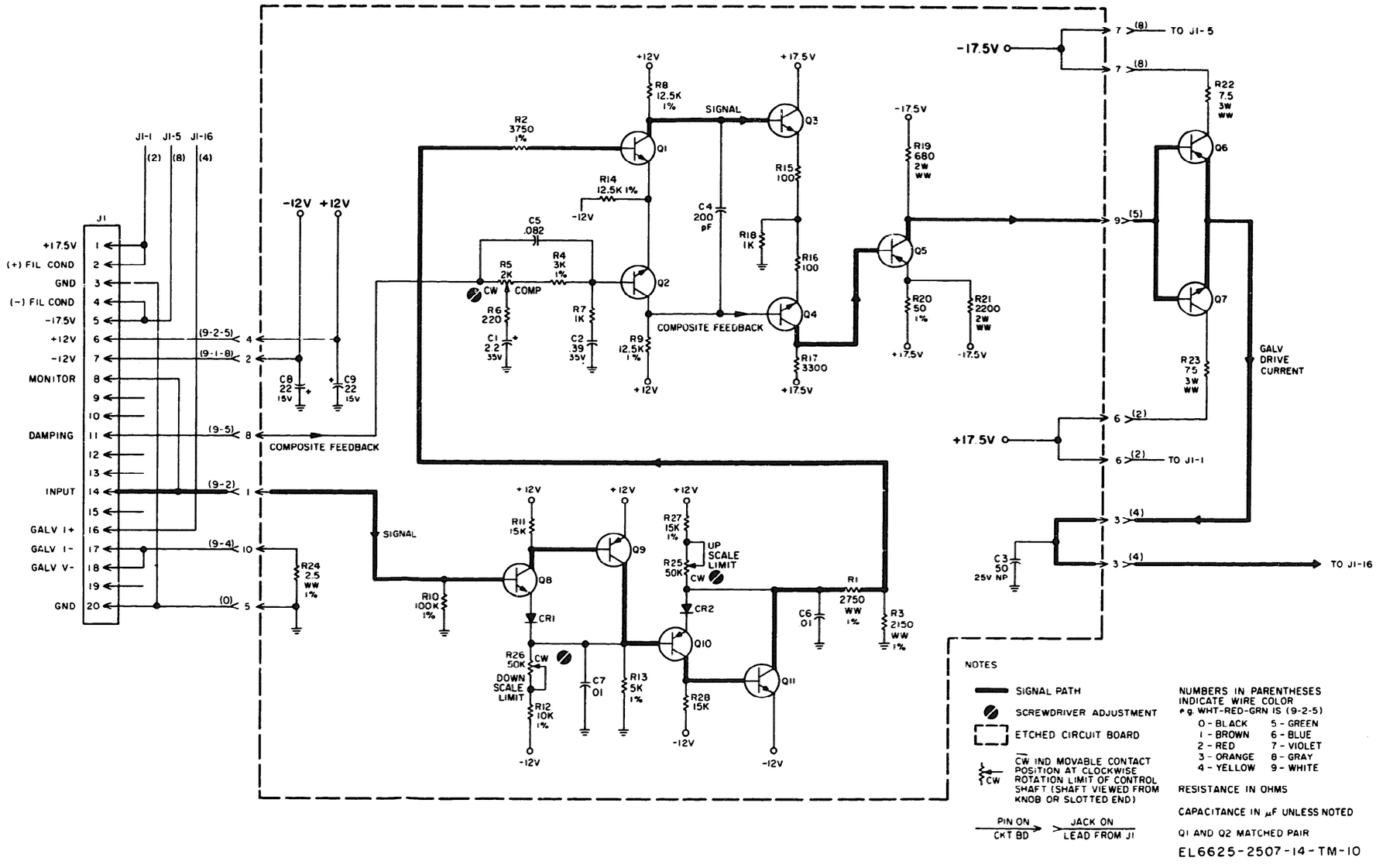
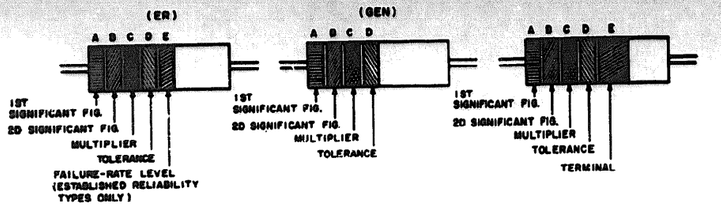


Figure 5-34. Driver amplifier 7700-02B schematic diagram.



COLOR CODE MARKING FOR COMPOSITION TYPE RESISTORS.

COLOR-CODE MARKING FOR FILM-TYPE RESISTORS.

TABLE I

COLOR CODE FOR COMPOSITION TYPE AND FILM TYPE RESISTORS.

BAND A		BAND B		BAND C		BAND D		BAND E		
COLOR	FIRST SIGNIFICANT FIGURE	COLOR	SECOND SIGNIFICANT FIGURE	COLOR	MULTIPLIER	COLOR	RESISTANCE TOLERANCE (PERCENT)	COLOR	FAILURE RATE LEVEL	TERM.
BLACK	0	BLACK	0	BLACK	1			BROWN	M=1.0	
BROWN	1	BROWN	1	BROWN	10			RED	P=0.1	
RED	2	RED	2	RED	100			ORANGE	R=0.01	
ORANGE	3	ORANGE	3	ORANGE	1,000			YELLOW	S=0.001	
YELLOW	4	YELLOW	4	YELLOW	10,000	SILVER	±10 (COMP. TYPE ONLY)	WHITE		SOLDERABLE
GREEN	5	GREEN	5	GREEN	100,000	GOLD	±5			
BLUE	6	BLUE	6	BLUE	1,000,000	RED	±2 (NOT APPLICABLE TO ESTABLISHED RELIABILITY).			
PURPLE (VIOLET)	7	PURPLE (VIOLET)	7							
GRAY	8	GRAY	8	SILVER	0.01					
WHITE	9	WHITE	9	GOLD	0.1					

BAND A — THE FIRST SIGNIFICANT FIGURE OF THE RESISTANCE VALUE (BANDS A THRU D SHALL BE OF EQUAL WIDTH.)

BAND B — THE SECOND SIGNIFICANT FIGURE OF THE RESISTANCE VALUE.

BAND C — THE MULTIPLIER (THE MULTIPLIER IS THE FACTOR BY WHICH THE TWO SIGNIFICANT FIGURES ARE MULTIPLIED TO YIELD THE NOMINAL RESISTANCE VALUE.)

BAND D — THE RESISTANCE TOLERANCE.

BAND E — WHEN USED ON COMPOSITION RESISTORS, BAND E INDICATES ESTABLISHED RELIABILITY FAILURE-RATE LEVEL (PERCENT FAILURE PER 1,000 HOURS). ON FILM RESISTORS, THIS BAND SHALL BE APPROXIMATELY 1-1/2 TIMES THE WIDTH OF OTHER BANDS, AND INDICATES TYPE OF TERMINAL.

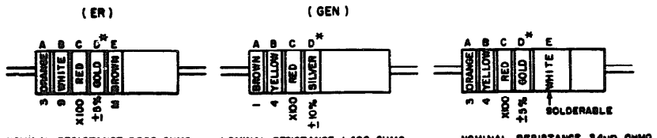
RESISTANCES IDENTIFIED BY NUMBERS AND LETTERS (THESE ARE NOT COLOR CODED)

SOME RESISTORS ARE IDENTIFIED BY THREE OR FOUR DIGIT ALPHA NUMERIC DESIGNATORS. THE LETTER R IS USED IN PLACE OF A DECIMAL POINT WHEN FRACTIONAL VALUES OF AN OHM ARE EXPRESSED. FOR EXAMPLE:

2R7 = 2.7 OHMS 10R0 = 10.0 OHMS

FOR WIRE-WOUND-TYPE RESISTORS COLOR CODING IS NOT USED, IDENTIFICATION MARKING IS SPECIFIED IN EACH OF THE APPLICABLE SPECIFICATIONS.

EXAMPLES OF COLOR CODING



NOMINAL RESISTANCE 3,900 OHMS
RESISTANCE TOLERANCE ±5%
FAILURE RATE LEVEL M

NOMINAL RESISTANCE 1,400 OHMS
RESISTANCE TOLERANCE ±10%

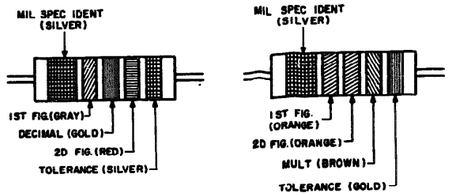
NOMINAL RESISTANCE 34,400 OHMS
RESISTANCE TOLERANCE ±5%
TERMINAL SOLDERABLE

COMPOSITION-TYPE RESISTORS

FILM-TYPE RESISTORS

* IF BAND D IS OMITTED, THE RESISTOR TOLERANCE IS ±20% AND THE RESISTOR IS NOT MIL-STD.

A. COLOR CODE MARKING FOR MILITARY STANDARD RESISTORS.



(A) 8.2UH ±10%

(B) 330UH ±5%

COLOR CODING FOR TUBULAR ENCAPSULATED R.F. CHOKES. AT A, AN EXAMPLE OF OF THE CODING FOR AN 8.2UH CHOKE IS GIVEN. AT B, THE COLOR BANDS FOR A 330UH INDUCTOR ARE ILLUSTRATED.

TABLE 2

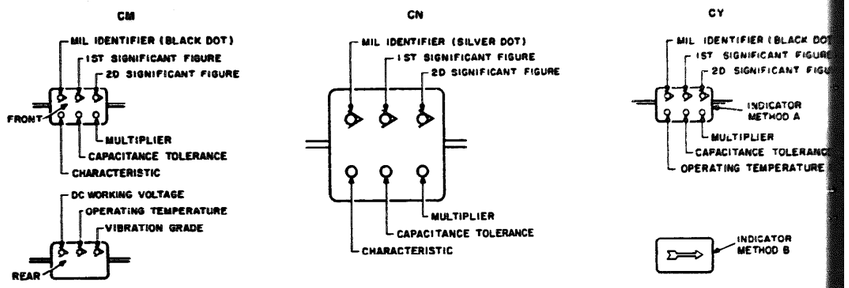
COLOR CODING FOR TUBULAR ENCAPSULATED R.F. CHOKES.

COLOR	SIGNIFICANT FIGURE	MULTIPLIER	INDUCTANCE TOLERANCE (PERCENT)
BLACK	0	1	
BROWN	1	10	1
RED	2	100	2
ORANGE	3	1,000	3
YELLOW	4		
GREEN	5		
BLUE	6		
VIOLET	7		
GRAY	8		
WHITE	9		
NONE			20
SILVER			10
GOLD	DECIMAL POINT		5

MULTIPLIER IS THE FACTOR BY WHICH THE TWO COLOR FIGURES ARE MULTIPLIED TO OBTAIN THE INDUCTANCE VALUE OF THE CHOKE COIL.

B. COLOR CODE MARKING FOR MILITARY STANDARD INDUCTORS.

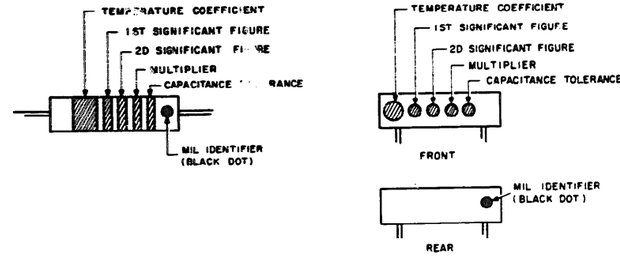
CAPACITORS, FIXED, VARIOUS-DIELECTRICS, STYLES CM, CN, CY, AND CB.



MICA-DIELECTRIC

PAPER-DIELECTRIC

GLASS-DIELECTRIC, GLASS CASE



AXIAL LEAD

RADIAL LEAD

C. COLOR

L SPEC IDENT (SILVER)

1ST FIG. (ORANGE)

FIG. (ORANGE)

MULT (BROWN)

TOLERANCE (GOLD)

(B) 330 UH ± 5%

R.F. CHOKES. AT A, AN EXAMPLE OF EN. AT B, THE COLOR BANDS FOR

2
CAPSULATED R.F CHOKES.

ER	INDUCTANCE TOLERANCE (PERCENT)
	1
	2
	3
	20
	10
	5

HICH THE TWO COLOR FIGURES DUCTANCE VALUE OF THE

ARY STANDARD INDUCTORS.

CAPACITORS, FIXED, VARIOUS-DIELECTRICS, STYLES CM, CN, CY, AND CB.

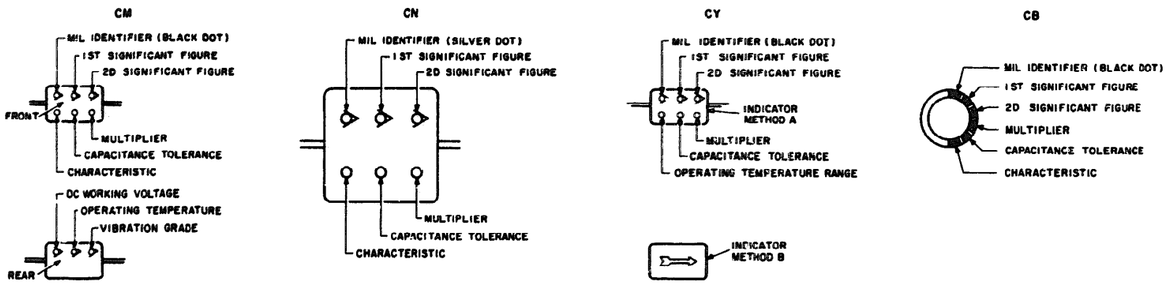


TABLE 3 — FOR USE WITH STYLES CM, CN, CY AND CB.

COLOR	MIL ID	1ST SIG FIG.	2D SIG FIG.	MULTIPLIER[1]	CAPACITANCE TOLERANCE				CHARACTERISTIC[2]			DC WORKING VOLTAGE	OPERATING TEMP RANGE	VIBRATION GRADE
					CM	CN	CY	CB	CM	CN	CB	CM	CY, CM	CM
BLACK	CM,CY CB	0	0	1			±20%	±20%		A			-55° TO +70°C	10-55 HZ
BROWN		1	1	10					B	E	B			
RED		2	2	100	±2%		±2%	±2%	C				-55° TO +85°C	
ORANGE		3	3	1,000		±30%			D		D	300		
YELLOW		4	4	10,000					E				-55° TO +125°C	10-2,000 HZ
GREEN		5	5		±5%				F			500		
BLUE		6	6										-55° TO +150°C	
PURPLE (VIOLET)		7	7											
GREY		8	8											
WHITE		9	9											
GOLD				0.1			±5%	±5%						
SILVER	CN				±10%	±10%	±10%	±10%						

C. COLOR CODE MARKING FOR MILITARY STANDARD CAPACITORS.

TABLE 4 — TEMPERATURE COMPENSATING, STYLE CC.

COLOR	TEMPERATURE COEFFICIENT[4]	1ST SIG FIG.	2D SIG FIG.	MULTIPLIER[1]	CAPACITANCE TOLERANCE		MIL ID
					CAPACITANCES OVER 10 UUF	CAPACITANCES 10 UUF OR LESS	
BLACK	0	0	0	1		± 2.0 UUF	CC
BROWN	-30	1	1	10	± 1%		
RED	-80	2	2	100	± 2%	± 0.25 UUF	
ORANGE	-150	3	3	1,000			
YELLOW	-220	4	4				
GREEN	-330	5	5		± 5%	± 0.5 UUF	
BLUE	-470	6	6				
PURPLE (VIOLET)	-750	7	7				
GREY		8	8	0.01			
WHITE		9	9	0.1	± 10%		
GOLD	+100					± 1.0 UUF	
SILVER							

1. THE MULTIPLIER IS THE NUMBER BY WHICH THE TWO SIGNIFICANT (SIG) FIGURES ARE MULTIPLIED TO OBTAIN THE CAPACITANCE IN UUF.
2. LETTERS INDICATE THE CHARACTERISTICS DESIGNATED IN APPLICABLE SPECIFICATIONS: MIL-C-5, MIL-C-25D, MIL-C-11272B, AND MIL-C-10950C RESPECTIVELY.
3. LETTERS INDICATE THE TEMPERATURE RANGE AND VOLTAGE-TEMPERATURE LIMITS DESIGNATED IN MIL-C-11015D.
4. TEMPERATURE COEFFICIENT IN PARTS PER MILLION PER DEGREE CENTIGRADE.

ESC-FM 1794-71

Figure 5-35. MIL STD, resistor and capacitor color code markings.

APPENDIX A

REFERENCES

The following publications contain information applicable to the AN/USM-365(V)1:

DA Pam 310-4	Military Publications: Index of Technical Manuals, Technical Bulletins, Supply Manuals (types 7, 8, and 9), Supply Bulletins, and Lubrication Orders.
DA Pam 310-7	US Army Equipment Index of Modification Work Orders.
SB 38-100	Preservation, Packaging, Packing and Marking Materials, Supplies and Equipment Used by the Army.
TB 746-10	Field Instructions for Painting and Preserving Electronics Command Equipment.
TB 9-6625-1870-50	Calibration Procedure for Wattmeter TS-430/U and Weston Model 310 Series.
TM 11-6625-200-15	Operator's, Organizational, DS, GS, and Depot Maintenance Manual: Multimeters ME-26A/U, ME-26B/U, ME-26C/U, and ME-26D/U.
TM 11-6625-537-15	Operator, Organizational, Field, and Depot Maintenance Manual: Differential Voltmeter ME-202/U.
TM 11-6625-537-15-1	Organizational, DS, GS, and Depot Maintenance Manual: Voltmeter, Electronic ME-202A/U.
TM 11-6625-700-10	Operator's Manual: Digital Readout, Electronic Counter AN/USM-207
TM 11-6625-322-12	Operator and Organizational Maintenance Manual: Signal Generator SG-321B/U.

TM 11-6625-2507-14	
TM 11-6625-2507-20P	Organizational Maintenance Repair Parts and Special Tools List: Recorder, Thermal Oscillograph AN/USM-365(V)1.
TM 11-6625-2507-40P	General Support Maintenance Repair Parts and Special Tools List: Recorder, Thermal Oscillograph AN/USM-365(V).
TM 36-750	The Army Maintenance Management System (TAMMS).
TM 740-90-1	Administrative Storage of Equipment.

APPENDIX B

MAINTENANCE ALLOCATION

Section I INTRODUCTION

B-1. General.

This appendix provides a summary of the maintenance operations covered in the equipment literature. It authorizes categories of maintenance for specific maintenance functions on repairable items and components and the tools and equipment required to perform each function. This appendix may be used as an aid in planning maintenance operations.

B-2. Maintenance Functions

Maintenance functions will be limited to and defined as follows:

a. Inspect. To determine serviceability of an item by comparing its physical, mechanical, and electrical characteristics with established standards.

b. Test. To verify serviceability and to detect incipient electrical or mechanical failure by use of special equipment such as gages, meters, etc. This is accomplished with external test equipment and does not include operation of the equipment and operator type tests using internal meters or indicating devices.

c. Service. To clean, to preserve, to charge, and to add fuel, lubricants, cooling agents, and air. If it is desired that elements, such as painting and lubricating, be defined separately, they may be so listed.

d. Adjust. To rectify to the extent necessary to bring into proper operating range.

e. Align. To adjust two or more components or assemblies of an electrical or mechanical system so that their functions are properly synchronized. This does not include setting the frequency control knob of radio receivers or transmitters to the desired frequency.

f. Calibrate. To determine the corrections to be made in the readings of instruments or test equipment used in precise measurement. Consists of the comparison of two instruments, one of which is a certified standard of known accuracy, to detect and adjust any discrepancy in the accuracy of the instrument being compared with the certified standard.

g. Install. To set up for use in an operational environment such as an encampment, site, or vehicle.

h. Replace. To replace unserviceable items with serviceable like item.

i. Repair. To restore an item to serviceable condition through correction of a specific failure of unserviceable condition. This function includes, but is not limited to welding, grinding, riveting, straightening, and replacement of parts other than the trial and error replacement of running spare type items such as fuses, lamps, or electron tubes.

j. Overhaul. Normally, the highest degree of maintenance performed by the Army in order to minimize time work in process is consistent with quality and economy of operation. It consists of that maintenance necessary to restore an item to completely serviceable condition as prescribed by maintenance standards in technical publications for each item of equipment. Overhaul normally does not return an item to like new, zero mileage, or zero hour condition.

k. Rebuild. The highest degree of materiel maintenance. It consists of restoring equipment as nearly as possible to new condition in accordance with original manufacturing standards. Rebuild is performed only when required by operational considerations or other paramount factors and then only at the depot maintenance category. Rebuild reduces to zero the hours or miles the equipment, or component thereof, has been in use.

l. Symbols. The uppercase letter placed in the appropriate column indicates the lowest level at which that particular maintenance function is to be performed.

B-3. Explanation of Format.

a. Column 1, Group Number. Column 1 lists group numbers, the purpose of which is to identify components, assemblies, subassemblies and modules with the next higher assembly.

b. Column 2, Functional Group. Column 2 lists the noun names of components, assemblies, subassemblies and modules on which maintenance is authorized.

c. Column 3, Maintenance Functions. Column 3 lists the maintenance category at which performance of the specific maintenance function is authorized. Authorization to perform a function at any category also includes authorization to perform that function at higher categories. The codes used represent the various maintenance categories as follows:

Code	Maintenance Category
C	Operator/Crew
O	Organizational Maintenance
F	Direct Support Maintenance
H	General Support Maintenance
D	Depot Maintenance

d. Column 4, Tools and Test Equipment. Column 4 specifies, by code, those tools and test equipment required to perform the designated function. The numbers appearing in this column refer to specific tools and test equipment which are identified in Table I.

e. Column 5, Remarks. Self-explanatory.

B-4.. Explanation of format of Table ITool and Test Equipment Requirements.

The column in Table I, Tool and Test Equipment Requirements are as follows:

a. Tools and Equipment. The numbers in this column coincide with the numbers used in the tools and equipment column of the applicable tool for the maintenance function.

b. Maintenance Category. The codes in this column indicate the maintenance category normally allocated the facility.

c. Nomenclature. This column lists tools, test, and maintenance equipment required to perform the maintenance functions.

d. Federal Stock Number. This column lists the Federal stock number of the specific tool or test equipment.

e. Tool Number. Not used.

SECTION II. MAINTENANCE ALLOCATION CHART

GROUP NUMBER	COMPONENT ASSEMBLY NOMENCLATURE	MAINTENANCE FUNCTIONS											TOOLS AND EQUIPMENT	REMARKS
		INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD		
	RECORDER, THERMAL OSCILLOGRAPH AN/USM-365(V)1	O	O						C				3 thru 6,10	Perform visual inspection. Fault isolate a failure to one of following assemblies: PL-1305/U PL-1306/U PL-1307/U Power Supply 356-400BW Driver Amplifier 7700-02B Power Supply 8848A Galvanometer Mechanical Section Cabinet
				O									10	Lubricate mechanical portion of recorder.
					O								8,10	Make following adjustments when necessary: Brake Roll Drive Roll Stylus Pressure Stylus Mechanical Stop Stylus Overhang Stylus Mechanical Center Marker Amplitude Galvanometer Sensitivity Paper Takeup Clutch
									O				10	Repair by replacement of following: Knobs Fuses Galvanometer Easily replaceable mechanical items
											D		1 thru 12	See note.

MAINTENANCE ALLOCATION CHART

GROUP NUMBER	COMPONENT ASSEMBLY NOMENCLATURE	MAINTENANCE FUNCTIONS											TOOLS AND EQUIPMENT	REMARKS
		INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD		
	PLUG-IN UNIT, ELECTRONIC TEST EQUIPMENT PL-1305/U	O	H										2 thru 7,9,11	Perform visual inspection. Fault isolate a failure to a discrete component (must be tested while being powered by recorder).
					H								3 thru 6,10	
										H			10	Repair by replacement of discrete components
	PLUG-IN UNIT, ELECTRONIC TEST EQUIPMENT PL-1306/U	O	H										2 thru 7,9,11	Perform visual inspection. Fault isolate a failure to a discrete component (must be tested while being powered by recorder).
						H							3 thru 6,10	
										H			10	Repair by replacement of discrete components.
	PLUG-IN UNIT, ELECTRONIC TEST EQUIPMENT PL-1307/U	O	H										2 thru 7,9,11	Perform visual inspection. Fault isolate a failure to a discrete component (must be tested while being powered by recorder).
					H								3 thru 6,10	
										H			10	Repair by replacement of discrete components.
	POWER SUPPLY 356-4008W01	O	H										1,3,6	Perform visual inspection. Fault isolate a failure to a discrete component (must be tested while being powered by recorder).
					H								1,3,6,10	
										H			10	Repair by replacement of discrete components.

MAINTENANCE ALLOCATION CHART

GROUP NUMBER	COMPONENT ASSEMBLY NOMENCLATURE	MAINTENANCE FUNCTIONS											TOOLS AND EQUIPMENT	REMARKS
		INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD		
	DRIVER AMPLIFIER 7700-02B	O												
			H										2 thru 7,9,11	Perform visual inspection. Fault isolate a failure to a discrete component (must be tested while being powered by recorder).
					H								2 thru 7,9 10	
										H				Repair by replacement of discrete components.
	POWER SUPPLY 6644A	O												
			H										1,3,4,6	Perform visual inspection. Fault isolate a failure to a discrete component (must be tested while being powered by recorder).
					H								1,3,4,6,10	
										H			10	Repair by replacement of discrete components.
	MECHANICAL SECTION	O												
			O										10	Perform visual inspection. Fault isolate a failure to one of following: Belt Takeup 1500-0738 Chain Silent 1500-0706 Chain Silent 1500-0708 Gear Train Assy 358-700A Guide Adj Paper Ind 358-150 Marker and Coil Holder Assy 608-100-C3 Hub Roll Paper 154-100-C3 Paper Spool Assy 358-100-C3 Motor Synchronous 115V 60HZ 3140-0334 Paper Spindle Assy 358-100-C25 Pulley Groove 561-1 Pulley and Clutch Assy 358-100-C23 Pulley and Pin Locating Assy 358-100-C18 Roll Drive 158-100-C2

MAINTENANCE ALLOCATION CHART

GROUP NUMBER	COMPONENT ASSEMBLY NOMENCLATURE	MAINTENANCE FUNCTIONS											TOOLS AND EQUIPMENT	REMARKS
		INSPECT	TEST	SERVICE	ADJUST	ALIGN	CALIBRATE	INSTALL	REPLACE	REPAIR	OVERHAUL	REBUILD		
														Timer Sequential 60Hz 14002G Sprocket Wheels Springs Gear Box
					O								10	
										O			10	Repair by replacement of faulty parts.
	GEAR BOX 356-700A	D												Perform visual inspection.
			D										10	Fault isolate a failure to a faulty part.
				D									10	Lubricate gear box after all repairs.
									H				10	
										D			10	Repair by replacement of faulty parts.
	CABINET	O												Perform visual inspection.
			H										12	Fault isolate a failure to plugs, connectors, and power cords.
										H			10	Repair by replacement of plugs, connectors, and power cords.
														NOTE For other repairs, see individual assemblies.

TABLE I. TOOL AND TEST EQUIPMENT REQUIREMENTS

TOOLS AND EQUIPMENT	MAINTENANCE CATEGORY	NOMENCLATURE	FEDERAL STOCK NUMBER	TOOL NUMBER
1	H,D	TRANSFORMER, VARIABLE POWER CN-16/U	5950-235-2086	
2	H,D	VOLTMETER ME-186/U	6625-720-3537	
3	O,H,D	OSCILLOSCOPE AN/USM-281A	6625-228-2201	
4	O,H,D	VOLTMETER, ELECTRONIC ME-202( )/U	6625-700-0288	
5	O,H,D	GENERATOR, SIGNAL SG-321/U	6625-674-7097	
6	O,H,D	MULTIMETER ME-26B/U	6625-542-6407	
7	H,D	WATTMETER TS-430( )/U	6625-498-3630	
8	O,H,D	TYLAN PRESSURE TESTER		HP 14015A
9	H,D	COUNTER, ELECTRONIC DIGITAL READOUT AN/USM-207( )	6625-911-6368	
10	O,H,D	TOOL KIT, ELECTRONIC EQUIPMENT TK-105/G	5180-610-8177	
11	H,D	TEST SET, SEMICONDUCTOR DEVICE TS-1836/U	6625-893-2628	
12	H,D	MULTIMETER AN/USM-223	6625-999-7465	

APPENDIX C

PLUG-IN UNIT, ELECTRONIC TEST EQUIPMENT

PL-1305/U

NOTE

This appendix provides operating and maintenance instructions for Plug-In Unit, Electronic Test Equipment PL-1305/U. Throughout the appendix the PL-1305/U is referred to as Model 8802A Medium Gain Dc Preamplifier

figure C-5

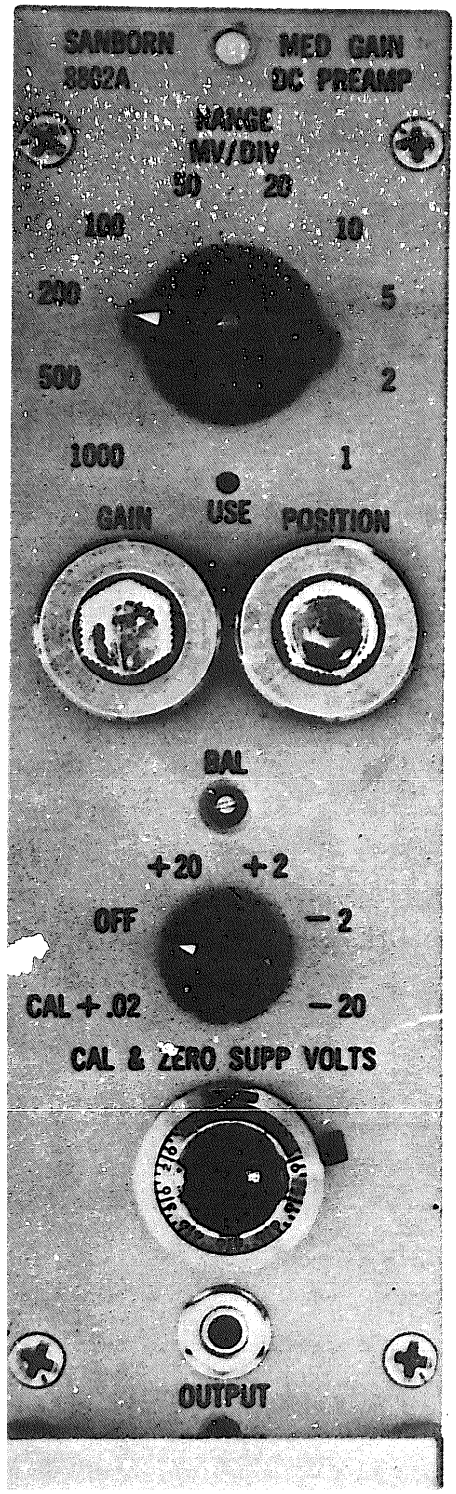


Figure C-O Model 8802a Gain DC Preamplifier

SECTION I

DESCRIPTION

C-1. INTRODUCTION

C-2. **The Model 8802A Medium Gain Preamplifier is a plug-in unit used as a component of a 7701B, 7704B, 7708B or 7858B Recording System. 8802A option 01 is mounted singly in a portable case with a built-in power supply for bench-top operation. Option 01 consists of the 8802A Preamplifier, a model 8849A Power Supply, and Carrying Case Model 860-1400. A multichannel Power Supply, Model 8848A is available for mounting up to 8 preamplifiers.**

C-3. The preamplifier is a direct coupled six stage amplifier, with balanced inputs and calibrated zero suppression. It accepts an input signal in the range of millivolts to volts, to provide an analog data recording from dc to 150 cps.

C-4 CHARACTERISTICS

ignal Input: Balanced to ground.

Input Impedance: 180K ohms ±1%, resistive, each side, **to ground, in parallel with approximately 100 pF.**

Output: Single-ended to ground, with capability of ±3 volts maximum across 1000 ohms minimum.

Output Resistance: Approximately 50 ohms.

C-5. PERFORMANCE DATA

Sensitivity: 1 mv input (single-ended or differential) produces 100 mv output at calibrated gain.

Offset Current: 0.5 μa maximum. This is a current which may exist in the input circuit and develop a voltage across any external source resistance.

Attenuation: X1, 2, 5, 10, 20, 50, 100, 200, 500, 1000. Accuracy is ±1%.

Common-Mode: Common-mode rejection ratio, dc to 150 cps, -60 db typically, but can be a minimum of -48 db (250:1).

Common-Mode Tolerance: ±12.5 volts maximum on three most sensitive ranges, ±125 volts maximum on next three ranges, ±500 volts maximum on other ranges, for no more than ±1% change of differential sensitivity.

Zero Suppression: Suppression precedes single attenuation and GAIN control, and may be used with single-ended or balanced inputs. Suppression ranges referred to input are ±2 and ±20 volts. Error of suppression is ±0.25% of suppression range, ±0.25% of indicated suppression maximum. On the three most sensitive attenuator ranges only, suppression can not be used above ±12.5 volts. Suppression is derived from the system power supply, with individual Zener diode regulators. Internal control is provided for amplitude trim.

Calibration: 20 mv, ±1%, internal, derived from zero suppression supply.

Bandwidth: DC to 10 KC, within 3 db.

Noise: Less than 10mv peak-to-peak at the output, over 0 to 150 cps bandwidth. Less than 50mv peak-to-peak at the output, entire bandwidth.

Drift: 100 mv/10°C maximum at output, 0 to 40°C. 10 mv maximum for line voltage variation from 103 to 127 volts. 50mv. for 8 hours.

Linearity: Over the range of -2.5 to +2.5 volts, departure of the output from a straight line through 0 and 2 volts output is less than ±5 mv for a load resistance of greater than 5,000 ohms, and less than ±25 mv with a 1,000-ohm load.

Gain Stability: 0.1%/10°C maximum, 0 to 40°C. 0.1% maximum for line voltage variation 103 to 127 volts.

RECORDING SYSTEM SPECIFICATION: Full scale is 50 divisions edge-to-edge.

Drift: 1 div/10°C maximum, 0 to 40°C. 1/10 division maximum for line voltage variation from 103 to 127 volts. 0.5 div. for 8 hours. **at constant ambient.**

Gain Stability: 0.5%/10°C maximum, 0 to 40°C. 0.5% maximum for line voltage variation from 103 to 127 volts.

Linearity: 0.25 division maximum non-linearity.

Sensitivity: 1, 2, 5, 10, 20, 50, 100, 200, 500 and 1000 mv/div., corresponding to .05, .1, .25, .5, 1, 2.5, 5, 10, 25, and 50 volts edge-to-edge on a 50-division chart.

Frequency Response: 0-125 cps within 3 db, 4 in. stylus, 10 divisions peak-to-peak amplitude.

0-150 cps, 3 in. stylus, 10 divisions peak-to-peak amplitude.

Transient Response: 5 milliseconds, 0 to 90% of 10 divisions displacement, 4 in. stylus, 4% maximum overshoot.

4 milliseconds, 0 to 90% of 10 divisions displacement, 3 in. stylus, 4% overshoot.

Noise: Less than 0.2 division peak-to-peak.

C-6. FRONT PANEL DATA

RANGE: A ten-position rotary switch with ten gain positions. A SIGNAL USE-OFF push-button is concentric with the range switch. When the amplifier is calibrated to its normal gain, the positions correspond to recording sensitivities of 1, 2, 5, 10, 20, 50, 100, 200, 500, and 1000 mv/division.

GAIN: Variable control to provide overlapping gain between RANGE steps.

BALANCE: Screwdriver adjustment to correct for inherent unbalance in the input amplifier.

CALIBRATION: Screwdriver adjustment sets calibration voltage level and zero suppression level.

POSITION: Variable control to precisely set the zero signal output of the preamplifier for zero signal input.

CAL-OFF-ZERO SUPPRESSION: Five-position rotary control plus an OFF position to select the 100 mv calibrate voltage or one of the zero suppression voltages (±2, ±20 volts).

ZERO SUPPRESSION: 10-turn potentiometer used to set the precise value of zero suppression voltages up to either ±2 or ±20 volts.

SECTION II

INSTALLATION

-7 INTRODUCTION

- 8 Before operating the Preamplifier, the signal and oad must be properly connected, and the Preamplifier hould be balanced and calibrated.

-9 CONNECTION INPUT SIGNAL

a. Supplied with the power supply accessories is a 5 pin connector 1251-1895 hich mates with the power supply rear nput connector. Connector wiring is hown in figure C-1. Connector con-- truction is shown in figure C-2.

Figure c-1. Input Connector Wiring Diagram

o construct the signal cable:

(1) Disassemble the input connector by removing the retaining ring on the face of the connector.

(2) Remove the guard extension shell from around the signal terminals (A & B). A guard connection is not used with this preamplifier.

(3) Slip the connector shell over the signal leads with the connector clamp facing away from the lead ends.

(4) Connect the signal + lead to pin A, and the signal - lead to pin B.

(5) Connect signal cable shield to pin C. Connect a jumper wire between C and the guard shield, as shown in figure C-1.

(6) Slip the connector shell over the connector, replace the retaining ring, and tighten the connector clamp as desired.

(7) Connect the signal cable to the appropriate input connector at the rear of the power supply.

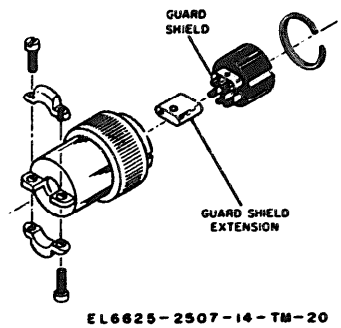


Figure c-2. Signal Input connector 1251-1895.

c-10 CONNECTING TO PREAMPLIFIER OUTPUT

C - 1 1 Refer to Table C-1 for output connector wiring.

Table C-1. Signal Interconnections

MODEL 8802A PREAMPLIFIER		POWER SUPPLY	
		8848A, 8848A – OPTION 01 8848A – OPTION 02	8849A
SIGNAL INPUT	+ SIGNAL INPUT	J11 PIN A (TYP CH 1–8)	J3 PIN A
	– SIGNAL INPUT	J11 PIN B	J3 PIN B
	INNER SHIELD	J11 PIN C	J3 PIN C
	OUTER SHIELD	J11 PIN C	J3 PIN C
OUTPUT	SIGNAL OUTPUT	J21 PIN E (TYP CH 1–8)	J2 PIN E
	GROUND	J21 PIN L	J2 PIN L

c-12. BALANCE AND CALIBRATION

a. The following steps are required for initial operation and need be repeated only as the preamplifier ages, or whenever components have been replaced:

(1) After 10 minute warm-up period, set the CAL-ZERO SUPP switch to the OFF position.

(2) Set the signal USE-OFF button in the OFF position, i.e., button extending about 5/16 in. If not, push in to release.

(3) Set POSITION control for zero output (chart center).

(4) Rotate the GAIN control throughout its full range. There should be no change in output indication.

(5) If change is observed, adjust the BALANCE control for zero change in output while rotating the GAIN control.

(6) Turn the CAL-ZERO SUPP control to the CAL position.

(7) Rotate the RANGE switch to the 1 MV/DIV position.

(8) Adjust the GAIN control for an output of 2 volts: 20 division deflection on the recorder chart.

(9) Set the CAL-ZERO SUPP switch to the OFF position.

C-13-ZERO SUPPRESSION OPERATION. fig. C-3

a. Without ZERO SUPPRESSION:

(1) Set CAL-ZERO SUPP switch to OFF.

(2) Set the signal USE-OFF push-button to OFF (button extended 5/16 in.).

(3) Set the POSITION for desired baseline.

(4) Apply signal and push signal USE-OFF push-button in (button extended 1/8 in.).

(5) Advance RANGE control for convenient output.

b. With ZERO SUPPRESSION:

(1) Set the signal USE-OFF push-button to OFF.

(2) Adjust the POSITION control for desired baseline.

(3) Set the CAL-ZERO SUPP switch to the desired zero suppression range.

(4) Set the signal USE-OFF push-button to the USE position.

(5) Set the RANGE switch for minimum gain and adjust the 10-turn potentiometer for original baseline.

(6) Advance the RANGE control to the desired sensitivity and readjust the potentiometer to maintain the baseline previously set.

NOTE

The voltage being measured is the algebraic sum of the voltage suppressed, as read from the zero suppression dial, plus the voltage indicated by stylus deflection if other than zero.

20 volts maximum suppression, ALL RANGES, with 1000 division dial, is equivalent to 0.02 volts/dial division or 50 dial divisions per volt.

2 volts maximum suppression, ALL RANGES, with 1000 division dial, is equivalent to 0.002 volts/dial division or 500 dial divisions per volt.

RANGE Switch Setting MV/Chart Division	Volts Input/50 Chart Division Deflection	Zero Suppression Dial Division/Chart Division Suppression Range		Maximum Zero Suppression In Chart Division Suppression Range	
		20V	2V	100V	10V
1000	50	50	500	20	2
500	25	25	250	10	4
200	10	10	100	100	10
100	5	5	50	200	20
50	2.5	2.5	25	400	40
20	1	1	10	1000	100
10	.5	.5	5	2000	200
5	.25	.25	2.5	4000	400
2	.1	.1	1	10000	1000
1	.05	.05	.5	20000	2000

NOTE

Figures within dashed lines indicate ranges which should NOT be used above 500 dial divisions (50 V).

Figure C-3. Range Setting. Input and Zero Suppression Chart

SECTION III

FUNCTIONING

C-14. INTRODUCTION

C-15. The Medium Gain DC Preamplifier, Model 8802A, consists of the input circuitry and two amplifier blocks. The first amplifier block is operated at selected fixed gains in a 1, 2, 4 ratio. The balance control circuit is included in this section. The second amplifier block has constant gain. The POSITION control circuit is in this section. The continuous GAIN control is between the two amplifier blocks. The overall gain of the amplifier is the product of the gain of the two blocks.

C-16. CAL-ZERO SUPPRESSION CIRCUIT

C-17. The Power Supply used with the 8802A preamplifier furnishes a +12 volt source for the calibration and zero suppression circuit. This is used to produce a very stable +10 volts by means of the current regulator Q1 and the Zener diode CR1 (Fig. C-4

C-18 The base and emitter voltages of Q1 are both proportional to the +12 volt source, thus maintaining their relationship, even though the source may vary. R8 has positive temperature coefficient to compensate for any changes in emitter to base voltages due to temperature changes affecting Q1. The constant current through Q1 is applied to the Zener diode CR1 in parallel with a 2 K ohm load. The CAL ADJUST control is a factory adjustment to set the value of collector voltage at precisely 10 volts, by adding a small stable voltage in series with the special temperature compensated Zener diode CR1. The voltage of CR1 is between 9.2 and 9.6 volts.

C-19 When the CAL-ZERO SUPP switch (S2) is in the CAL position, (fig. C-5 the +10 volts from the collector of Q1 is applied to the series-parallel resistors R11 through R15. The voltage at the junction of R14 and R15 is the 0.02 volt calibration source and this voltage is fed to the input of the preamplifier.

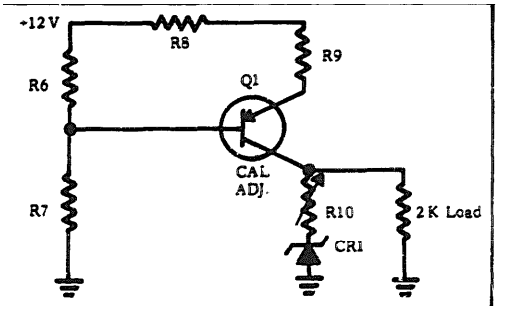


Figure C-4. Simplified schematic- CAL-ZERO Suppression Source

C-20. When the switch S2 is in the ±20 volt Zero Suppression ranges, the +10 volts from Q1 is connected across the ten-turn precision potentiometer (R13). The potentiometer is bridged by R12 which is selected so that the combination R12 and R13 presents the proper 2 K ohm load to the +10 volt source. The potentiometer is adjusted to set the exact values of zero suppression voltage to be applied to the preamplifier. When S2 is on the ±2 volt ranges, the voltage across the potentiometer is reduced to +1 volt by R11, R14, and R15. Polarity reversal is accomplished by injecting the suppression voltage into one side or the other of the amplifier, at the junction of either R1 and R2 or R17 and R18. 10 volts from Q1 is equivalent to 100 volts signal at the input. Positive suppression is defined as a voltage which will cancel a positive signal applied to input terminal A.

C-21. INPUT CIRCUIT THEORY

C-22 The input signal is applied to the A and B terminals of connector J1, which is connected to the signal USE-OFF push-button switch on the RANGE switch. The signal from the push-button switch to the CAL-ZERO SUPP switch, which will then pass the input signal in any position except the CAL position. This signal is then applied through resistive networks to the bases of the input transistors Q2 and Q3. These networks prevent excessive signal currents from damaging the input transistors, allow a high and stable value of input resistance, and isolate the input transistors from the effects of unbalanced signal source resistance. Additional factors of attenuation of 10 and 100 are provided on each side of the input.

C-23. INPUT AMPLIFIER CIRCUIT THEORY

C-24 The input amplifier block consists of transistors Q2 through Q9 and their associated components. This block is made up of four direct coupled differential amplifiers. The input signal is applied to the base of Q2 and Q3; the output from this section is taken from the collectors of Q8 and Q9. The BALANCE control is in the emitter circuits of Q4 and Q5 and is used to correct for the inherent unbalance of the input circuit.

C-25 The output from the fourth stage is fed back through resistors to the emitters of Q2 and Q3. This serves to maintain linearity and gain stability for the input amplifier block. Shunts are applied to the feedback loop to increase gain by factors of 2 and 4. The shunting resistors, R21 and R22, are selected by the RANGE switch. Signal gain for the input amplifier is approximately 160 times, in the most sensitive range. The GAIN control provides smooth gain variation with overlapping gain for each RANGE step, by shunting the inputs to Q10 and Q11.

c-26. OUTPUT AMPLIFIER CIRCUIT THEORY

C-27/ The output amplifier block consists of transistors Q10 through Q12 and associated components, connected in a differential to single-ended output configuration. The differential signal from the input amplifier is applied to the bases of Q10 and Q11. A portion of the output from Q12 is also fed back into the base of Q11 to maintain the stability of output stages. The POSITION control produces variations in the voltage applied to the base of Q11 for the purpose of exactly setting the position of the writing arm stylus. The POSITION control is connected across the +12 and -12 volt sources. The gain of the output amplifier is designed to be of such value that nominal gain will be attained with the smooth GAIN control in the middle of its range, thus allowing more flexible operation. The gain of this stage is approximately 2-1/2 times.

SECTION IV
MAINTENANCE

C-28. REMOVAL AND REPLACEMENT

a. Power Supply

(1) Disconnect all connectors at the amplifier power supply rear, checking that these can be replaced in their proper order when re-installing the unit.

(2) Remove the four screws which hold the front of the rack slide assembly to the cabinet and pull part way out.

(3) With the help of an assistant, press the lock-springs on both sides of the rack and pull the unit out the rest of the way, and place on a work bench.

(4) To replace amplifier power supply, reverse the preceding steps.

b. Amplifier(s)

To remove the amplifier(s), remove the screws from the top and bottom of the amplifier front panel, and slide the amplifier out of the rack.

To replace the amplifier(s), slide the amplifier into the slot in the weldment, and seat the amplifier connector firmly into the power supply connector.

c. Regulator and Oscillator Cards

These cards are located at the rear of the amplifier power supply under a black plastic cover and are accessible at the rear of the power supply. For access, remove the power supply (a above), and proceed as follows:

(1) Remove the white nylon screw that is on the black cover.

(2) Remove the first two amplifiers on the left (viewed from the front). This will make the second screw to be removed from the black cover available. Remove this screw and remove the cover.

(3) Locate card(s) to be removed using figure C-6 as a guide.

(4) Remove the two screws that secure the card to the chassis, then pull the card out of its connector.

To replace the card(s), press the card firmly into its connector. DO NOT INSERT THE CARD(S) INTO THE WRONG CONNECTOR SOCKET. Replace the two screws through the bracket and into the chassis. Replace the black cover and replace the nylon screws. Replace the two amplifiers.

d. Fuse(s)

The power supply circuits as well as the amplifier circuits are protected by the fuses located at the rear of the power supply. Refer to paragraph C-30 for fuse type and location.

C-29. CHECKS AND ADJUSTMENTS

a. Power Supply

(1) Remove each power supply fuse in turn, and check that its value matches its required value.

(2) Check for 115 volt power line.

(3) Prepare other parts of the system for normal operation and allow at least 15 minutes warm-up time.

(4) Connect an accurate voltmeter for 12 volt measurements, connecting between pin R(the power supply ground) of connector J33 and pin D(-12 V). Set the -12 volt VOLTS ADJ control for a reading of -12 volts on the meter.

(5) Now connect the meter between pins R and B of the same connector. Voltage should be within ±.25 volt of the +12 volts required. If outside the limits, the -12 volt setting can be changed to divide the error, as long as the reading at either potential is within ±.25 volts of the 12 volt point.

If any of the dc voltages or the 440 cps excitation voltage are not present, the power supply should be checked to see that power is applied (line voltage 115 V rms) and that the fuses are not blown. If any of the dc voltages or 440 cps excitation voltage are present but are not the correct values, check the fuses.

Remove the amplifiers to eliminate shorts in amplifier(s) from causing apparent power supply problems.

The dc voltages +12 and -12 regulated depend upon the +18 and -18 volt unregulated sources so that if the regulated voltages are not present, inspect the unregulated points.

The ripple on the unregulated supply is approximately 2 volts peak-to-peak at 120 cycles when fully loaded with 1.4 amps. If the ripple is 60 cycles, it indicates that some of the appropriate diodes CR1 through CR10 are open.

If it is not possible to obtain ±18 volts, it may be that any of the diodes CR1 through CR10 are shorted.

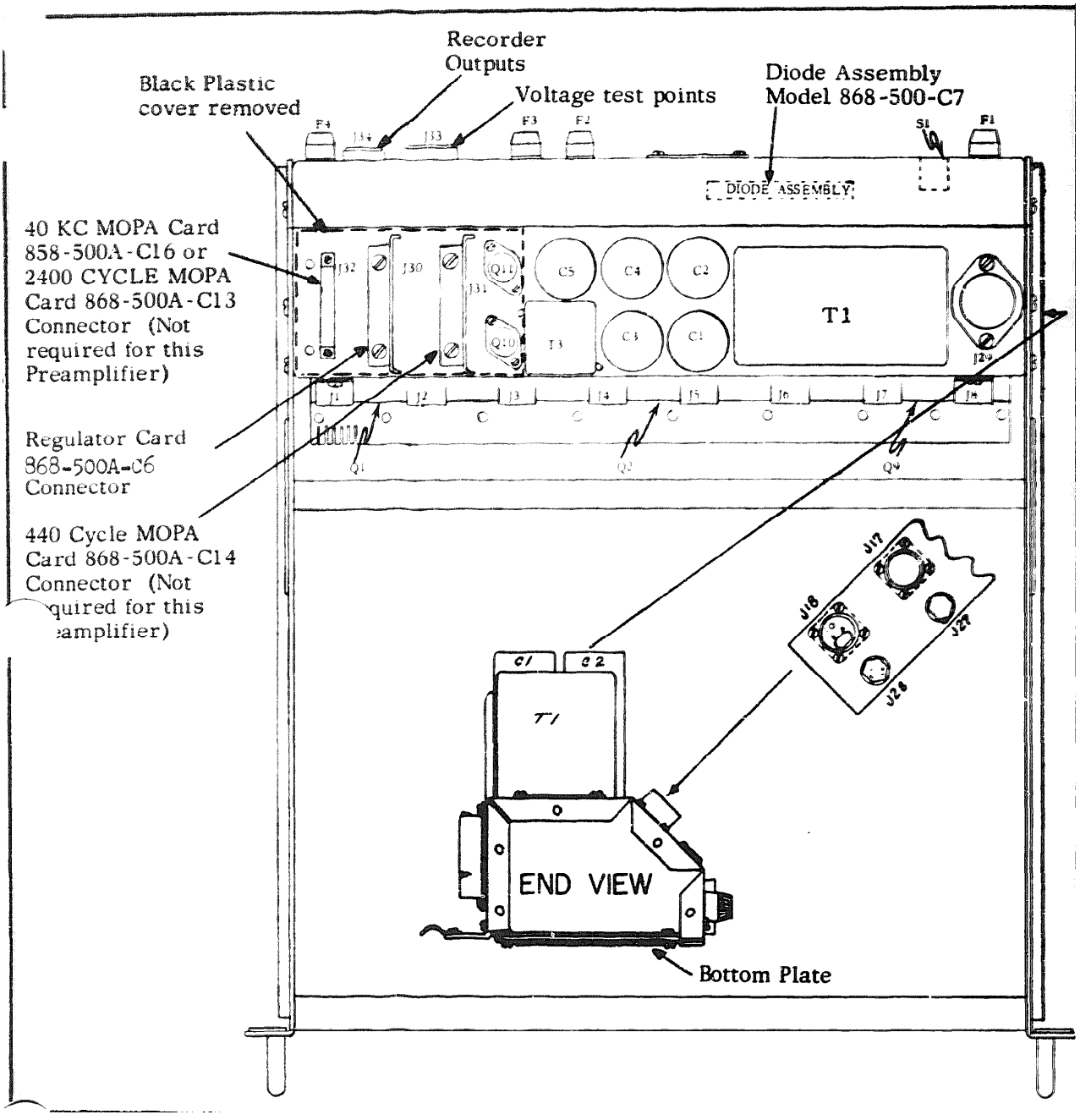


figure C-6. Preamplifier Power Supply (Top View)

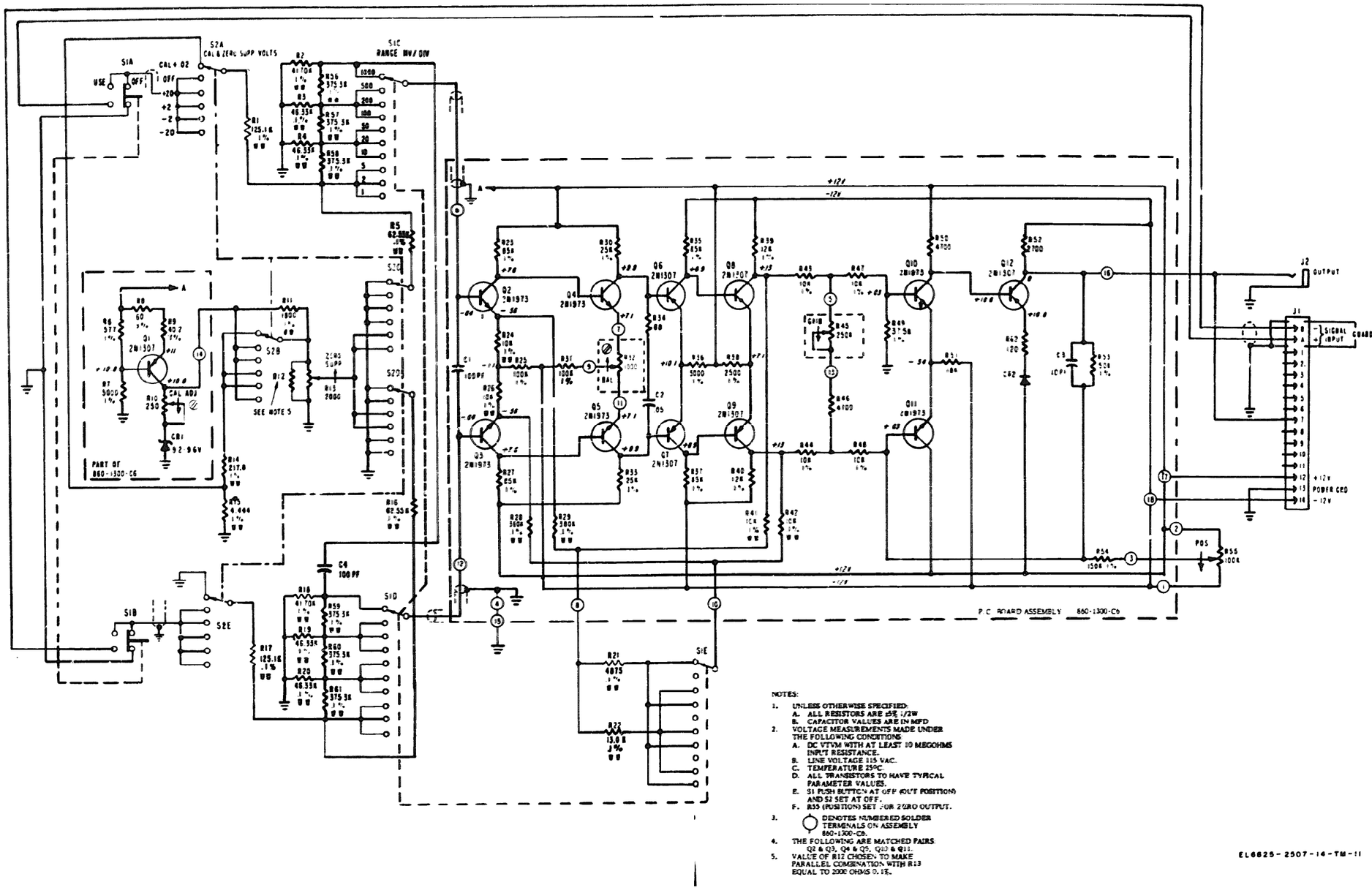


Figure C-5. Medium gain preamplifier model 8802A

Regulated ±12 Volt Problems:

If it is not possible to obtain ±12 volts, check that the unregulated voltages appear at connector J30 (pin C -18 volts, pin H +18 volts, pin A common).

Check to see that Q1 and Q2 are not shorted to the chassis. These transistors are located on the chassis between channels 1 and 2 (Q1) and between channels 4 and 5 (Q2). Check for short by removing the rack from the cabinet and removing the amplifiers from the rack to expose the transistors.

If Q1 and Q2 are shorted, the regulator will not function and the ±12 volt points will assume a value close to ±18 volts.

If ±18 volts is present and Q1, Q2 do not appear to be shorted to the chassis or otherwise inoperative, the problem appears to be isolated to the 868-500A-C6 card as far as the ±12 volts is concerned.

C-30. FUSE DATA

See list below:

FUSE LIST

Symbol No.	Description	Location	Circuit
F1 (115 V)	1.0 Amp Slow Blow Fuse	Rear Panel	115 V Line Power
F2	1.5 Amp Fuse	Rear Panel	-18 Volt Supply
F3	1.5 Amp Fuse	Rear Panel	+18 Volt Supply
F4 *	1.6 Amp Slow Blow Fuse	Rear Panel	Oscillator Supply

* Not active for this Preamplifier.

APPENDIX D

PLUG-IN UNIT, ELECTRONIC TEST EQUIPMENT

PL-1306/U

NOTE

This appendix provides operating and maintenance instructions for Plug-In Unit, Electronic Test Equipment PL-1306/U. Throughout the appendix the PL-1306/U is referred to as Model 8803A High Gain DC Preamplifier fig. D-1

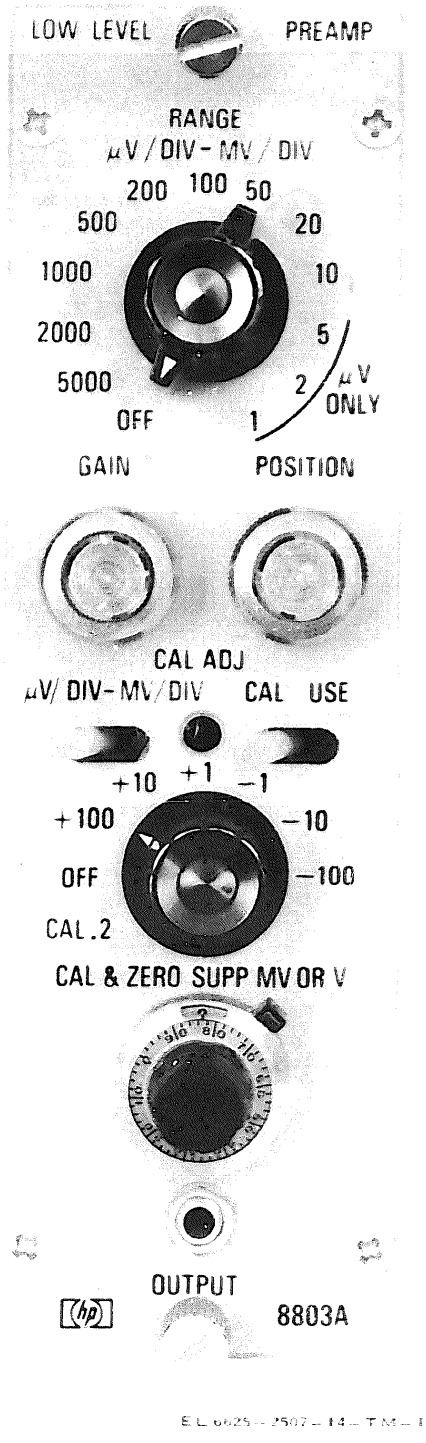


Figure D-1. Model 8803A high gain dc preamplifier.

SECTION I

DESCRIPTION

D-1. INTRODUCTION

HP Model 8803A is a plug-in High Gain Dc Preamplifier designed for use in the HP7701B, 7702B, 7706B/7708B or 7858B Recording Systems. 8803A option 01 is mounted in a portable case with built-in power supply for bench-top operation. Option 01 consists of the 8803A Preamplifier, a Model 8849A option 01 Power Supply, and Carrying Case Model 860-1400.

D-2. CHARACTERISTICS

SIGNAL INPUT: Isolated from chassis and from output (circuit is guarded) with guard shield connected isolation impedance is greater than 10^{11} ohms in parallel with 3 pf.

INPUT IMPEDANCE: 1 megohm minimum in the μv range
5 megohms minimum in the mv range
} independent of gain

Impedance is measured by placing a 1 K ohm in series with the input signal and noting the change in gain. Up to 500 K ohms may be inserted in series with the signal to measure the input impedance in the mv range.

INPUT OVERLOAD: Input circuit is not damaged by differential signals of ±60 volts peak in the μv range, and ±500 volts in the mv range.

OUTPUT: The output is isolated from chassis and input. The output is automatically grounded when preamplifier is installed in the recording system.

OUTPUT IMPEDANCE: 100 ohms. If the output filter damping control is not set for proper damping, the impedance can be as low as 50 ohms and as high as 150 ohms.

OUTPUT PROTECTION: A sustained short circuit across the output terminals will not damage the preamplifier.

D-3. PERFORMANCE DATA

OUTPUT CAPABILITY: 3 volts into 1 K ohm load.

GAIN: 12 fixed steps plus an OFF position are provided on the range switch. Gain steps on the range switch are labelled in μv/div. or mv/div. and cover the following ranges: 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, and 5000 μv/div; 10, 20, 50, 100, 200, 500, 1000, 2000, and 5000 mv/div. These steps correspond to gains of 100,000, 50,000, 20,000, 10,000, 5000, 2000, 1000, 500, 200, 100, 50, 20, 10, 5, 2, 1, 1/2, 1/5, 1/10, 1/20, and 1/50.

GAIN ACCURACY: Initial gain setting is based on a calibration from the built-in calibration source (or an external source). Ratios of fixed gain steps are within ± 1% for gains of 5000 μv/div. to 20 μv/div. and 2% from 10 μv/div. to 1 μv/div. The accuracy of the 1000:1 attenuation is maintained at 1%, if the preamplifier is re-calibrated, whenever the μv or mv range is changed.

GAIN STABILITY: (System) Less than ± 1.25%/10°C from 20°C to 40°C.
Less than ± 0.5% for variation from 103 to 127 volts.

(Preamplifier only)
TEMPERATURE: Less than 0.1%/10°C from 20°C to 40°C.
LINE VOLTAGE: Less than ±0.05%, all other ranges 103-127 volts.

COMMON MODE REJECTION:

Range	Maximum Source Unbalance	DC	60 Cycles
μv Range	1 K ohm	160 db	120 db
mv Range	500 K ohms	100 db	60 db

AC COMMON MODE TOLERANCE (Frequency: 60 cps)

Sensitivity	Tolerance (Volts RMS)
1 μv/div.	10
2 μv/div.	20
5 μv/div.	50
10 μv/div.	100
20 μv/div. through 5000 μv/div.	220
10 mv/div.	100
20 mv/div. through 5000 mv/div.	220

DC COMMON MODE TOLERANCE: ±300 volts.

CALIBRATION: An internal calibration voltage is provided. This voltage is derived from a zener diode reference. In the μv range, this voltage is 200 μv ±1% and is inserted in series with the input signal. In the mv range, this voltage corresponds to 200 mv ±1% at the input terminals. It is inserted after the 1000:1 attenuator and is independent of the input signal connection.

ZERO SUPPRESSION: Zero suppression ranges are ±1, ±10, ±100 mv or volts. With the 1000:1 attenuator in the μv range, zero suppression ranges are in mv. When the 1000:1 attenuator is in the mv range, the zero suppression ranges are in volts. Settings within a range are determined by a 10-turn 100 divisions/turn dial. Accuracy is ±1% of full scale. Resolution is 0.05% of full scale. Temperature stability is ±0.05%/°C for the range of 20°C - 40°C. Stability is ±0.02% for line voltage variations from 103 to 127 volts.

FREQUENCY RESPONSE: (Preamplifier only) DC to 20 cps within ±1%.
DC to 3 db down at 110 cps.

FREQUENCY RESPONSE: (System) DC to 20 cps ±1%.
DC to 3 db down at 100 cps for 10 divisions peak to peak on 4 cm channels.
DC to 3 db down at 90 cps for 10 divisions peak to peak on 5 cm channels.

STEP RESPONSE: (Preamplifier only) 5 milliseconds rise from 10% to 90% of final value for step input.

STEP RESPONSE: (System) 7 milliseconds rise from 10% to 90% of final value.

LINEARITY: (Preamplifier) Better than 0.1% of full scale output (5 volts) Sensitivities of 2 μv/div. or less; .2% at 1 μv/div.

LINEARITY & HYSTERESIS: (System) Better than 0.25 divisons over 50 divisions.

NOISE: (Preamplifier only) Noise over a dc to 400 KC bandwidth is 2.5 μv peak to peak referred to the input plus 1.5 mv peak to peak at the output in the μv range; 3.0 mv peak to peak referred to the input plus 1.5 mv peak to peak at the output in the mv range at zero signal.

NOISE: (System)

Sensitivity	Noise Divs. Peak to Peak
1 μv/div.	1
2 μv/div.	0.5
5 μv/div.	0.2
10 μv/div.	0.1
20 μv/div.	negligible
10 mv/div.	0.2
20 mv/div.	0.1
50 mv/div.	negligible

RIPPLE: In addition to the noise, there is a ripple which appears if the output is not zero. This ripple is primarily 880 cps and does not affect the trace in a recording system. Its peak to peak amplitude is less than 0.25% of the output for an input signal and less than 1% of the output for a position signal.

ZERO DRIFT: (Preamplifier) For 24 hours at constant ambient, drift is less than ± 1 μv in the μv range, and ± 1 mv in the mv range referred to the input. Output drift is less than ± 0.1 mv with the position control set for zero output. With the position control set for ± 2.5 volts output (25 divisions) with no signal, output drift is less than ± 10 mv.

TEMPERATURE COEFFICIENT OF DRIFT: (Preamplifier) ± 0.1 μv/^{o}C in the μv range, ± 0.1 mv/^{o}C in the mv range referred to the input. ± 0.1 mv/^{o}C at the output with the position control set for zero output. With the position control set for ± 2.5 volts output with zero signal, output drift is less than 4 mv/^{o}C.

DRIFT (20^{o}C - 40^{o}C): (System)

Sensitivity	Drift In Divisions
1 μv/div.	± 2.5
2 μv/div.	± 1.5
5 μv/div.	± 0.9
10 μv/div.	± 0.7
20 μv/div.	± 0.6
50 μv/div. through 5000 μv/div.	± 0.5
10 mv/div.	± 0.7
20 mv/div.	± 0.6
50 mv/div. through 5000 mv/div.	± 0.5

With the position control set for ± 2.5 volts output with zero signal, add ± 0.9 div. to the above numbers.

OFFSET VOLTAGE: Less than ±5 μv in the μv range; ±7 mv in the mv range. Offset voltage is the equivalent dc voltage which exists in the preamplifier input circuitry in the absence of a signal. Offset voltage can also exist in the external input circuits and may be as large or larger than the preamplifier offset. Therefore, for certain low level dc measurements, offset voltages must be taken into consideration.

When measuring a change in a dc voltage with or without zero suppression, it is not necessary to consider offset voltages, since the change in input will produce the proper change in preamplifier output, regardless of the initial signal or offset. The principle is used to calibrate the preamplifier by switching the "CAL" signal on and off, and noting the shift in output.

When measuring the absolute value of a small dc voltage, the offset must be considered and proper connection made. In order to determine the offset, the input signal must be reduced to zero without changing the input circuitry so that a reference can be established. This offset can be measured and subtracted from each signal measurement, or it can be nulled at either the input or output of the preamplifier.

Nulling at the output is accomplished by setting preamplifier output to zero (or any other desired value) with the POSITION control. The signal must be reduced to zero and the amplifier RANGE switch kept at the desired value.

Nulling at the input is accomplished by using the zero suppression to null the offset voltages, so that with the signal set to zero there is no change in output when the preamplifier RANGE switch position is changed. This technique has the advantage of allowing measurements to be made at the various RANGE switch settings without re-compensating for offset.

Switching the 1000:1 attenuator produces an additional offset which corresponds to not more than ±2 μv in the μv ranges or ±2 mv in the mv ranges (±20 mv at the output or ±0.2 div. on the recorder sensitivities of 10 μv/div. or mv/div.).

OFFSET CURRENT: ±1 nano-amp maximum, this is an equivalent dc current which exists in the preamplifier input circuit and generates a voltage across any external source resistance. This applies to the μv range only. Approximately ±1 PA on mv range.

STABILITY AGAINST LINE VOLTAGE VARIATIONS: (Preamplifier) For line voltage variations from 103 - 127 volts, the output zero will remain within ±2 mv and the output level within 2.5 volts position voltage and no signal will remain within ±30 mv.

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The gain will remain within ±0.05% at sensitivities up to 10 μv/div. and within ±0.25% at sensitivities up to 1 μv/div.

STABILITY AGAINST LINE VOLTAGE VARIATIONS: (System) For line voltage variations from 103 - 127 volts, the output zero will remain within ±0.1 div. and the output level with 25 divisions position deflection and no signal will remain within ±0.4 div. The gain will remain within ±0.3% at sensitivities up to 10 μv/div. and within ±0.5% at sensitivities up to 1 μv/div.

The above specifications are for 1K source impedance and for a rate of change of ambient temperature not to exceed 10^{o}C/hour. Specifications (gain stability and drift) apply after 1 hour warmup in the Sanborn 7700 Recording System. The preamplifier will operate in ambients to 60^{o}C without damage.

SOURCE IMPEDANCE ABOVE 1K OHM: Source impedance above 1K ohm can be used with the following affects:

(1) Increased noise in the μv range with 10K ohm source impedance. Noise referred to the input is no more than twice the noise as with 1K ohm source.

(2) Increased mv range calibration error by the percentage:

$$K_1 = + \frac{\text{R source}}{\text{R source} + 5 \text{ megohm}} \times 100$$

with R source expressed in megohms (total error 0 to +2% for 50K ohm source impedance).

(3) Increased 1000/1 attenuator error by the percentage:

$$K_2 = \pm \left[\frac{\text{R source}}{\text{R source} + R_{in}} \times 100 - K_1 \right]$$

Where R_{in} is the μv range input impedance and K_1 is calculated from (2) (total error ±3% maximum for 10K ohm source).

The 1000:1 attenuator error can be reduced to the percentage found in step (2) above, by recalibrating whenever the range is changed.

POWER REQUIREMENTS:	-17 at 90 ma
	-12 at 20 ma
	+12 at 20 ma
	5 V 440 cps 1/4 watt
WEIGHT:	6 pounds.
DIMENSIONS	2" wide x 7" high x 14.9" deep.

D-4. FRONT PANEL CONTROLS

USE-CAL SWITCH (S4): A two-position toggle switch which disconnects the input connector and shorts the input in the Cal position. This allows calibration in the presence of an input signal.

GAIN TOGGLE SWITCH (1000:1 Attenuator) (Labelled μv-mv/div) (S3): Changes the gain by a factor of 1000:1.

RANGE SWITCH (Gain Step) (S1): The range switch provides 12 fixed steps plus an OFF position. The gain steps on the range switch are in μv/div. or mv/div. and cover the following ranges: 1, 2, 5, 10, 20, 50, 100, 200, 500, 1000, 2000, and 5000 μv/div; 10, 20, 50, 100, 200, 500, 1000, 2000, and 5000 mv/div.

GAIN: A variable control for setting the gain of the preamplifier. This control provides overlapping gain for the range steps.

POSITION: A variable control capable of covering ±25 chart divisions (±2.5 volts). This control is used to set the zero signal output of the preamplifier.

CAL-ZERO SUPP. (mv or volts) (S2): This switch controls the selection of the calibration voltage, and the zero suppression ranges of ±1, ±10, and ±100 mv or ±1, ±10, and ±100 volts.

ZERO SUPPRESSION DIAL: Ten-turn, 1000 division dial with lock, this dial determines the settings within the zero suppression ranges.

FRONT OUTPUT JACK: Two-circuit miniature jack, for connecting an external indicator to the preamplifier.

D-5. ADDITIONAL CONTROLS AND CONNECTORS

CAL ADJ (R43): A recessed front panel screwdriver adjustment for setting the initial accuracy of the calibration and zero suppression voltages.

SCREWDRIVER ADJUSTMENT (R50): Calibrates the 1000:1 attenuator, located inside the guard box on the printed circuit board assembly 860-1500-C3. This is a factory adjustment, and is locked with Duco cement.

SCREWDRIVER ADJUSTMENT (R54): Sets the damping of the output filter located near the rear connector on the filter assembly board 860-1500-C11.

INPUTS: J3, shielded and guarded 5-pin connector at the rear of Power Supply, Model 8849A option 01. J11 through J18, shielded and guarded 5-pin connectors at the rear of Power Supply 8848A.

OUTPUTS: J2, 10-pin connector at the rear of Power Supply, Model 8849A, option 01 J21 through J28, 10-pin connectors at the rear of Power Supply 8848A. J4, 16-pin connector for power input from and signal output to Power Supply, Model 8849A, option 01. J1 through J8, 16-pin connectors for power input from and signal output to Power Supply 8848A.

SECTION II

OPERATION

D-6. INTRODUCTION

Before operating the preamplifier, the signal and load must be properly connected, and the preamplifier should be calibrated.

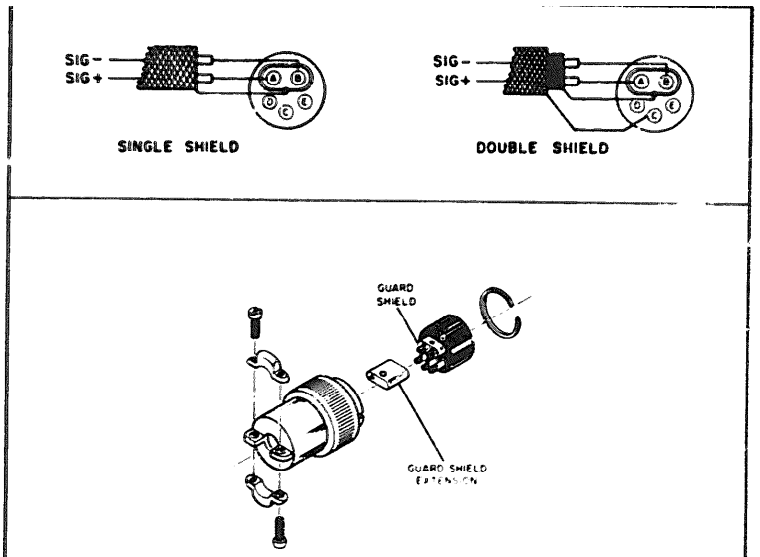
D-7. CONNECTING INPUT SIGNAL

a. The amplifier includes a guard shield in the input circuit to obtain high common mode rejection. Supplied with the accessories is a 5-pin connector, Part No. 1251-1895, for connecting a double shielded signal cable to the twin-ax guarded input connectors on the rear of Power Supply, Model 8848A and Power Supply, Model 8849A, option 01. Prepare the connector for connection to the signal cable as follows:

(1) Use a screwdriver to pry out the retaining ring. CAUTION: The retaining ring is spring steel.

(2) Force the connector forward and out of the shell with a pencil.

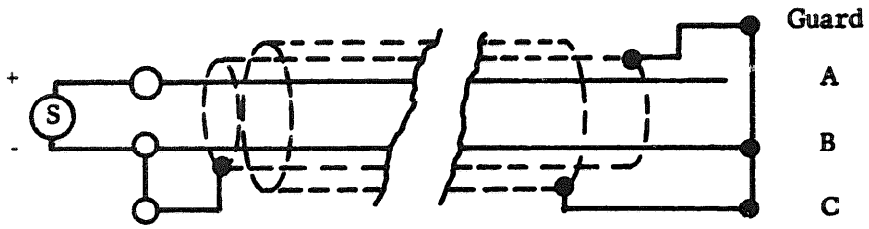
(3) When the connector is out, remove the brass guard extension from the rear of the connector.



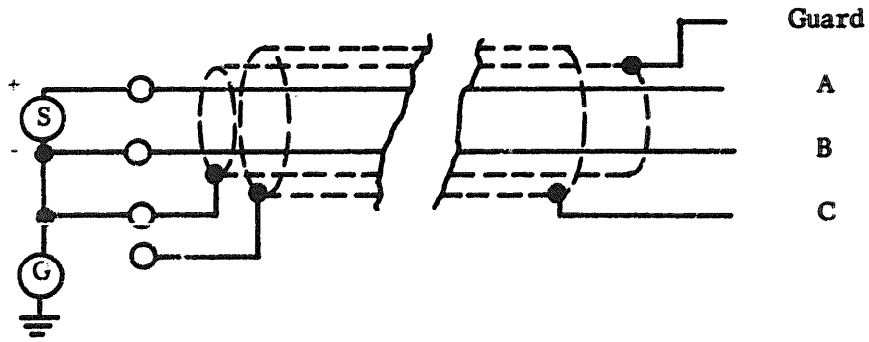
MODEL 8803A PREAMPLIFIER		POWER SUPPLY	
		8848A, 8848A–OPT 01, 8848A–OPT 02	8849A–OPT 01
SIGNAL INPUT	+SIGNAL INPUT	J11 PIN A (TYP CHI–8)	J3 PIN A
	–SIGNAL INPUT	J11 PIN B (TYP CHI–8)	J3 PIN B
	INNER SHIELD	J11 GUARD SHIELD	J3 GUARD SHIELD
	OUTER SHIELD	J11 PIN C	J3 PIN C
SIGNAL OUTPUT	SIGNAL OUTPUT	J21 PIN E(TYP CHI–8)	J2 PIN E
	GROUND	J21 PIN L (TYP CHI–8)	J2 PIN L

Figure D-2. Signal connector wiring.

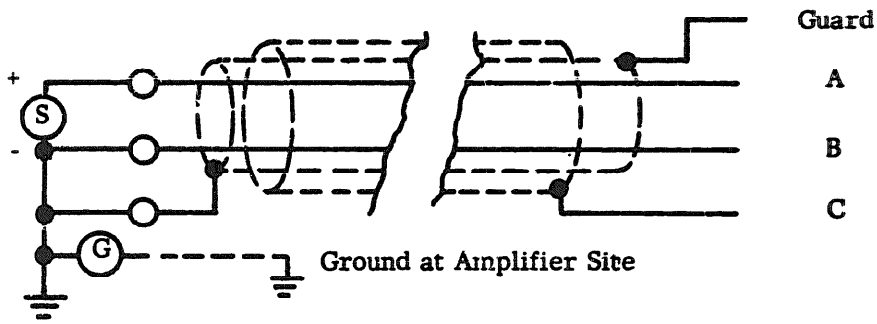
A. Connections when source is floating and ground is desired at the amplifier:



B. Connections in presence of a known common-mode signal:



C. Connections when source is grounded and a ground loop voltage is present:

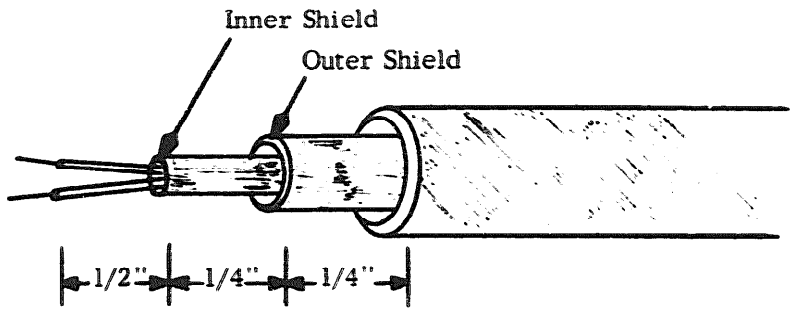


D. Finally, connect the signal cable to the appropriate input connector at the rear of the power supply.

N O T E The outer shield is generally not necessary. It may, however, be required to prevent large common-mode voltages from coupling into the unshielded circuits of nearby equipment.

Figure d-3. INPUT SIGNAL CONNECTIONS

b. Two conductor double-shielded cable (HP 8120-0800), is recommended for use with the input connector.



Connect the cable to the connector as follows:

(1) Slip the connector shell over the cable, followed by the guard extension.

(2) Prepare the cable as shown in the above diagram.

(3) Tin the outer and inner shield with solder. CAUTION: To prevent a short between the inner and outer shield, do not apply excessive heat.

(4) Connect and solder the signal cables (A) and (B) to the connector.

(5) Slip the guard extension over the guard on the connector. Connect and solder the inner shield to the guard extension. CAUTION: When making this connection, be careful not to short the inner shield to the signal connections.

(6) Connect and solder the outer shield to the ground connection (C) on the connector.

(7) Slide the connector shell over the connector, insert the retaining ring, and tighten the clamp assembly as desired.

c. Having constructed the signal cable, the input signal source is connected to the cable as shown in Figure D-3

D-8. CONNECTING THE AMPLIFIER OUTPUT.

a. The OUTPUT of the amplifier is a filter network. When the damping is set properly, the amplifier has a frequency response and output impedance as specified (para D-2).

b. The signal output is available from the 10-pin connectors at the rear of the 8-channel Power Supply, Model 8848A, J21 through J28, from a 10-pin connector at the rear of the single channel Power Supply, Model 8849A, option 01, and from a front panel jack on the preamplifier. Note: The output is automatically grounded when the preamplifier is installed in Model 8848A or 7701A Recording Systems.

D-9. CALIBRATION

a. Set the USE-CAL switch to the CAL position. This disconnects the input signal and shorts the input terminals.

b. Set the GAIN toggle switch (μv-mv) to the μv position, and rotate the RANGE switch to the 10 μv/div. position.

c. Adjust the POSITION control for zero output on the chart.

d. Adjust the GAIN control for 20 divisions (2 volts) change in the output while switching the CAL-ZERO SUPPRESSION switch back and forth between OFF and 0.2 CAL.

Calibrating in the mv range is the same as above with the exception of setting the GAIN toggle switch (μv-mv) to the mv position.

D-10. OPERATION WITHOUT ZERO-SUPPRESSION

Set panel controls: CAL and ZERO-SUPP to OFF and RANGE switch to OFF. Set USE-CAL switch to USE and adjust the position control for zero output. Then apply the signal and advance the range switch for a convenient output. At high gains, reset the baseline to correct for offset with the position control.

D-11. OPERATING WITH ZERO-SUPPRESSION

a. Set RANGE control to the OFF position, the USE-CAL switch to the USE position, and adjust POSITION control for zero output. Set CAL and ZERO SUPP switch to the desired zero suppression range.

SWITCH SETTING	MAXIMUM ZERO SUPP		ZERO SUPP IN VOLTS/DIAL DIV.	
	μv/div.	mv/div.	μv/div.	mv/div.
+100	+100 mv	+100 volts	+100 microvolts/div.	+100 mv/div.
+ 10	+ 10 mv	+ 10 volts	+ 10 microvolts/div.	+ 10 mv/div.
+ 1	+ 1 mv	+ 1 volt	+ 1 microvolt/div.	+ 1 mv/div.
- 1	- 1 mv	- 1 volt	- 1 microvolt/div.	- 1 mv/div.
- 10	- 10 mv	- 10 volts	- 10 microvolts/div.	- 10 mv/div.
-100	-100 mv	-100 volts	-100 microvolts/div.	-100 mv/div.

b. Set RANGE switch to minimum gain (5000 μv) and adjust the 10-turn potentiometer for zero output. Advance the range switch to the desired sensitivity and readjust the helipot to maintain the baseline previously set. The voltage being measured is the algebraic sum of the voltage suppressed, as read from the zero suppression dial, plus the voltage read on the direct wiring recorder.

SECTION III

FUNCTIONING

D-12. INTRODUCTION
fig D-6

The High Gain Preamplifier, Model 8803A, is a sensitive and stable dc to 100 cycles chopper amplifier which operates by changing the input signal into a 440 cycle signal by means of an electromechanical chopper. The Preamplifier amplifies the modulated output signal of the chopper and converts the waveform to an amplified copy of the input signal.

D-13. INPUT CIRCUIT THEORY

a. The signal is connected to the input connector as described in paragraph D-2, and internally coupled to the chopper through the USE-CAL switch and the limiter consisting of CR9, CR10, CR11, CR12, R63, R64, which prevents excessive input signals from reaching the chopper contacts or the input transformer. The chopper alternately applies the signal to each side of the input transformer (T1). The secondary output of the input transformer is a 440 cycle square wave.

b. The "A" terminal of the input socket is connected to the chopper arm through a 100 ohm resistor and the CAL and ZERO SUPP switch. When the CAL 0.2 position is used, this calibration voltage is developed across the 100 ohm resistor. When zero suppression is used, the voltage is taken from a ten-turn precision potentiometer which has 1 mv, 10 mv, or 100 mv across its terminals. A portion of this voltage is injected in series with the input depending upon the setting of the ten-turn potentiometer. Moving the CAL and ZERO SUPP switch selects the resistance network which gives the required suppression range and polarity.

c. The built-in power supply furnishes the source for the CAL and ZERO SUPP voltages. The power supply is a standard full wave rectifier configuration utilizing the 440 cycles excitation for its input. A low noise 6.2 volt Zener diode stabilizes the output of the power supply and provides the constant voltage for the calibration and zero suppression networks. The CAL ADJUST is provided, for the CAL zero suppression circuit, to adjust for tolerances in the potentiometer and Zener diode.

d. The resistor R48 and the thermistor TM1 provide temperature compensation for the Cal and Zero Suppression network.

e. The 1000:1 attenuator consists of R39, R40, R50, R59, R60, and R61 and the switch S3. The mv-μv switch (S3) connects the input directly to the preamplifier through the limiters in the μv range and through the 1000:1 attenuator in the mv range. R50 sets the accuracy of the 1000:1 attenuator.

D-14. Amplifier Theory

a. The amplifier is a transistorized amplifier having seven stages of amplification and an overall gain of 100,000. The signal from the secondary of T1 is applied to the first stage, amplified, and directly coupled to the succeeding three stages. A dc feedback from the emitter of the third stage through R11 to the emitter of the first stage stabilizes the operating points. A portion of the output of the fourth stage is fed back through a resistive network resulting in overall gain steps of 200, 100, 40, 20, 10, and 4 for these stages. The gain control (R22) influences the attenuator circuit by producing overlapping variations of gain for the range steps. The negative voltage thus fed back maintains linearity and an accurate gain for the first stages of amplification. The emitter follower output of the fourth stage is coupled to the fifth stage through C7 and directly coupled to the sixth stage and from the sixth to the seventh stage. A negative feedback voltage from the emitter of the seventh stage through R28 to the emitter of the fifth stage stabilizes the dc operation points for the last three stages of amplification. Capacitors C9 and C10 bypass the ac signal from the dc feedback path and provide the high ac open loop gain.

b. Gain stability and linearity for the last three stages are obtained by means of a feedback voltage developed across the feedback winding of the output transformer T2 and R21, R25, R27, and R58. This network provides a change in gain of 5, 50, and 500. Also introduced to the fifth stage is a 440 cycle voltage from the POSITION control which, when amplified and demodulated, produces variations in the dc output level of the preamplifier for the purpose of positioning the writing arm stylus.

D-15. Demodulator

a. The demodulator is a synchronous switch biased to operate inside the dwell times of the input chopper. This is done to minimize changes in gain that might be caused by changes in chopper dwell times. Q8, Q9, and Q10, Q11 are alternately turned on and synchronously connect the signal at the secondary of the output transformer (T2) to capacitor C15. The capacitor provides peak detection and the ripple components are reduced by the filter.

b. The demodulator is divided into two sections: the emitters of Q8 and Q9 are connected together to one side of the modulation transformer (T3) secondary, the other side of the secondary is connected through R36 to the bases of Q8 and Q9. These transistors are biased by CR7, C16, R35, and R36 to operate inside the dwell times of the input chopper. During the positive half cycle of the 440 cycle switching signal, the polarity of the modulation transformer secondary is such that the bases of Q8 and Q9 are negative with respec to the emitters. The two transistors will conduct heavily offering a low impedance to the output signal of the amplifier which appears at the secondary of the output transformer. This signal then appears at the collector of Q9.

c. In the other section of the demodulator, Q10 and Q11 are connected and operate identically to Q8 and Q9. These transistors are triggered by the negative half cycle of the 440 cycle switching signal and the output appears at the collector of Q11. The junction of collectors Q9 and Q11 is essentially a summing junction with each transistor offering the signal alternately at a rate of 440 cycles. The output therefore is a signal which is an amplified version of the input signal; this signal is filtered and appears at the OUTPUT connectors.

D-16. Output

The demodulated signal is applied across the low pass filter consisting of L1, C6, C21, and R54. R54 sets the damping of the filter network and when set properly, the amplifier has the frequency response and the output impedance specified. Improper setting allows excessive overshoot or too low a frequency response.

D-17. Guard Shield Circuit

a. The guard shield circuit is provided so that cable capacity to ground (with an unbalanced signal source) will not manufacture a differential signal out of a common-mode signal. With normal (non-guarded) input signals, the equivalent source and the cable is:

R1, R2 = equivalent source resistance
C1, C2 = cable capacity

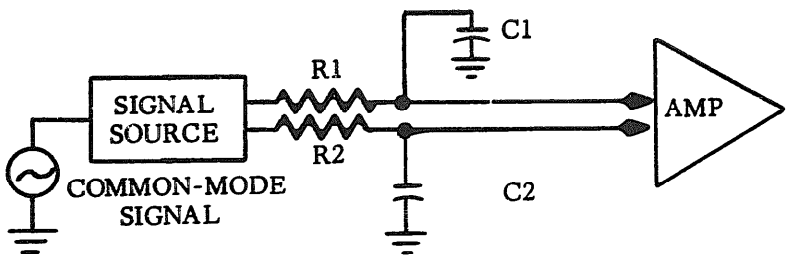


Figure D-4.①. Guard shield circuit (sheet 1 of 2)

b. R1/C1 and R2/C2 form a pair of filters. If thest two filters are not identical, (if, for instance, R1 is different from R2), then the common-mode component at one input terminal of the preamplifier is not the same as the common-mode component at the other input terminal. This difference in common-mode signals is a differential component, which is amplified along with the desired signal, and cannot be separated from it.

If, however, the cabling between source and amplifier uses a shield, connected to the common-mode voltage, then the equivalent source and the cable schematic diagram is:

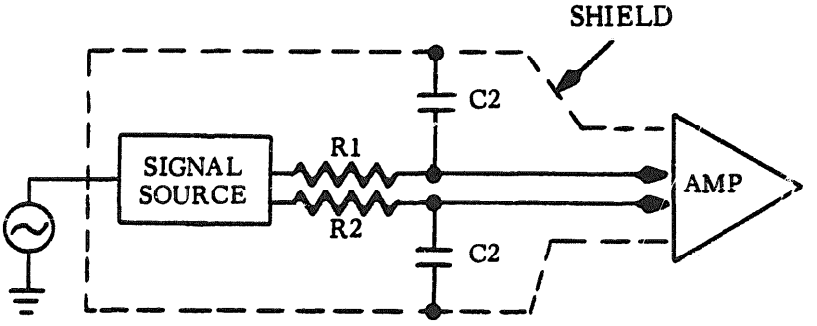


Figure D-4②. Guard shield circuit (sheet 2 of 2)

c. Now both terminals of each capacitor are at the same common-mode potential, so that no common-mode signal component can flow. The R1/C1 circuit and the R2/C2 circuit will therefore not attenuate the common-mode signal, and the common-mode potential at one input terminal of the amplifier will equal common-mode potential at the other input terminal of the amplifier. In this way, there is no differential component made out of the common-mode signal.

SECTION IV

POWER SUPPLY

D-18. DESCRIPTION

a. Power Supply, Model 8849A, option 01, provides all the operating voltages, including 440 cps excitation, for one model, 8803A preamplifier. The power supply mounts at the rear of Portable case, Model 860-1400 (for one 8803A preamplifier), or two power supplies mount at the rear of Two-Channel Module, model 860-200 or 860-200A.

b. Power Supply, Model 8848A, provides all the operating voltages, including 440 cps excitation, for up to eight preamplifiers. The power supply mounts at the rear of the 8-channel-wide rack which holds the eight preamplifiers. The connector channel is located between the power supply and the preamplifiers and is an integral part of the power supply.

D-19. POWER SUPPLY CHARACTERISTICS

REGULATED OUTPUTS:	+12 volts, 100 ma 8849A, option 01, 800 ma (8800-20A).
	-12 volts, 100 ma 8848A, 800 ma (8800-02A).
UNREGULATED OUTPUTS:	+17.5 volts at 100 ma.
	-17.5 volts at 100 ma.
AC OUTPUTS:	5 volts, RMS, at 440 cps.
REGULATION:	8849A, option 01 Regulation of the +12 and - 12 volt outputs, with 103 to 127 volt change in line voltage, give 150 mv overall change in output voltage. With temperature changes from 25°C to 60°C there is not more than 250 mv change in output voltage. 8848A Regulation of the +12 and - 12 volt outputs, with 20% change in line voltage, give 40 mv overall change in output voltage. With load changes from zero to full load, there is not more than 2% change in output voltage. Temperature coefficient is 0.6 mv per centigrade degree of temperature change.
RIPPLE:	On the +12 and - 12 volt lines, ripple is less than 5.0 mv peak-to-peak.

FUSES:	8849A, option 01 Three 0.5 ampere fuses; one in power line circuit, one in +17.5 volt circuit, and one in the - 18 volt circuit. 8848A 1 amp fuse on power line input, 1.6 amp fuse for - 17.5 volt unregulated oscillator supply; 1.5 amp fuses in + 18 and - 18 volt supplies.
LINE SWITCH:	Selects 115 or 230 volts ac.

D-20. POWER SUPPLY OPERATION

a. 8849A, option 01

A line switch is provided on the power supply which selects 115-230 volts ac. An Aux. ON/OFF switch is also provided which is designed for bench operation of the power supply. Input and output connectors are provided at the power supply rear, for use with the associated preamplifier. These connectors are:

OUTPUT (J2)	Terminal "E" is the signal output; terminal "L" is the signal ground.
INPUT (J3)	Terminal "A" is the "+" input; terminal "B" is the "-" input; terminal "C" is the outer shield terminal and chassis ground. A guard ring provides the guard shield connection.

b. 8848A

(1) No controls are required as a part of power supply operation. For adjustments, the VOLTS ADJ control R4 in the - 12 volt line can require adjustment to bring the output voltage to within its required limits, for both the - 12 and +12 volt supplies. The Regulator Assembly is the center card mounted at the right side, when viewing the assembly from the rear.

(2) The VOLTS ADJ control will be found at the top center of the regulator card within this assembly. To adjust, connect a voltmeter having at least 2000 ohms resistance, and an error of less than 1/4 volt in the vicinity of +12 volts, to test point J33-B. After at least

two minutes warmup, check the voltmeter; it should read between 11.75 and 12.75 volts. If outside these limits, set the VOLTS ADJ control to bring the voltage between these limits.

Input and output signal connectors are provided at the power supply rear for use with the associated preamplifier. These connectors are:

INPUT (J11-J18)	Eight connectors, each a 5-pin male connector, for the eight channels. Each socket has pins A and B
OUTPUT (J21-J28)	Eight connectors, each a 10-pin female connector, for the eight channels. Terminal "E" is the signal output; terminal "L" is signal ground.
OUTPUT (J34)	14-pin male connector with galvanometer output for eight channels.

c. The following connector information is applicable to the 8849A, option 01(4) and 8848A(J1).

PIN NUMBER	FUNCTION
A	+Input signal.
B	-Input signal.
Guard ring	Guard potential.
1	Not used.
2	Not used.
3	Not used.
4	Not used.
5	Not used.
6	Not used.
7	Output signal.
8	-18V Unregulated.
9	440-Hz chopper excitation.
10	Not used.
11	440-Hz chopper excitation.
12	+12V regulated.
13	Signal ground.
14	-12V regulated.

D-21. EXCITATION SUPPLY DETAILS

a. 8849A, option 01

The 440 cps excitation supply is provided by plug-in card 860-500-C2.

b. 8848A

The 440 cps excitation supply is provided by plug-in card 868-500A-C14. There are no adjustments or controls on these supplies.

SECTION V

MAINTENANCE

D-22. INPUT TEST POINTS

a. Tie pin 1 of the input transformer T1 to pin 3 of T1. Connect an oscilloscope between 1 and 2 of T1. The indication will be a square wave of proper amplitude which is a peak-to-peak signal twice the value of the dc input signal. Use no more than 20 to 30 mv of dc input signal. Remove the jumper between pin 1 and 3 of the input transformer.

b. Output Of First Block

Measure the dc voltage at terminal 9 (main board) with respect to signal ground. DC voltage at this point should be approximately - 0.6 volts. The square wave will have the peak-to-peak voltage indicated below with the (μv-mv) switch in the μv position:

DC Input to Amplifier	Input Range Control (μv/div)	Peak-to-Peak at Terminal 9
50 μv	1	20 mv
100 μv	2	20 mv
250 μv	5	20 mv
500 μv	10	20 mv
1 mv	20	200 mv
2.5 mv	50	200 mv
5 mv	100	200 mv
10 mv	200	200 mv
25 mv	500	200 mv
50 mv	1000	2 volts
100 mv	2000	2 volts
250 mv	5000	2 volts

c. Position Control Check

Set the oscilloscope for 440 cps. Connect to terminal 4 (main board) and signal ground, and look for null as position control is rotated throughout its range.

d. Q6 Operating Current

Measure voltage at terminal 11 (main board) to determine whether output block Q4, Q5 and Q6 are functioning. A voltage of approximately - 0.9 volts appears at this point.

e. Square Wave Output

Connect the oscilloscope between terminals 24 and 27 (main board), the signal should be ten volts peak-to-peak when the dc input to the amplifier and the input range control are maintained as listed in b above.

f. Unfiltered Output

Connect oscilloscope across C15. Ripple should appear as shown in the following waveform:

D-23. SETTING ZERO OUTPUT

a. Set USE-CAL switch to CAL position.

b. Set output to zero by means of position control (R23) located on front panel.

D-24. TROUBLESHOOTING

a. Common Symptoms of Equipment Malfunctions

Should a malfunction occur, it is most likely to be in one of the following categories:

Symptom	Component	Check
Noise (probably 60 cps)	Input cable or connector	Open or grounded guard shield or open signal wires.
Noise (usually excessive ripple of 440 cps)	Chopper (K1)	MU metal shield dislocated. Adjust so that it is tight against its locating pin and as far distant from chopper as possible.
Noise (random)	Q1 Transistor	Replace transistor.

b. Other Possible Malfunctions. Listed below are other possible malfunctions that might occur, and the resultant symptoms:

(1) Failure of any component between terminals 2 and 9 on the schematic will probably cause the dc level at test point 9 to be far from its normal value.

(2) Failure of any component between test points 9 and 11 will probably cause a deviation in the dc level at test point 11 from its normal value.

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(3) Failure of any of the demodulator transistors (Q8 through Q11) will probably cause a large gain error and excessive ripple as measured at output.

(4) Failure of any component associated with the demodulator switching circuit will result in effects similar to a failure of a demodulator transistor.

D-25. REMOVAL AND REPLACEMENT

a. Power Supply

(1) Disconnect all connectors at the amplifier power supply rear, checking that these can be replaced; in their proper order when re-installing the unit.

(2) Remove the four screws which hold the front of the rack slide assembly to the cabinet and pull part way out.

(3) With the help of an assistant, press the lock-springs on both sides of the rack and pull the unit out the rest of the way, and place on a work bench.

(4) To replace the amplifier power supply, reverse the preceding steps.

b. Amplifier(s)

(1) To remove the amplifier(s), remove the screws from the top and bottom of the amplifier front panel, and slide the amplifier out of the rack.

(2) To replace the amplifier(s), slide the amplifier into the slot in the weldment, and seat the amplifier connector firmly into the power supply connector.

c. Regulator and Oscillator Cards

(1) These cards are located at the rear of the amplifier power supply under a black plastic cover and are accessible at the rear of the cabinet, when the rear door of the cabinet is opened.

(a) Remove the white nylon screw that is on the black cover.

(b) Remove the first two amplifiers on the left (viewed from the front). This will make the second screw to be removed from the black cover available. Remove this screw and remove the cover.

(c) Locate the card(s) to be removed using Figure D-5 as a guide.

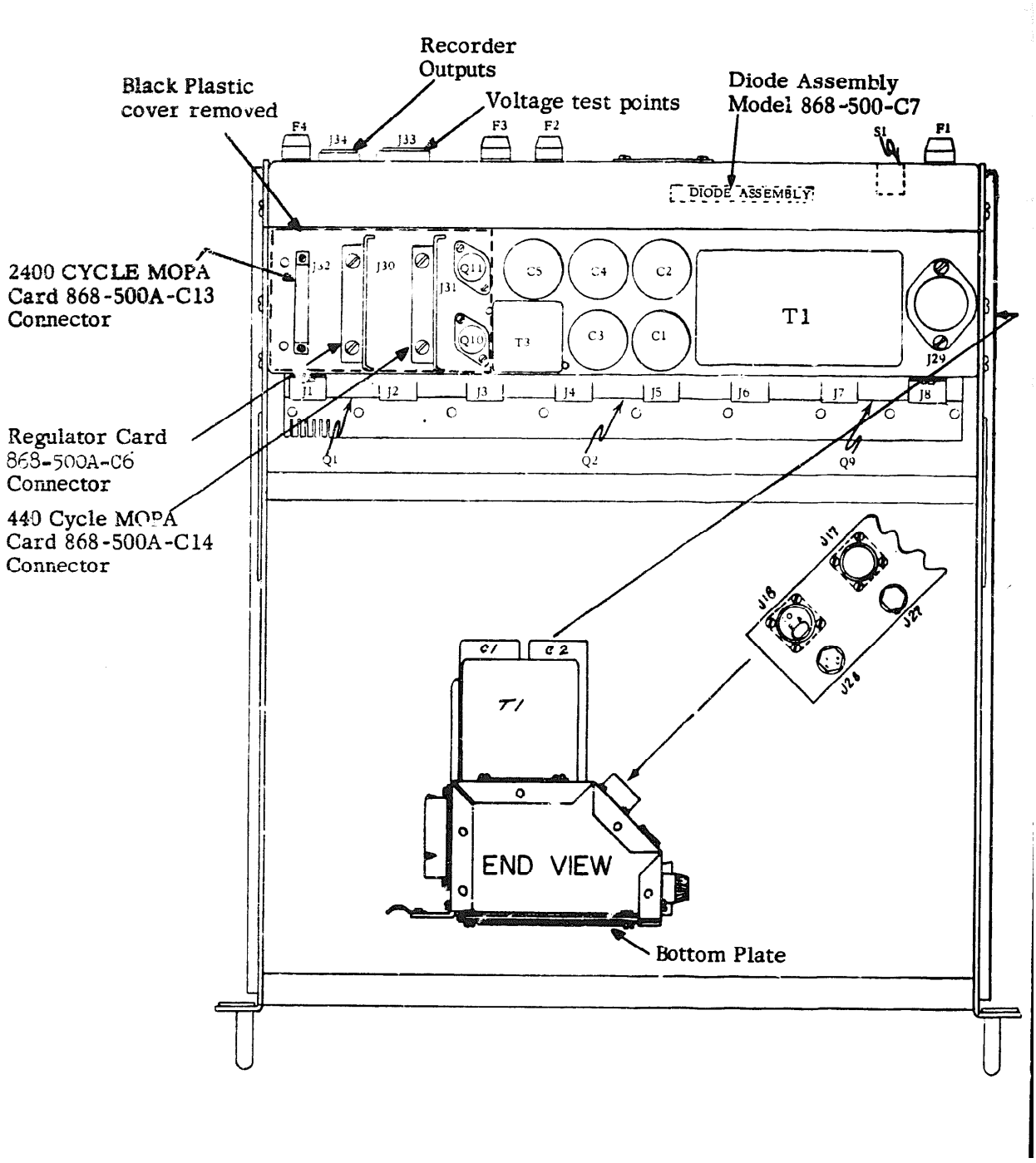


Figure D-5. PREAMPLIFIER SUPPLY (TOP VIEW)

(d) Remove the two screws that secure the card to the chassis, then pull the card out of its connector.

(2) To replace the card(s), press the card firmly into its connector. DO NOT INSERT THE CARD(S) INTO THE WRONG CONNECTOR SOCKET. Replace the two screws through the bracket and into the chassis. Replace the black cover and replace the nylon screws. Replace the two amplifiers.

d. Fuse(s)

The power supply circuits as well as the amplifier circuits are protected by the fuses located at the rear of the power supply. Refer to paragraph D-27 for fuse type and location.

D-26. POWER SUPPLY, CHECKS AND ADJUSTMENTS

a. General.

(1) Remove each power supply fuse in turn, and check that its value matches its required value.

(2) Check for 115 volt power line.

(3) Prepare other parts of the system for normal operation and allow at least 15 minutes warmup time.

(4) Connect an accurate voltmeter for 12 volt measurements, connecting between pin R (power supply ground) of connector J33 and pin D (12V). Set the -12 volt VOLTS ADJ control for a reading of -12 volts on the meter.

(5) Now connect the meter between pins R and B of the same connector. Voltage should be within ±.25 volt of the +12 volts required. If outside the limits, the -12 volt setting can be changed to divide the error, as long as the reading at either potential is within ±.25 volts of the 12 volt point.

(6) Connect an ac indicator between pins L and H (J33). Reading should be a nominal 14 volts peak-to-peak. This may be done easily with a calibrated oscilloscope. This procedure checks the 440 cps excitation for four of the amplifiers (1 through 4). Check that the other four amplifiers have 440 cps excitation present by connecting the indicator between pins 11 (J5 through J8) and pin H (J33). If excitation is not present, or low, check the oscillator supply fuse F4, transistors Q9, Q10, Q11, and the 440 cps oscillator plug-in card 868-500A-C14.

(a) If any of the dc voltages or the 440 cps excitation voltage are not present, the power supply should be checked to see that power is applied (line voltage 115 V rms) and that the fuses are not blown. If any of the dc voltages or 440 cps excitation voltage are present but not the correct values, check the fuses.

(b) Remove the amplifiers to eliminate shorts in amplifier(s) from causing apparent power supply problems.

(c) The dc voltages +12 and -12 regulated depend upon the +18 and -18 volt unregulated sources so that if the regulated voltages are not present, inspect the unregulated points.

(d) The ripple on the unregulated supply is approximately 2 volts peak-to-peak at 120 cycles when fully loaded with 1.4 amps. If the ripple is 60 cycles, it indicates that some of the appropriate diodes CR1 through CR10 are open.

(e) If it is not possible to obtain ±18 volts, it may be that any of the diodes CR1 through CR10 are shorted.

b. Regulated ±12 Volt Problems:

(1) If it is not possible to obtain ±12 volts, check that the unregulated voltages appear at connector J30 (pin C -18 volts, pin H +18 volts, pin A common).

(2) Check to see that Q1 and Q2 are not shorted to the chassis. These transistors are located on the chassis between channels 1 and 2 (Q1) and between channels 4 and 5 (Q2). Check for short by removing the rack from the cabinet and removing the amplifiers from the rack to expose the transistors.

(3) If Q1 and Q2 are shorted, the regulator will not function and the ±12 volt points will assume a value close to ±18 volts.

(4) If ±18 volts is present and Q1, Q2 do not appear to be shorted to the chassis or otherwise inoperative, the problem appears to be isolated to the 868-500A-C6 card as far as the ±12 volts is concerned.

c. 440 cps Excitation Problems:

(1) Remove the amplifiers to eliminate this source of trouble.

(2) Check that pin B on J31 is approximately -15.5 volts. If this value is not obtained with the 868-500A-C14 card removed (refer to paragraph D-33 for location and removal instructions) the most likely source of the trouble is a failure of Q9. Q9 is located between channels 7 and 8 on the rack and the rack must be removed, as well as the amplifi in order to get at Q9 for check or replacement.

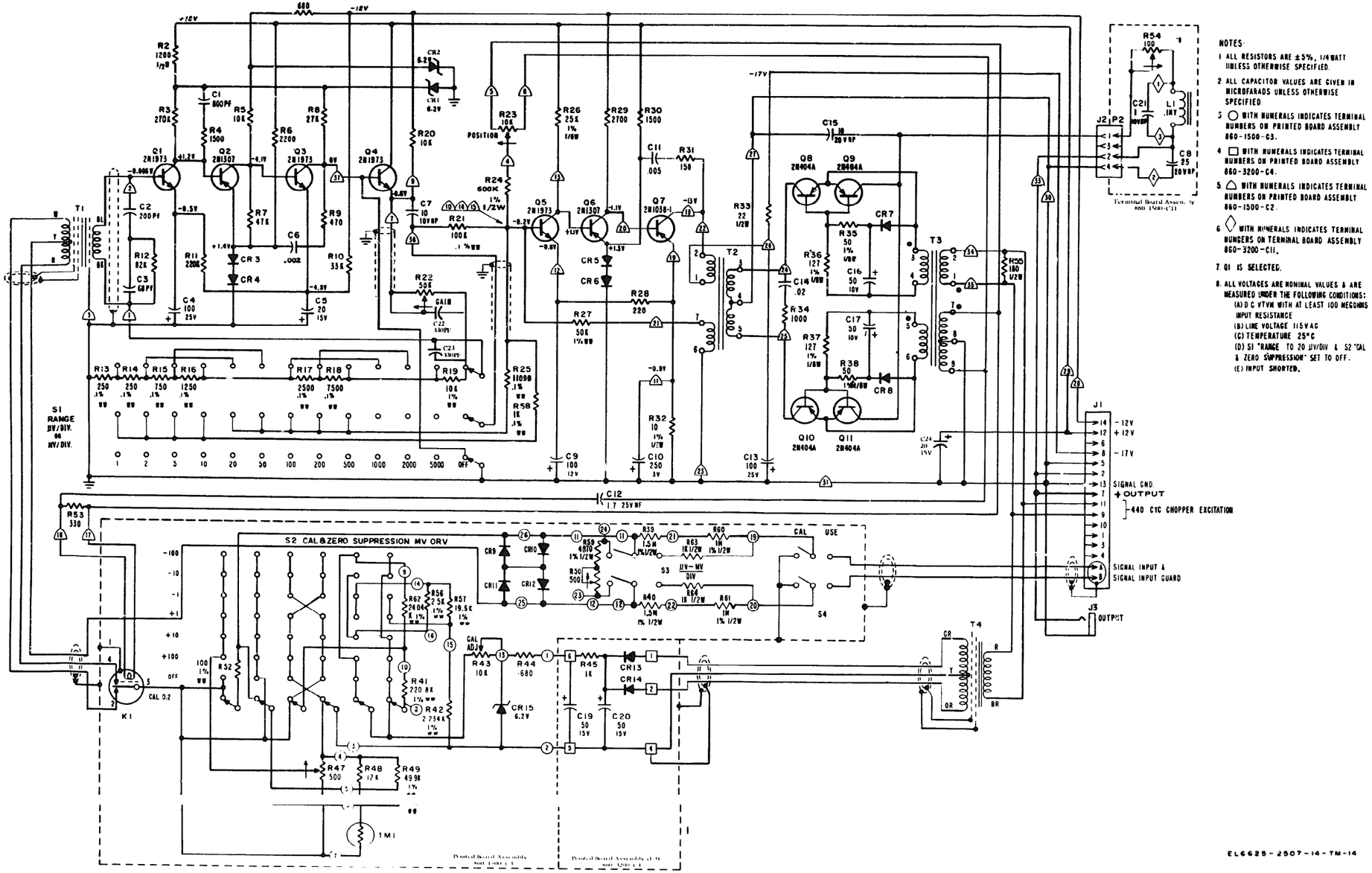
(3) If this voltage appears at pin B of J31 then the source of the trouble is in the oscillator circuit Q12, Q13, or the output amplifier Q10, Q11 may be at fault.
(4) The oscillator portion of the circuit can be checked by removing Q10 and Q11 and measuring from either base to power supply common. Voltage across these points should be approximately 16 volts peak-to-peak and nearly sinusoidal.

D-27. MAINTENANCE DATA

Note: The following list is given for quick reference during maintenance.

FUSE LIST

Symbol No.	Description	Location	Circuit
F1 (115 V)	1.0 Amp Slow Blow Fuse	Rear Panel	115 V Line Power
F2	1.5 Amp Fuse	Rear Panel	-18 Volt Supply
F3	1.5 Amp Fuse	Rear Panel	+18 Volt Supply
F4	1.6 Amp Slow Blow Fuse	Rear Panel	Oscillator Supply



NOTES:

1. ALL RESISTORS ARE ±5%, 1/4 WATT UNLESS OTHERWISE SPECIFIED.
2. ALL CAPACITOR VALUES ARE GIVEN IN MICROFARADS UNLESS OTHERWISE SPECIFIED
3. ○ WITH NUMERALS INDICATES TERMINAL NUMBERS ON PRINTED BOARD ASSEMBLY 860-1500-C3.
4. □ WITH NUMERALS INDICATES TERMINAL NUMBERS ON PRINTED BOARD ASSEMBLY 860-3200-C4.
5. △ WITH NUMERALS INDICATES TERMINAL NUMBERS ON PRINTED BOARD ASSEMBLY 860-1500-C2.
6. ◇ WITH NUMERALS INDICATES TERMINAL NUMBERS ON TERMINAL BOARD ASSEMBLY 860-3200-C11.
7. Q1 IS SELECTED.
8. ALL VOLTAGES ARE NOMINAL VALUES & ARE MEASURED UNDER THE FOLLOWING CONDITIONS:
   (A) D C VTVM WITH AT LEAST 100 MEGOHMS INPUT RESISTANCE
   (B) LINE VOLTAGE 115 V AC
   (C) TEMPERATURE 25°C
   (D) S1 "RANGE TO 20 μV/DIV & S2 "CAL & ZERO SUPPRESSION" SET TO OFF.
   (E) INPUT SHORTED.

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Figure D-6. Low Level preamplifier model 8803A.

APPENDIX E

PLUG-IN UNIT, ELECTRONIC TEST EQUIPMENT PL-1307/U

NOTE

This appendix provides operating and maintenance instructions for Plug-In Unit, Electronic Test Equipment PL-1307/U. Throughout the appendix, the PL-1307/U is referred to as Model 8806B Phase Sensitive Demodulator Preamplifier (fig. E-1).

SECTION I

GENERAL INFORMATION

E-1. DESCRIPTION

E - 2 . The Model 8806B Phase Sensitive Demodulator Preamplifier is a plug-in signal conditioner used as a recording system component, or as an individual unit amplifier.

E-3. The Preamplifier provides a dc signal output proportional to the rms value of the input signal component that is in phase, or 180° out of phase, with respect to a variable phase shift reference signal. Application flexibility is possible through interchangeable plug-in phase shift modules.

E - 4 .Complete specifications for the Preamplifier are included in Table E-1. Specifications are measured at the preamplifier output after a one-hour warm-up using test equipment which does not degrade the characteristic being measured. Calibration in terms of "Divisions" corresponds to a nominal output level of 100mV per chart division of recorded paper. Charts have 50 divisions edge-to-edge. Chart center corresponds to approximately ±2.5 volts.

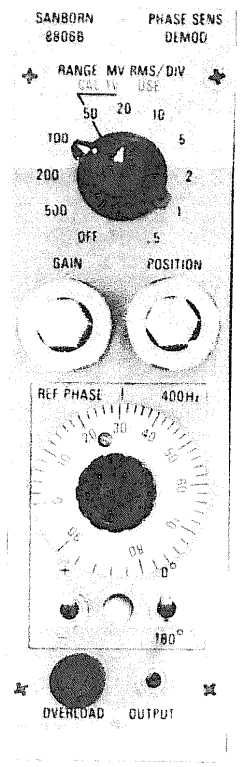

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Figure E-1. Model 8816B Phase Sensitive Demodulator Preamplifier

Table E-1. Electrical Specifications

MAXIMUM CALIBRATED SENSITIVITY: 0.5mV rms/div corresponding to a gain of 200 rms AC to DC.

SENSITIVITY RANGE: 0.5, 1, 2, 5, 10, 20, 50, 100, 200 and 500 mV/div. Accuracy: ±1% 50 Hz to kHz; ±2% 10 kHz to 20 kHz; ±3% 20 kHz to 40 kHz. OFF position provides gain of zero for baseline positioning. Smooth GAIN control permits continuous adjustment between ranges.

SIGNAL INPUT: Floating and guarded, transformer isolated; 1 megohm input resistance.

REFERENCE INPUT: Differential, transformer coupled 500 K ohm input resistance each side to ground. May be used single ended.

REFERENCE VOLTAGE RANGE: Two ranges, 3 to 20 volts rms and 20 to 133 volts rms (internal switch).

REFERENCE FREQUENCY: Standard fixed frequency of 400 Hz.

REFERENCE VOLTAGE PHASE CONTROL: 0° to 90° dial, 2° gradations; 0° or 180° reference phase switch; lead (+) and lag (-) reference phase switch. Dial accuracy on any range (after calibrating for zero error at 90° position of dial): 0°, 180°, 270°, ±0.5°; other angles ±2°.

SIGNAL CHANNEL PHASE SHIFT: Maximum variation in phase shift through signal channel (any range compared with 100 mV/div range): 50 Hz to 10 kHz ±1 ; 10 kHz to 20 kHz ±2 ; 20 kHz - 40 kHz ±3 .

QUADRATURE VOLTAGE TOLERANCE: Preamplifier performance is within specification on any range if rms value of input voltage is not greater than that which causes full scale (50 div) output change when signal and reference are in phase. (When signal and reference are in quadrature, a signal of this amplitude causes a negligible output change).

COMMON-MODE REJECTION AND TOLERANCE: (Signal input): greater than 40 dB 50 Hz to 10 kHz, 500V rms maximum common-mode signal.

OUTPUT CAPABILITY: ±3 volts DC across 1000 ohms minimum, single ended to ground.

OUTPUT IMPEDANCE: Less than 5 ohms.

FREQUENCY RESPONSE:[1] Less than 3 dB down at 1/5 of the reference frequency.

DRIFT AT OUTPUT: Temperature: less than 25 mV/10°C, 0°to 40°C. Line Voltage: 20 mV maximum, 103 to 127 volts.

BASELINE OFFSET: (Equivalent input signal due to coupling from reference channel): 50 Hz to 20 kHz, 250 μV rms maximum. 20 kHz to 40 kHz, 500 μV rms maximum.

GAIN STABILITY:[1] Temperature: less than 0.25%/10°C, 0°to 40°C. Line Voltage: 0.1% maximum, 103 to 127 volts.

NOISE:[1] Less than 7μV rms x $\sqrt{8806B}$ freq. resp., refered to input.

RIPPLE:[1] Less than 25 mV peak-to-peak; predominant frequency 2x carrier reference frequency.

LINEARITY:[1] Departure from straight line through zero and +2 volts output over the range of -2,5 to +2.5V is less than ± ±12.5 mV for load resistance of 1000 ohms or higher.

CALIBRATION: 1 volt internal, accuracy: ±1% 50 Hz to 10 kHz; ±2% 10 kHz to 20 kHz; ±3% 20 kHz to 40 kHz.

1 When preamplifier is used in a recording system, these specifications are affected by performance of the recorder and driver amplifier (consult data sheet of appropriate system for details).

SECTION II

INSTALLATION

E-5. IN RECORDING SYSTEMS.

E-6. The Model 8806B can be installed in 7701A, 7702A, 7704A, 7706A, 7706B, or 7708A Recording Systems for 1, 2, 4, 6, or 8 channels of recorded information. See the recording system instruction manual for installation instructions.

E-7. AS A SELF-CONTAINED INSTRUMENT.

E-8. The 8806B is operated as a self-contained instrument using the Model 860-500 Power Supply, for use with 115 or 230 volts, 50-400 cycles. The Preamplifier and Power Supply combination may be housed in a Model 860-1400 Portable Case for single channel operation.

E-9. SIGNAL CONNECTIONS

E-10. Two inputs are required for the Model 8806B Preamplifier; an ac signal input, and a reference signal. The ac signal input can be applied single ended or differentially. Two conductor shielded cable 3/16" O. D., with single braided shield is required for connecting the signal source to the input connectors. If high common mode rejection is required, use double shielded cable for a fully guarded input circuit. The inner shield connects to the common mode potential of the signal source to reduce capacitive and resistive currents between the signal conductors and ground. The outer shield is grounded to prevent capacitive coupling of the inner shield common mode potential into other circuitry. Wire the input and output signals to the appropriate Power Supply connectors as indicated in table E-1.

E-11. The Model 8806B output is also available at the Preamplifier front panel OUTPUT jack. Wire the mating connector as follows: Plus (+) signal output to tip, and ground to sleeve. Refer to the appropriate system instruction manual for output connections to all Preamplifiers in a system, using one multiple output connector.

Table E-2. Signal Interconnections

NOTE

When connected as shown, a signal in-phase with the adjustable reference signal at the + lead will give an up-scale deflection on the recorder, or a positive output from the Preamplifier.

MODEL 8806B PREAMPLIFIER		POWER SUPPLY MODEL	
		8848A, 8848A – OPTION 01 8848A – OPTION 02	8849A
AC SIGNAL INPUT [1]	+	J11 PIN A (TYP CHI–8)	J3 PIN A
	–	J11 PIN B (TYP CHI–8)	J3 PIN B
	INNER SHIELD	J11 GUARD (TYP CHI–8)	J3 GUARD
	OUTER SHIELD	J11 PIN C (GROUND)	J3 PIN C (GROUND)
REFERENCE INPUT [2]	+	J21 PIN A (TYP CHI–8)	J2 PIN A
	–	J21 PIN B (TYP CHI–8)	J2 PIN B
	SHIELD	J21 PIN F (TYP CHI–8)	J2 PIN F
OUTPUT	SIGNAL	J21 PIN E (TYP CHI–8)	J2 PIN E
	GROUND	J21 PIN L (TYP CHI–8)	J2 PIN L

[1] FOR SINGLE ENDED AC INPUT SIGNALS, CONNECT UNUSED INPUT TERMINAL TO GUARD.

[2] FOR SINGLE ENDED REFERENCE INPUT, CONNECT UNUSED REFERENCE TERMINAL TO GROUND.

SECTION III

OPERATION

E-12. FRONT PANEL CONTROLS

E-13. PREAMPLIFIER

a. **RANGE MV RMS/DIV:** Ten step attenuator plus OFF position. At calibrated gain, recording sensitivities as marked on panel.

b. **CAL 1V-USE:** Selector switch concentric with RANGE switch, for inserting an internal calibrated signal (equivalent to 1 volt) to provide a 20 division stylus deflection (2 volts output) with RANGE switch at 50 MV RMS/DIV.

c. **GAIN:** Potentiometric control provides smooth gain with a ratio greater than 2.5:1, and overlap gain for each RANGE position. Control has locking device to maintain settings.

d. **POSITION:** Potentiometric control adjusts dc voltage output to vary stylus position at least ±25 divisions. Control has locking device to maintain settings.

e. **OVERLOAD:** Indicator lamp; illuminates when peak voltage swings are overloading the signal amplifier.

f. **OUTPUT:** Miniature jack for connecting an external monitoring device; i.e., oscilloscope, meter, etc.

E-14. FIXED FREQUENCY PLUG-IN MODELS

a. **REF PHASE:** Dial 0° to 90° in 2° increments; operates in conjunction with the 0°/180° switch and the +/- switch (quadrant selectors) to shift the reference phase 360°, in four quadrants. Figure E-2 illustrates control settings and respective reference phase shifting.

b. **0°/180°:** Miniature toggle switch; selects the 1st and 4th quadrants (0°), and the 2nd and 3rd quadrants (180°).

c. **+/-:** Miniature toggle switch; selects the direction of the reference phase, leading (+), or lagging (-).

E-15 VARIABLE FREQUENCY PLUG-IN MODELS

a. **KHZ:** Frequency range switch; six position selector switch covers reference frequency bands from 50 Hz to 40 kHz.

b. **PHASE 0° - 360°:** Potentiometric control concentric with KHZ switch; reference phase from 0° to 360°; counterclockwise rotation of control retards reference phase, clockwise rotation advances reference phase.

c. **0° SET:** Momentary pushbutton activates quadrature null circuit; i.e., provides quadrature signal in conjunction with CAL 1V-USE switch.

E-16. ADJUSTMENT CONTROLS

E-17. Adjustments to the Model 8806B and Fixed Frequency Plug-In Modules can be performed routinely to insure maximum instrument accuracy. The control descriptions, locations, and adjustment procedures are included in Section V.

E-18. REFERENCE VOLTAGE RANGE SWITCH

E-18 A two position slide switch provides range selection of the ac reference signal input. This switch is one of the internal controls and is identified in Section V, Figure E-6 as REF VOLT. In the up position, the reference voltage range is 3 to 20 volts rms, and in the down position the reference voltage range is 20 to 133 volts rms. For optimum instrument performance, the 90° ADJ and 30° ADJ controls (Fixed Frequency Plug-In Modules only) should be checked when the reference voltage range switch setting is changed. Refer to Section V for adjustment procedures.

E-20. CALIBRATION

a. Place CAL 1V-USE selector switch to CAL 1V.

b. Place RANGE switch to OFF.

c. Adjust POSITION control for center-scale on recorder or zero volts on output indicating device; lock the control.

d. Place RANGE switch to 50 MV/DIV, and adjust GAIN control for 20 divisions stylus deflection or 2 volts on output indicating device; lock the control.

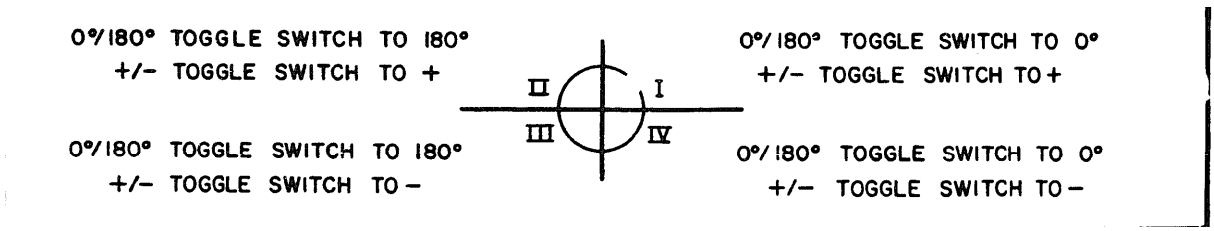


Figure E-2. Quadrant Phase Shifting

E-21. OPERATION

E-22. Operation of the Model 8806B assumes that the installation (preceding section) is complete. Figure E-3 illustrates a typical input circuit configuration to the Preamplifier.

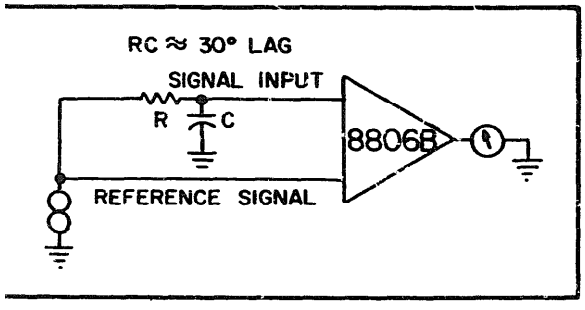


Figure e-3. Amplifier and Input Circuit

E-32. OPERATION WITH FIXED FREQUENCY PLUG-IN MODULE

E-24 To determine the vector (phase angle and amplitude) of the input circuit shown in Figure E-3 set preamplifier and plug-in controls as follows:

a. Set the REF VOLT internal range switch to the appropriate position for reference voltage to be used.

b. Calibrate the Preamplifier as described in paragraph E-20.

c. Set Plug-In controls to agree with approximate phase of input signal. Figure E-4 illustrates the Plug-In Control settings, with the arrow representing the input signal phase angle; i. e., 30° lag with respect to reference signal.

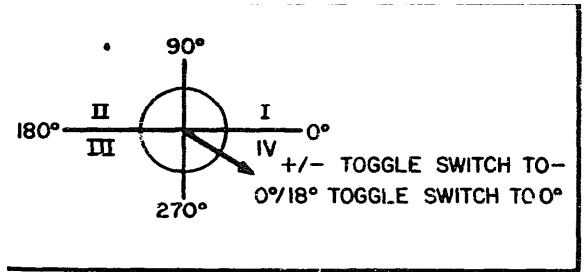


Figure E-4. Input Signal and control Settings

d. Adjust REF PHASE dial for maximum output indication, and adjust RANGE switch to obtain an output that is nearly full scale (exceeding full scale output can cause an overload condition). The dc output voltage is proportional to the rms value of the input signal, and the input signal phase angle is indicated by the REF PHASE dial setting.

NOTE

If the OVERLOAD indicator on the Preamplifier becomes illuminated, decrease sensitivity by turning RANGE switch counterclockwise until OVERLOAD indication is extinguished.

e. For maximum phase angle information, it is recommended that the reference signal phase be displaced from the signal input phase by 90° to obtain an output null indication. From the REF PHASE dial and switch settings obtained in Step 3-13c, displace the reference phase 90°; i. e., REF PHASE dial to 60, +/- switch to -, and 0°/180° switch to 180°. (Note that a 90° displacement is also achieved by setting REF PHASE dial to 60, +/- switch to +, and 0°/180° switch to 0°).

f. Slowly adjust REF PHASE dial to obtain a null at the output. The final REF PHASE dial setting, less 90° (or 270°) is the phase angle of the input signal.

SECTION IV

PRINCIPALS OF OPERATION

3-25. CIRCUIT DESCRIPTION.

E-26. **The Model 8806B measures the amplitude of an in-phase, or 180° out of phase, component of a signal with respect to a reference voltage. The Preamplifier requires two inputs: the signal to be measured, and a reference voltage which provides the time base for phase comparison. The Preamplifier expresses the in phase, or 180° out of phase, component as a proportional dc voltage output which is positive when the signal is 180° out of phase with the reference. The reference phase may be shifted to any angle by controls on the plug-in phase shift modules. The reference voltage is taken from the system under measurement. This voltage is transformed to a square wave, differentiated, and then used as a drive for the demodulator gating circuitry. A block diagram of the Model 8806B is illustrated in Figure E-5.**

E-27. SIGNAL CHANNEL DESCRIPTION.

E-28. **The Signal Channel has a transformer isolated input amplifier with feedback attenuation for decade range changing, followed by a 1-2-5 attenuator string, isolation amplifier, smooth gain control, full wave gated demodulator, and output amplifier including an active filter.**

E-29 REFERENCE CHANNEL DESCRIPTION.

E-30 **The reference channel has a transformer coupled amplifier with feedback selection for range changing, followed by an RC phase shifter, high gain clipper amplifier, and differentiator which provides narrow gates to the demodulator. Output of phase shifter is shaped to provide the calibration signal.**

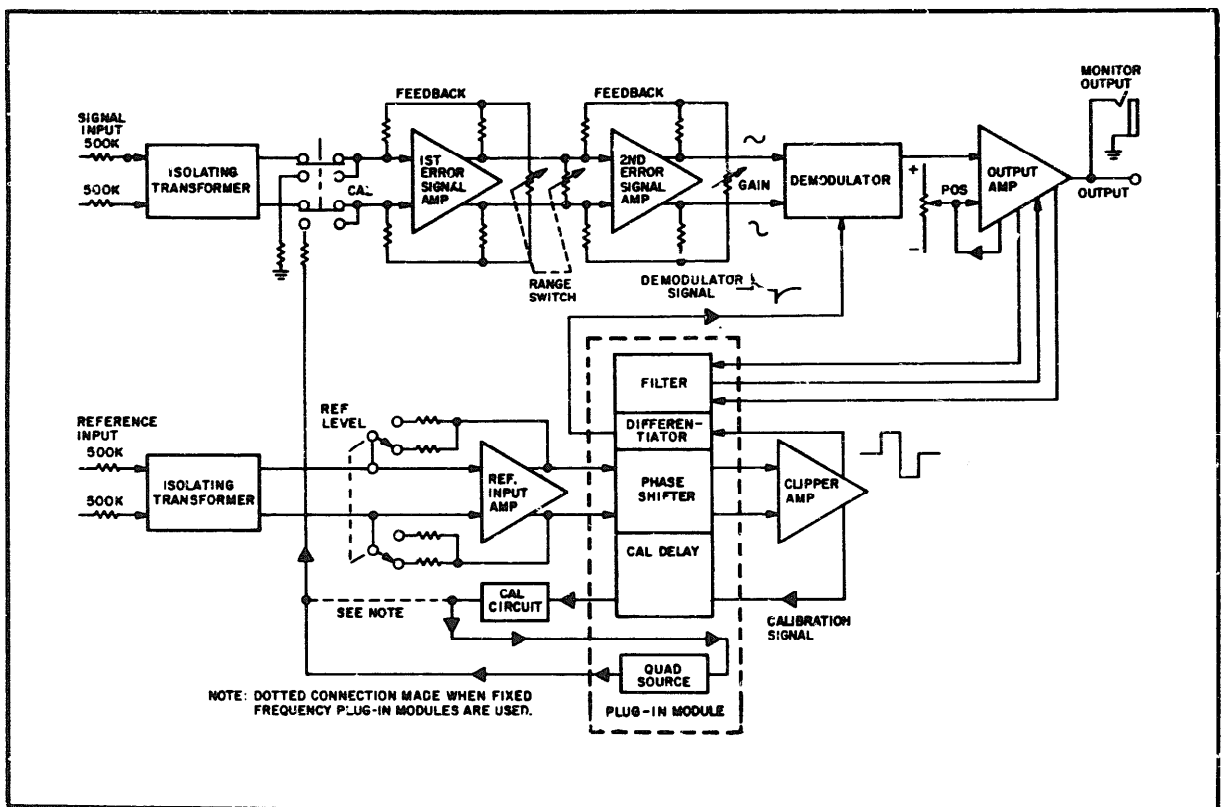


Figure 8-5. Block Diagram Model 8806B

SECTION V
MAINTENANCE

E-31. ADJUSTMENTS

E-32. **Internal adjustments to the Model 8806B and fixed frequency Plug-In Modules are recommended for optimum instrument performance. Adjustment procedures should be performed as a periodic operational check, or after repairs have been made to the instrument. The adjustment controls are illustrated in** figure E-6 descriptions and adjustment procedures are described in the following paragraphs.

E-33. CONTROL DESCRIPTIONS

a. REF VOLT: Located inside Preamplifier; two position slide switch accessible when side panel is removed; selects reference voltage range; in up position, range is 3 - 20 volts rms, in down position, range is 20 - 133 volts rms.

b. CAL ADJ: Located inside Preamplifier; screwdriver adjustment accessible when side panel is removed; sets calibration voltage applied to input when CAL 1V-USE switch is set to CAL 1V.

c. 90° ADJ: Located inside Fixed Frequency Plug-In Module; screwdriver adjustment accessible through the hole in reference phase dial when dial is placed at the 90° position; sets 90° point of reference phase control.

d. 30° ADJ: Located inside Fixed Frequency Plug-In Module; screwdriver adjustment accessible through the hole in reference phase dial when dial is placed at the 30° position; sets 30° point of reference phase control.

e. COMMON MODE REJECTION ADJUST: Located inside Preamplifier; screwdriver adjustment accessible when side panel is removed; provides a variable setting to minimize common mode signal output.

f. HIGH FREQUENCY PHASE ADJUST (+ REF INPUT): Located inside Preamplifier; screwdriver adjustment matches high frequency phase tracking of reference channel to signal channel; control is adjusted at factory prior to shipment.

g. HIGH FREQUENCY PHASE ADJUST (-REF INPUT): Same as above.

E-34. ADJUSTMENT PROCEDURES

E-35. Cal Adj.

a. Apply sufficient reference voltage and an accurate 1 volt in-phase signal.

b. Place RANGE switch to OFF, CAL 1V-USE to USE, and adj. POSITION control for zero volts output.

c. Place RANGE switch to 50 mV/DIV and adjust GAIN control for 2 volts output.

d. Place CAL 1V-USE to CAL 1V and adjust Cal Adj control for exactly the same voltage as obtained in c above.

e. Repeat procedure to assure proper calibration.

E-36. 90° Adj

a. Apply sufficient reference voltage and a nearly full-scale in-phase input signal.

b. Place the REF PHASE dial to 90°.

c. Adjust the +90° ADJ control, R205 (accessible through hole in REF PHASE dial when dial is set at 90°) and simultaneously actuate +/- toggle switch for the same output indication when toggle switch is in either position.

3-37. 30° Adj

a. Place the REF PHASE dial to 30°, and adjust the 30° ADJ control, R202 (accessible through hole in REF PHASE dial when dial is set at 30°) and simultaneously actuate toggle switch for the same output indication when +/- toggle switch is in either position.

E-38. Common Mode Rejection Adj.

a. Place REF PHASE to 90°; connect the two input leads and the guard shield together.

b. Apply a 10 V ac input at 40 kHz (or highest frequency of Plug-In Module being used).

c. Adjust the Common Mode Rejection Adj control and simultaneously advance RANGE switch (to higher sensitivities) for minimum output offset.

E-39. INSTRUMENT REPAIR

E-40. **All components in the Model 8806B and associated Plug-In Modules are identified by reference designation on the schematic diagrams,** (fig. E-7, E-8, and E-9).

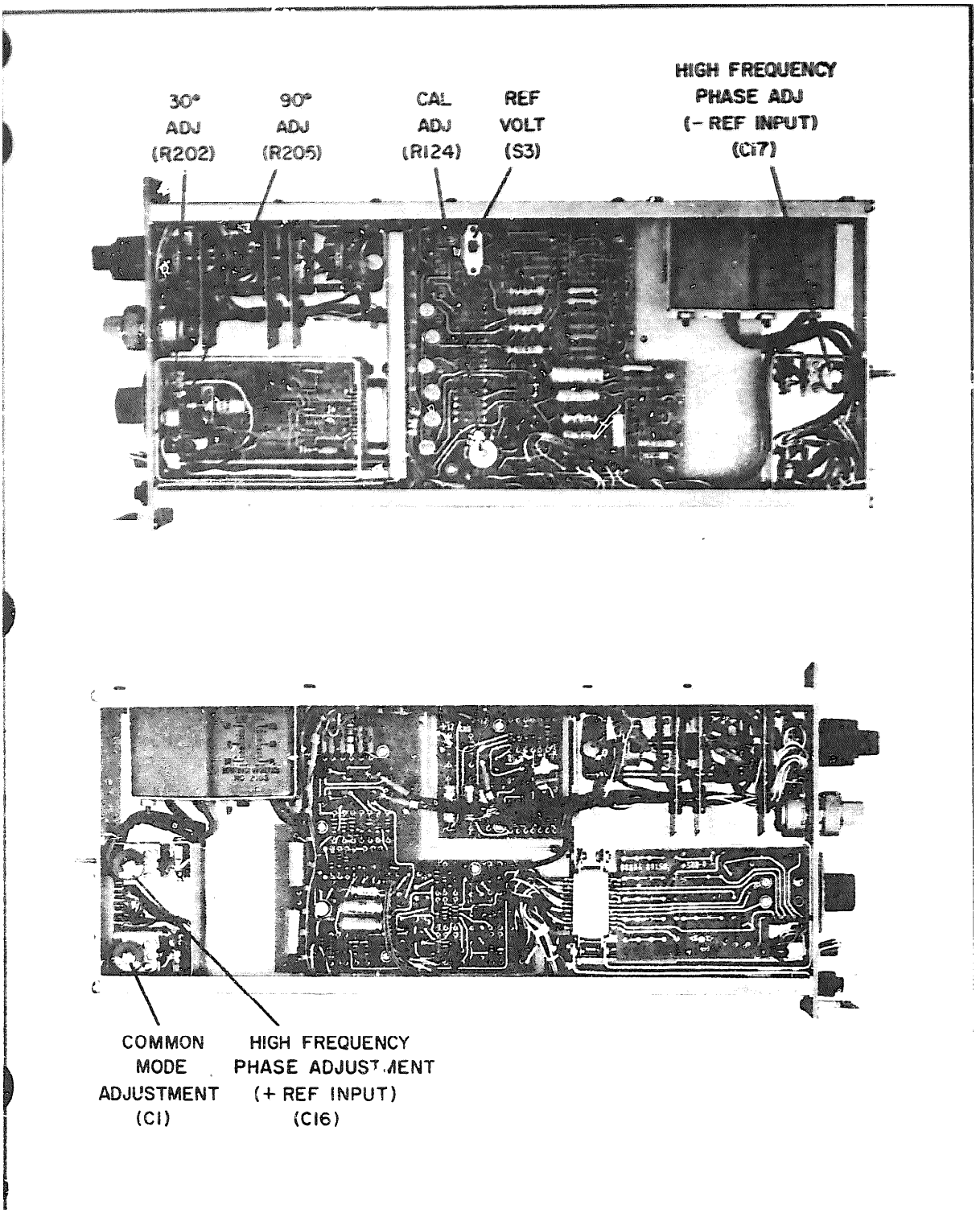
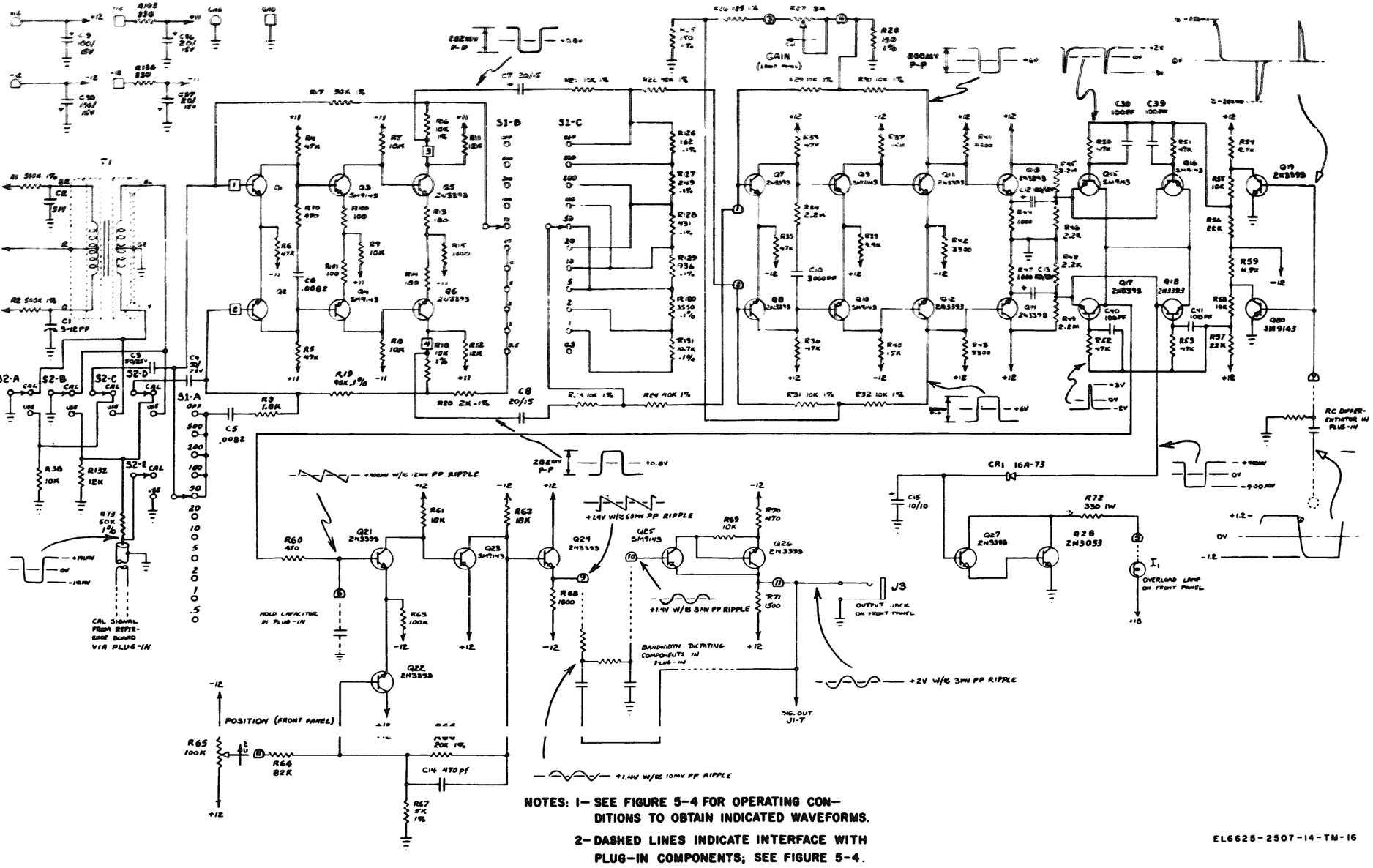


Figure E-6. Adjustment Controls.



NOTES: 1— SEE FIGURE 5-4 FOR OPERATING CONDITIONS TO OBTAIN INDICATED WAVEFORMS.

2— DASHED LINES INDICATE INTERFACE WITH PLUG-IN COMPONENTS; SEE FIGURE 5-4.

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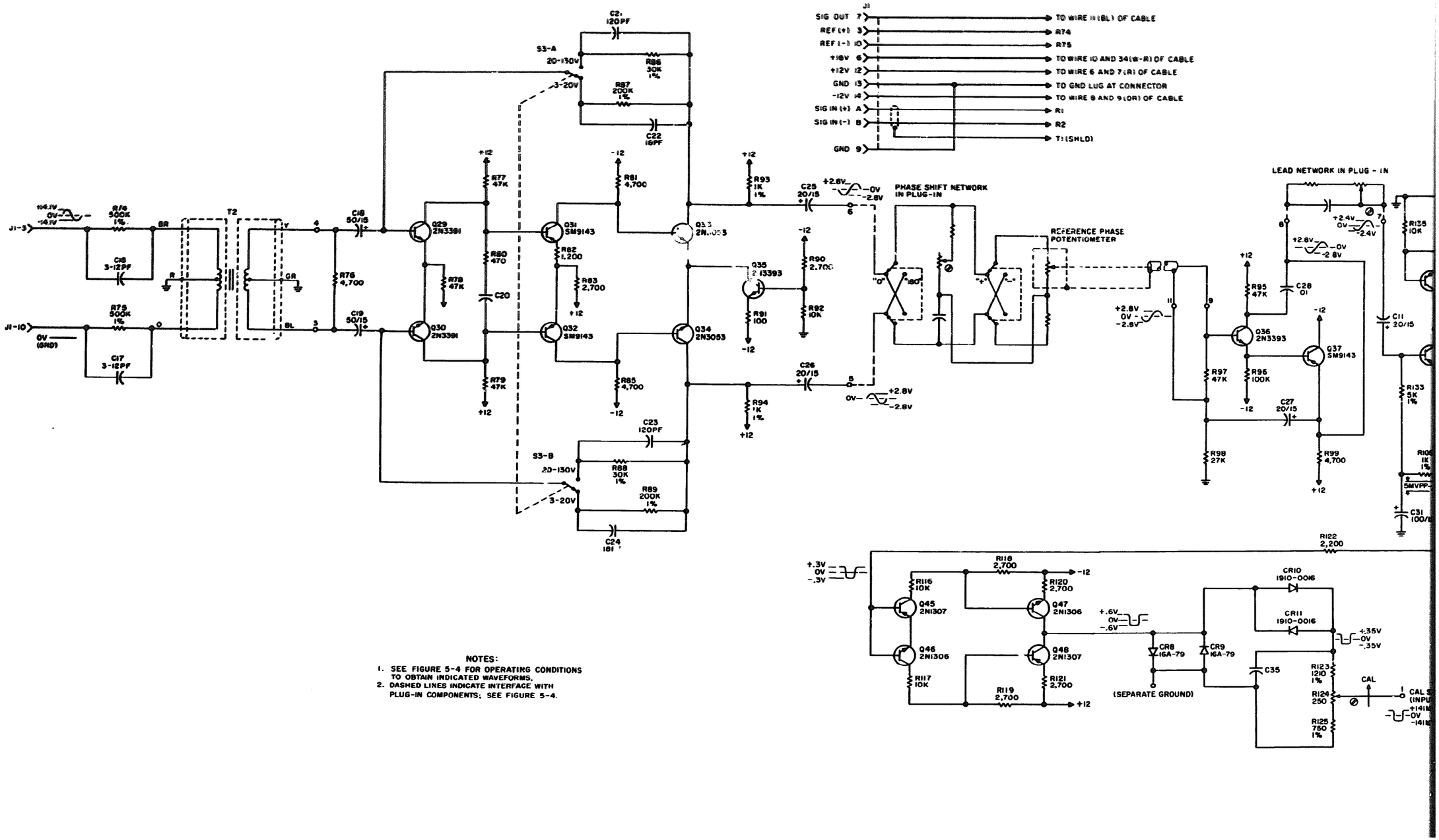
Figure E-7. Phase sensitive demodulator amplifier model 8806B, signal channel.



NOTES:

1. SEE FIGURE 5-4 FOR OPERATING CONDITIONS TO OBTAIN INDICATED WAVEFORMS.
2. DASHED LINES INDICATE INTERFACE WITH PLUG-IN COMPONENTS; SEE FIGURE 5-4.

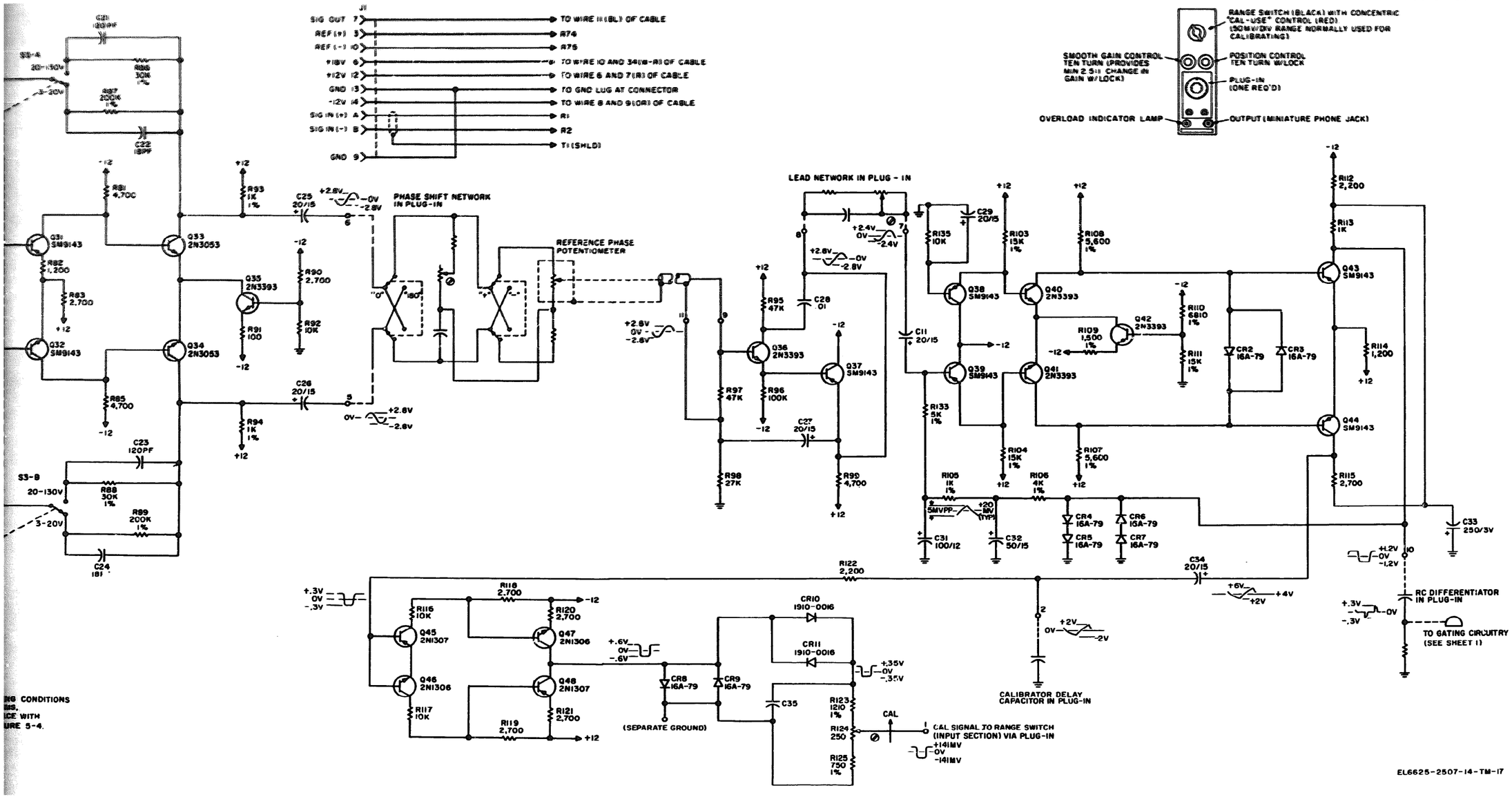


Figure E-8. Phase sensitive modulator preamplifier model 8806B, reference channel.

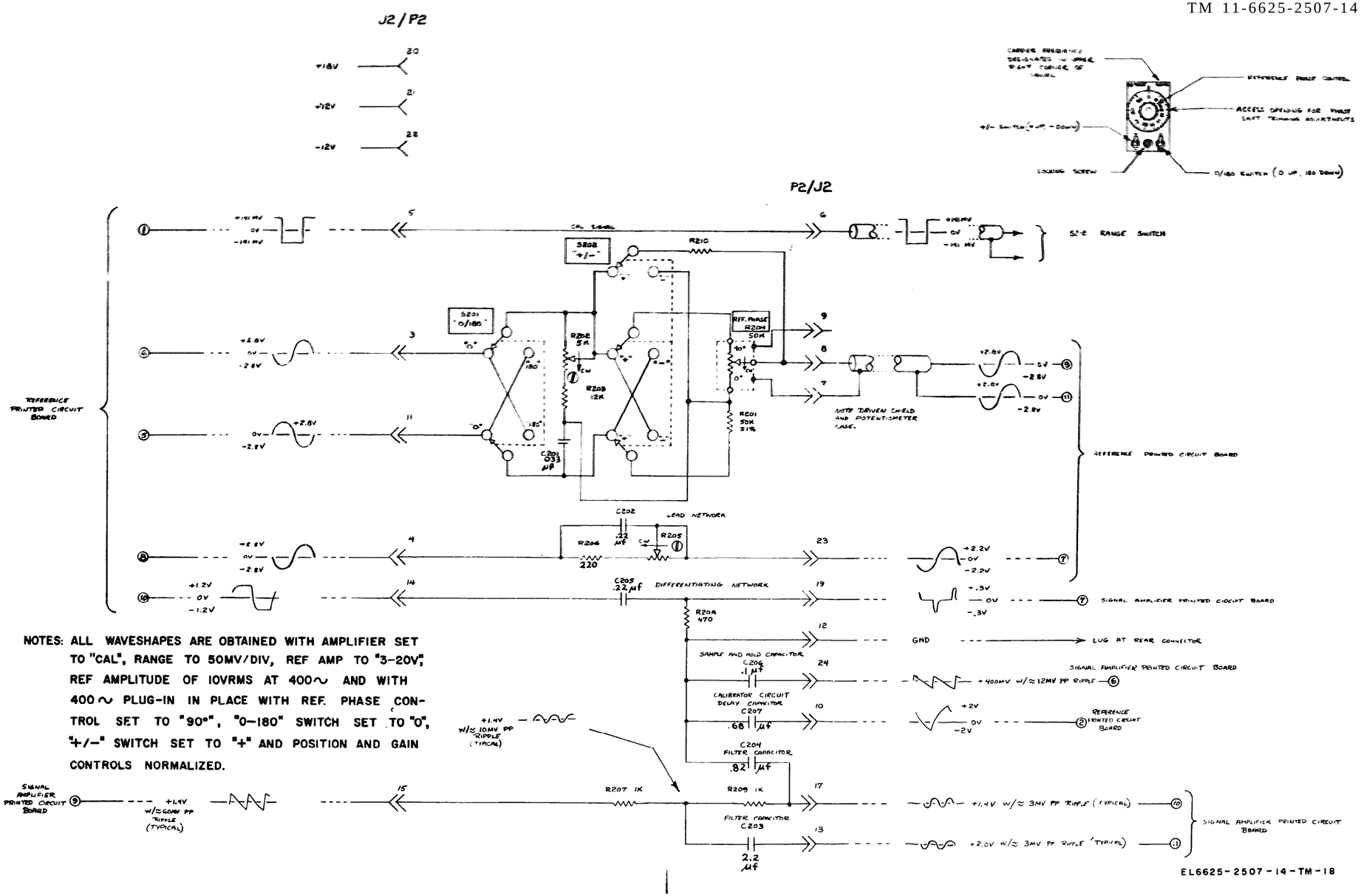


Figure E-9. Fixed frequency plug-un module module 8806B-03B.

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CREIGHTON W. ABRAMS
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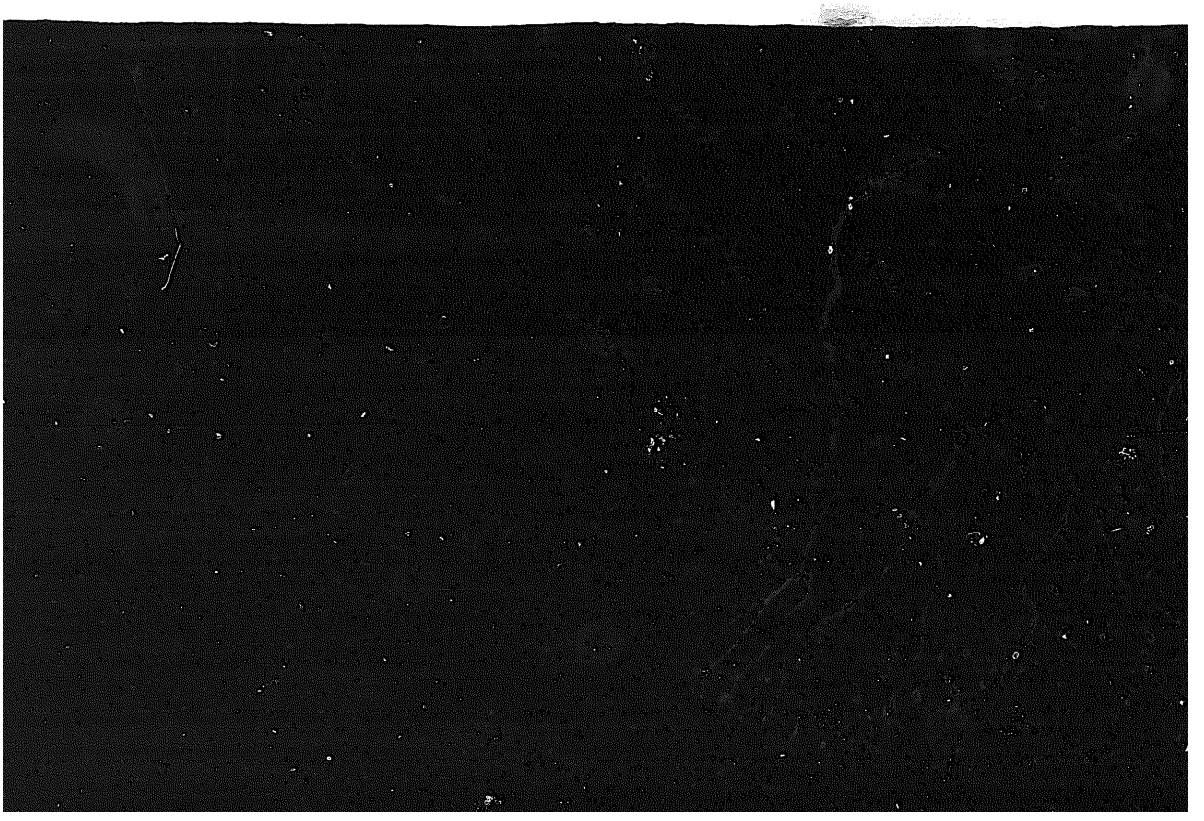

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