TM-101378A

INSTRUCTION MANUAL

FOR

PHASEMETER

MAIN FRAME MODELS 305, 305B, 305C AND 305D

PLUG-IN MODEL 305-PA-3001

PLUG-IN MODEL 305-PA-3002

DRANETZ

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SERIAL NUMBER EFFECTIVITY

Instruction Manual TM-101378A provides maintenance and operating instructions for Phasemeter Models 305, 305B, 305C and 305D and Plug-In Models 305-PA-3001 and 305-PA-3002 units determined by the following Serial No. codes:

MODELS	SERIAL NUMBERS
305, 305B, 305C and 305D	1. For all 9-digit serial numbers 2. For 10-digit serial numbers when the significant digit (5th digit from right side) is 7 or greater.
10-DIGIT EXAMPLE □ □ □ □ □ □ □ □ □ □ ↑ Significant Digit	
Plug-In 305-PA-3001	1. For all 9 digit serial numbers 2. For 10-digit serial numbers when the significant digit is 5 or greater.
Plug-In 305-PA-3002	1. For all 9-digit serial numbers 2. For 10-digit serial numbers when the significant digit is 1 or greater.

SECTION I
GENERAL INFORMATION

1-1. INTRODUCTION

1-2. This manual provides operating and service instructions for the Phasemeters Series 305 (hereinafter referred to as Model 305), manufactured by Dranetz Engineering Laboratories, Incorporated. This section discusses the purpose, application, and technical characteristics of Models 305, 305B, 305C and 305D.

1-3. PURPOSE

1-4. Model 305 Phasemeter (figure 1-1) represents a totally new concept in the measurement of phase angle. A precision phase angle measurement is obtained simply by connecting the signals and reading the display. No adjustments are required during normal use. Model 305 senses the signal frequency and adjusts its output time constant for maximum speed commensurate with low ripple. It remains operational in the presence of up to 10% high frequency noise. Model 305 sensitivity to waveform distortion is reduced over that of other phasemeters which normally require filters to remove distortion effects.

1-5. The use of the automatic dual mode switching allows for continuous phase plotting between $<-160^{\circ}$ to $>+340^{\circ}$ with no discontinuities. The front panel controls on Model 305 main frame are used only for self checking of the main frame and calibration of remotely connected accessories such as a recorder or printer.

1-6. Standard plug-in units covering a frequency range of 1 Hz to 11 MHz are available with Model 305 Phasemeter. Special plug-in units are available on request.

1-7. SPECIAL FEATURES

1-8. Model 305 provides special features when used with Plug-in Model 305-PA-3001 or 305-PA-3002.

a. No operating controls.

b. Excellent stability -- no operating adjustments.

c. 0.05° accuracy independent of input voltage.

Figure 1-1. Model 305 Phase Meter (305C Main Frame With 305-PA-3001 Plug-in)

d. Versatile plug-in concept.

e. Basic frequency range: 2 Hz to 700 kHz (extendable to 1 Hz or 11 MHz with other plug-ins).

f. Digital readouts on Models 305B, 305C and 305D.

g. Digital outputs on Models 305B, 305C and ~~305D~~ for use with printers, etc.

h. 1 Megohm input impedance.

i. Levels extendable to 40 KV using Tektronix probes.

j. Indicator lights on each input to indicate either low or high input levels (305-PA-3001 only).

k. High overvoltage capability.

1-9. EQUIPMENT CHARACTERISTICS AND SERIES 305 CONFIGURATIONS.

Table 1-1 provides the technical characteristics for Model 305. Table 1-2 and 1-3 lists the configurations and options which comprise the different models within the Series 305 phasemeters. Table 1-4 describes the additional plug-in units available.

Table 1-1. TECHNICAL CHARACTERISTICS

1. MODEL 305 MAIN FRAME (PHASE TO DC CONVERTER) with Model 305-PA-3001 Plug-in)	
Type	Specification
INPUT LEVELS (Independent) (Signal or Reference)	10 mV to 300V rms up to 10 kHz decreasing to 50V rms above 100 kHz (up to 700 kHz)
INPUT IMPEDANCE (Both inputs)	1 Megohm +40 pf (usable with standard oscilloscope probes)
ANALOG OUTPUT:	-1.800 volts dc to +3.600 volts dc
Sensitivity:	10 millivolts/degree
Ouput Impedance:	100 ohms maximum
Ripple:	>25 Hz: 0.5% full scale rms maximum; at 5 Hz: 2.5% full scale maximum
ACCURACY:	$\pm 0.05^{\circ}$ maximum at 50 Hz to 50 kHz from 50 mV rms to 50V rms; typically $\pm 0.25^{\circ}$ from 5 Hz to 500 kHz
TIME CONSTANTS:	0 to 63%: Automatically selected, with override capability available through a rear connector Typical Values of Time Constant (T) 2 to 50 Hz: 700 mS 50 to 500 Hz: 350 mS 0.5 to 5 kHz: 50 mS 5 to 700 kHz: 10 mS NOTE Output change is to within 90% after 2.3T; 99% after 4.6T; 99.9% after 6.9T
OPERATING MODES:	Zero to $+360^{\circ}$ and -180° to $+180^{\circ}$ a. Automatically selected as follows: Switch to 0 to $+360^{\circ}$ mode at $< -160^{\circ}$ and $> +160^{\circ}$. Switch to -180° to $+180^{\circ}$ mode at $< +20^{\circ}$ and $> +340^{\circ}$. b. Manually selected as follows: angles between -160° to -20° and $+200^{\circ}$ to $+340^{\circ}$ can be interchanged with the front panel mode select switch. c. Auto Mode selection override is available through rear connector and the front panel momentary action switch (contact closure).
AVERAGE TEMPERATURE COEFFICIENT (0 to $+50^{\circ}C$)	$0.001^{\circ}/^{\circ}C$ typical
SELF-CHECK FEATURE:	-180°, 0°, $+180^{\circ}$, and 360° are available in the CHECK position. These points verify main frame operation. Plug-in accuracy may be checked by simply connecting REFERENCE and SIGNAL inputs to the same signal source.
OPTIONS:	Refer to Section VIII for details of options available for use with the Series 305 Phasemeters.

Table 1-1. TECHNICAL CHARACTERISTICS (cont)

1.(cont) MODEL 305 MAIN FRAME (PHASE TO DC CONVERTER) with Model 305-PA-3001 Plug-in)	
Type	Specification
LEVEL INDICATORS: (302-PA-3001)	LOW and HIGH indicator lights on the plug-in along with TTL/DTL compatible outputs available through a rear connector, indicate when the reference or signal levels exceed specification.
OVERVOLTAGE CAPABILITY (with Plug-in Model 305-PA-3001):	Phase meter will remain operational with reduced specification with input voltages to 300 volts rms from 5 Hz to 10 kHz, decreasing to 50 volts rms above 100 kHz.
UNDERVOLTAGE CAPABILITY:	to 10 millivolts rms with typical ±0.25° accuracy, at 50 Hz to 100 kHz
REFERENCE AND SIGNAL INPUT CONNECTORS:	BNC types mounted on front panel of plug-in. (Rear input connectors are optional.)
POWER REQUIREMENTS:	115 volts rms ±10% or 230 volts rms ±10%, 50 to 60 Hz, 35 watts
SIZE:	3-1/2"high,19"wide rack or portable package, 16 inch depth
WEIGHT:	Net 20 lbs; shipping 30 lbs.
2. MODEL 305B PHASEMETER - Same as Model 305 except for the following additions:	
DIGITAL READOUT:	4-digit (-180.0° to +360.0°) 0.1° resolution presentation with polarity indication.
DIGITAL OUTPUT:	4 digit BCD coded (1248) with polarity bit 15 lines, TTL/DTL compatible (<+0.8 volts to >+2.4 volts dc), READ and HOLD on command features available on rear connector.
ACCURACY (including readout)	±0.2° from 50 Hz to 50 kHz from 50 mV rms to 50V rms; typically ±0.4° from 5 Hz to 500 kHz. NOTE: Accuracy of analog DC output same as Model 305.
3. MODEL 305C PHASEMETER - Same as Model 305 except for the following additions:	
DIGITAL READOUT:	5-digit (-180.00° to +360.00°) 0.01° resolution presentation with polarity indication.
DIGITAL OUTPUT:	5 digit BCD coded (1248) with polarity bit, 21 lines, TTL/DTL compatible (<+0.8 volts to >+2.4 volts dc). READ and HOLD on command features available on rear connector.
ACCURACY (including readout)	±0.05° from 50 Hz to 50 kHz from 50 mV rms to 50V rms; typically ±0.25° from 5 Hz to 500 kHz.

NOTE

A leading "SIGNAL" phase shift is displayed as a "+" or LEAD angle. If a lagging positive angle is desired, interchange the REFERENCE and SIGNAL inputs.

Table 1-1. TECHNICAL CHARACTERISTICS (cont)

4. MODEL 305D PHASEMETER - Same as Model 305C except for the following additions:	
Analog Meter	Front panel analog null meter, approximately 0.2°/division near null for easy comparison of measured phase angle to preset reference angle.
Offset Controls Coarse and Fine	Front panel coarse and fine adjustments allowing setting offset angles from +360.0° to -180° with better than 0.1° resolution.
Offset Stability	±0.1° with warm-up.
Offset Accuracy	±0.1° after warm-up (30 minutes) for either panel meter or analog output.
5. With PLUG-IN MODEL 305-PA-3002 - Same as for Plug-in Model 305-PA-3001 except for the following changes.	
Type	Specification
INPUT LEVELS (Independent) (Signal or Reference)	10 mV rms to 3V rms from 2 Hz to 700 kHz
ACCURACY (DC Analog output)	±0.05° from 50 Hz to 50 kHz from 50 mV rms to 500 mV rms; typically ±0.25° from 5 Hz to 500 kHz.
NOTE For specifications with other Plug-ins, refer to the instruction manual of the individual Plug-in.	
6. ACCESSORIES SUPPLIED: a. Power Line Cord Belden No. 17258 b. For Model 305 Main Frame Only: 2 each, Connector, Cannon DB25P 2 each, Hood, Cannon DB20962 c. For Models 305B, 305C and 305D Main Frames: 3 each, Connector, Cannon DB25P 3 each, Hood, Cannon DB20962 d. Circuit board extender, Dranetz Assy No. 101219, mounted in main frame e. Extender cable, Dranetz Assy No. 101685, mounted in main frame	

Table 1-2. Series 305 Configurations

SERIES 305 CONFIGURATION

CIRCUIT CARD REF. DESIG.	MODEL 305 (NOTE 1)		MODEL 305B		MODEL 305C		MODEL 305D		REMARKS
	ASSY NO.	SCHEMATIC NO.	ASSY NO.	SCHEMATIC NO.	ASSY NO.	SCHEMATIC NO.	ASSY NO.	SCHEMATIC NO.	
A1	101668	101669	101668	101669	101668	101669	101668	101669	
A2	101319	101326	101319	101326	101319	101326	101319	101326	
A3	101668	101669	101668	101669	101668	101669	101668	101669	
A4	101320	101327	101320	101327	101320	101327	101320	101327	
A5	102516	102518	102516	102518	102516	102518	102516	102518	
A6	101322	101329	101322	101329	101322	101329	101322	101329	
A7	102520	102522	102520	102522	102520	102522	102520	102522	
A8	101324	101331	101324	101331	101324	101331	101324	101331	
305D A10	-	-	-	-	-	-	102222	102224	WAS OPTION 104 - NOW INCLUDED IN MODEL 305D.
POWER SUPPLY	101213	101215	101213	101215	101213	101215	101213	101215	
PANEL METER (NOTE 2)	-	-	(NEWPORT 400AS)* Assy No. 101373		(NEWPORT 2000B/SER)* Assy No. 101749		(NEWPORT 2000B/SER) Assy No. 101749		MODELS 305B, C AND D PROVIDE BCD OUTPUTS FROM METER TO A REAR CONNECTOR.
FRONT PANEL	NO READOUT		4 DIGIT READOUT		5 DIGIT READOUT		ADDITION OF TWO OFFSET CONTROLS: FINE/COARSE AND ANALOG NULLMETER		

NOTE 1: MODEL 305 IS ANALOG OUTPUT ONLY.
2. PANEL METER (NEWPORT 400A) PROVIDES 0.1° RESOLUTION AND PANEL METER (NEWPORT 2000B/SER) PROVIDES 0.01° RESOLUTION.

PLUG-IN CARD REF. DESIG.	PLUG-IN MODEL 305-PA-3001		PLUG-IN MODEL 305-PA-3002	
	ASSY NO.	SCHEMATIC NO.	ASSY NO.	SCHEMATIC NO.
A1 & A2	102616	102619	102841	102842
A3 & A4	101359	101358	-	-
A5	102620	102623	102620	102623

*Owners Manual for appropriate Digital Panel Meter supplied with equipment.

Table 1-3. Series 305 Options and Detail Information

<table>
<tr><th>OPTION</th><th>DESCRIPTION</th><th>TECHNICAL MANUAL REFERENCE</th><th colspan="3">OPTION INSTALLATION</th><th>REMARKS</th></tr>
<tr><td>101</td><td>REAR BNC CONNECTORS FOR BOTH SIGNALS AND REFERENCE INPUTS</td><td>PARAGRAPH 8-3</td><td colspan="3"></td><td>OPTION 101 MUST BE SPECIFIED ON PLUG-IN AS WELL AS MAIN FRAME. OPTION 101 IS NOT COMPATIBLE WHEN PLUG-IN MODELS 305-PA-3005 AND 305-PA-3008 ARE USED.</td></tr>
<tr><td rowspan="3">102</td><td rowspan="3">REMOTE CONTROL</td><td rowspan="3">PARAGRAPH 8-6</td><td colspan="3">ADD CARD AND REMOTE/LOCAL SWITCH</td><td rowspan="3">PARALLEL TTL COMPATIBLE INPUTS.</td></tr>
<tr><td>CARD</td><td>ASSY NO.</td><td>SCHEMATIC NO</td></tr>
<tr><td>A9</td><td>101672</td><td>101673</td></tr>
<tr><td rowspan="4">103</td><td rowspan="4">HIGH SPEED RESPONSE</td><td rowspan="4">PARAGRAPH 8-21</td><td colspan="3">REMOVE EXISTING CARDS A5 AND A7 FROM MAIN FRAME AND REPLACE WITH NEW CARDS:</td><td rowspan="4">OPTION 103 CANNOT BE USED WHEN OPTION 107 IS INCLUDED.</td></tr>
<tr><td>CARD</td><td>ASSY NO.</td><td>SCHEMATIC NO.</td></tr>
<tr><td>A5</td><td>102201</td><td>102203</td></tr>
<tr><td>A7</td><td>101670</td><td>101671</td></tr>
<tr><td>105</td><td>REMOTE ZERO ADJUSTMENT</td><td>PARAGRAPH 8-28</td><td colspan="3">REQUIRES ADDITIONAL COMPONENTS ON MAIN FRAME T.B.3.</td><td></td></tr>
<tr><td rowspan="3">107</td><td rowspan="3">AUTOMATIC CALIBRATION OF DIGITAL READOUT AND OUTPUTS</td><td rowspan="3">PARAGRAPH 8-31</td><td colspan="3">ADDITION OF CARD A11 TO A CONNECTOR ADDED UNDER PANEL METER:</td><td rowspan="3">OPTION 107 CANNOT BE USED WITH OPTION 103. OPTION 107 IS AVAILABLE ON 305C ONLY.</td></tr>
<tr><td>CARD</td><td>ASSY NO.</td><td>SCHEMATIC NO.</td></tr>
<tr><td>A11</td><td>102524</td><td>102526</td></tr>
</table>

Table 1-4. ADDITIONAL PLUG-IN UNITS AVAILABLE

MODEL	FREQUENCY RANGE	INPUT LEVELS (independent)	INPUT Z	ACCURACY[2] WITH INDEPENDENT LEVELS UNLESS OTHERWISE INDICATED Analog output accuracy: As specified below. Digital phase accuracy: For model 305C, same as analog accuracy. For model 305B, add ±0.15° digital readout error to analog accuracy specified.
305-PA-3005 High Frequency Plug-in	200 kHz to 11 MHz	1 mV to 3 V rms; manual level controls in 10 dB steps. Lamps indicate when inputs are out of range or when level controls are improperly set.	50 ohms	Broadband with equal inputs above 10 mV rms: ±0.4° from 200 kHz to 4 MHz; ±1° from 4 MHz to 11 MHz. With independent levels above 10 mV rms: ±1° up to 4 MHz and ±2° up to 11 MHz. Single frequency — above 10 mV rms: ±0.3° at any frequency from 200 kHz to 11 MHz at any fixed levels.
305-PA-3007 Programmable and Auto-Ranging Plug-in	2 Hz to 700 kHz	Auto-ranging: similar to levels of 305-PA-3001. Programmable: over-rides autoranging; extends low levels to 1 mV rms; DTL, TTL logic; program connector in rear of mainframe.	1 megohm shunted with 40 pF	Same as 305-PA-3001 for levels above 10 mV rms; typically ±0.35° from 50 Hz to 50 kHz for levels below 10 mV rms.
305-PA-3008 Power Freq. Plug-in	50-500 Hz without filters. 50 Hz, 60 Hz and 400 Hz L.P. filters available[3]	25 V to 250 V rms; 0.1 A to 5 A rms. Inputs are transformer isolated.	100 k ohm (voltage) 1 Ω max. (current)	At any single frequency, with filter set: ±0.1°, 25 V to 250 V rms, or 0.1 A to 5 A rms.
305-PA-3009 Network Analyzer (Gain/Phase/Amplitude)	5 Hz to 700 kHz (Note: 305-PA-3009A operates to 1 Hz with 305 mod. 14)	10 mV to 40 V rms. Each channel has automatic gain ranging. Direct reading of phase angle, amplitude ratio and level of each input. Compatible with Tektronix probes.	1 megohm shunted with 40 pF	Phase: ±0.1° from 40 mV to 40 V rms from 50 Hz to 50 kHz; typically ±0.25° at all other levels from 5 Hz to 500 kHz. Voltage Amplitude: above 40 mV (channel A or B): ±2% reading ±0.03% FS, 50 Hz to 50 kHz; ±5% reading ±0.03% FS, 100 kHz to 500 kHz.[5] Ratio: ±0.5 dB, 50 Hz to 50 kHz; ±1 dB, 50 kHz to 500 kHz.[5]
305-PA-3010 Special Purpose Plug-in (with filter)	For use at 125 ±10 Hz; matched filters in both channels reject higher frequencies	500 mV to 5 V rms. Other ranges available on request.	1 megohm shunted with 40 pF	±0.1°, 500 mV to 5V rms; ±0.25°, 100 mV to 500 mV rms.
305-PA-3015 Selectable Filter Plug-in	5 Hz to 500 kHz without filters; uses 2 of type 305-PA-3008-( ) filters [3]; filter selection programmable	Ranges of 50-500 mV rms, 0.5 to 5 V rms, and 5-50 V rms selectable by remote contact closures.	1 megohm shunted with 40 pF	With filters, ±0.1° at fixed frequencies over all levels; without filters ±0.1° from 50 Hz to 50 kHz at all levels (typically ±0.03°), typically ±.25°, 5 Hz to 500 kHz.

[1] Can be provided for other voltage levels.

[2] For sinusoidal signal; can be used for square wave inputs over limited frequency range; can be used for amplitude modulated signals up to 97% modulation, depending upon model, level and frequency.

[3] 50 Hz filter, P/N 305-PA-3008-50; 60 Hz filter, P/N 305-PA-3008-60; 400 Hz filter, P/N 305-PA-3008-400. (Other frequencies available on request.)

[4] Available for use with 305-PA-3001, -3002, -3007 and -3010. Specify when ordering plug-in.

[5] For higher accuracy below 50 Hz, specify Model 305-PA-3009A.

SECTION II
OPERATION

2-1. GENERAL

2-2. This section contains the operating procedures for Model 305 Phasemeter. Operating controls, connectors and indicators are referred to by the nomenclature that appears on the front and rear panels.

2-3. CONTROLS, CONNECTORS AND INDICATORS

2-4. Figures 2-1 through 2-3 show the front and rear panel operating controls, connectors, and indicators for Model 305C & 305D Phasemeter with a Model 305-PA-3001 Plug-in, respectively. The illustrations are supported by tables 2-1 and 2-2 which list the index number, nomenclature, and the function of those items called out in the figures.

2-5. UNPACKING

2-6. Unpack Model 305 and visually inspect both the main frame and the Plug-in for possible shipping damage. IF DAMAGE EXISTS NOTIFY DRANETZ ENGINEERING LABORATORIES AND CARRIER, AND RETAIN SHIPPING CARTONS. DO NOT RETURN WITHOUT INSTRUCTIONS FROM MANUFACTURER.

2-7. OPERATION

2-8. To prepare Model 305 for operation, proceed as follows:

a. Insert the Plug-in, if separately packed, into the main frame.

b. Connect the power cord supplied between the AC PWR receptacle (figure 2-3) and a 50 to 60 Hz power source having the nominal voltage specified on rear panel.

c. If the main frame is a Model 305 Phase to DC Converter, an external readout is required. Connect the readout to Pin 5 (CKT. GND). and pin 7 (Analog Output, -1.8 to +3.6 VDC) of connector J3 MAIN FRAME.

d. For normal operation, the three terminals on the ground terminal board on the rear, should be connected together.

e. Turn the PWR switch to the ON position.

f. Set the MEAS-CHECK switch to MEAS (measure) position.

g. Refer to the specifications for the level and frequency ranges of the appropriate Plug-in.

h. Connect the REFERENCE and SIGNAL inputs to their respective BNC connectors on the Plug-in.

i. Read the phase angle on the readout device.

j. For CHECK operation, refer to the functional description in table 2-1.

CAUTION

Although the 305-PA-3001 Plug-in is usable at up to 300 volts rms at frequencies to 10 kHz, sudden application of high frequency, high voltage inputs may damage the input stage before the auto range circuitry switches in appropriate attenuation. Direct application of large signals to 300 volts rms is not recommended above 1 kHz. If the voltage is greater than 50 volts rms and the product of (frequency in Hz) X (voltage in volts rms) exceeds 700,000, the signals must first be applied at levels not exceeding 50 volts rms, and then gradually increased to operating levels.

2-9. Preparing Model 305 for operation requires a minimum performance check to insure that damage to the equipment has not occurred during shipment. (See Section III.)

2-10. MAIN FRAME REAR CONNECTORS TERMINAL DESIGNATIONS

2-11. For connection to external meters or recorders, or for remote control of the unit, rear connector terminal designations are provided in tables 2-3 through 2-6.

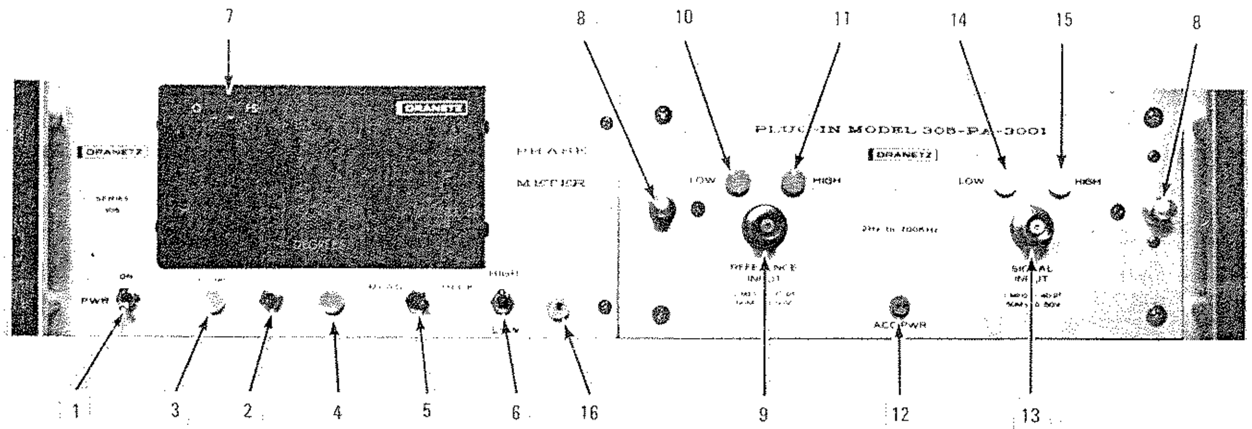


Figure 2-1. Model 305C Main Frame With Model 305-PA-3001 Plug-In, Front Panel

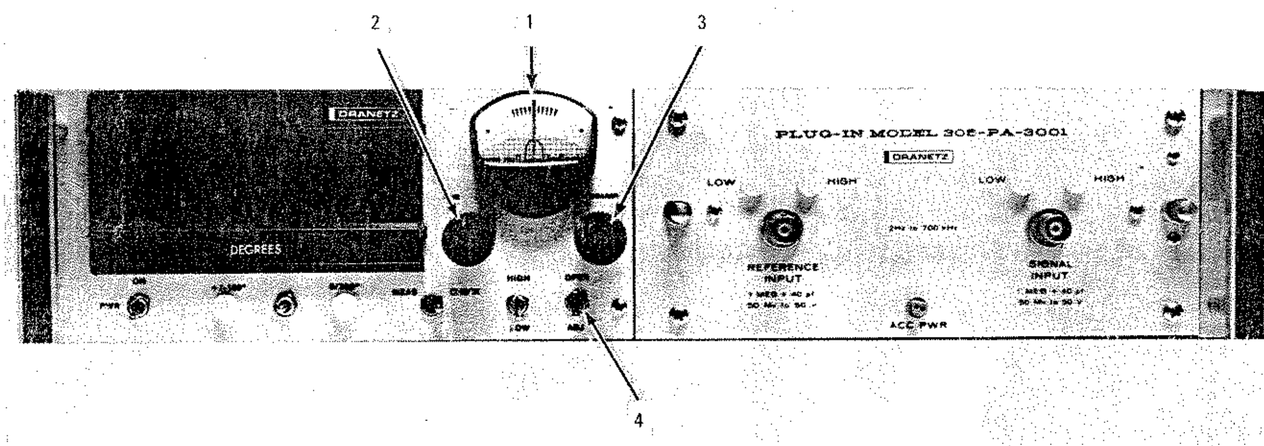


Figure 2-2. Model 305D Controls

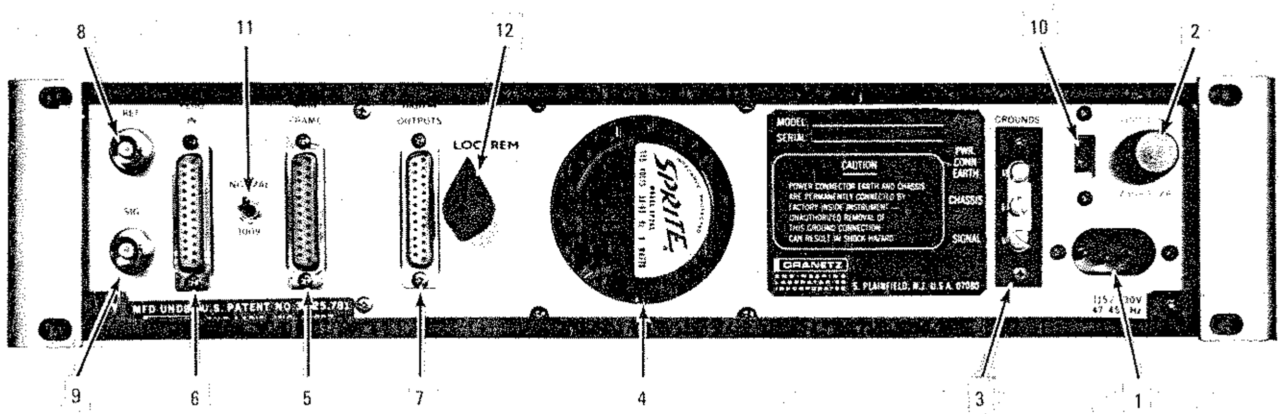


Figure 2-3. Model 305C Rear Panel Layout

Table 2-1. FRONT PANEL OPERATING CONTROLS, INDICATORS AND CONNECTORS (See Figure 2-1.)

Index No.	Controls, Indicator or Connector	Function
1	PWR ON switch	Applies AC power in the on (up) position.
2	Mode select switch	Selects the operating range: -180° to +180° or 0° to +360°.
3	+/-180° mode indicator	When lit, indicates the operating range of -180° to +180°.
4	0/360° mode indicator	When lit, indicates the operating range of 0° to 360°.
5	MEAS-CHECK select switch	When placed in the CHECK position, disables the plug-in and allows for checking the main-frame performance in conjunction with the HIGH-LOW switch.
6	HIGH-LOW CHECK select switch	When placed in the LOW CHECK position, provides an output corresponding to -180.0° when the Model 305 is in the +/-180° MODE and 0.0° in the 0/360° mode. When placed in the HIGH CHECK position, provides an output corresponding to +180.0° in the +/-180° MODE and 360.0° in the 0/360° MODE.
7	Digital readout in degrees	Model 305: None Model 305B: 4 digit, -180.0° to +360.0° readout. Model 305C: 5 digit, -180.00° to +360.00° readout. Model 305D: 5 digit, -180.00° to +360.00° readout.
8	Plug-in lock fasteners	To unlock and remove plug-in turn CCW; to secure plug-in, turn CW.
9	REFERENCE INPUT	BNC Type Connector for input use to establish the phase reference for the signal channel. Input impedance = 1 megohm shunted by 40 pf.
10	LOW reference indicator	Lights when the reference level goes below the low level specification limit (approximately 50 millivolts rms).
11	HIGH reference indicator	Lights when the reference level goes above the high level specification limit (approximately 50 volts rms).

Table 2-1. FRONT PANEL OPERATING CONTROLS, INDICATORS AND CONNECTORS (cont)

Index No.	Controls, Indicator or Connector	Function
12	ACC PWR (accessory power)	Provides regulated DC power to operate external accessories: ±24 volts dc at 50 ma. maximum
13	SIGNAL INPUT	BNC Type Connector for input whose phase shift is measured with respect to the REFERENCE INPUT. Input impedance = 1 megohm shunted by 40 pf. NOTE A leading SIGNAL INPUT phase shift is displayed as a "±" or LEAD angle.
14	LOW signal indicator	Lights when the signal level goes below the low level specification limit (approximately 50 mv rms).
15	HIGH signal indicator	Lights when the signal level goes above the high level specification limit (approximately 50 volts rms).
16	REMOTE programming indicator	Lights when unit is set for Remote operation (Option 102 only).
	MODEL 305D CONTROLS (See Figure 2-2)	
1	Analog Null Meter	Provides accurate adjustments of test angles
2	FINE offset adjustment	Provide setting of offset angles from +360.0° to -180.0° with better than 0.1% resolution
3	COARSE offset adjustment	
4	OPER/ADJ toggle switch	In OPER position the unit operates as a standard Series 305C. In ADJ, the offset angle is displayed on the front panel meter.

Table 2-2. REAR PANEL CONNECTORS AND FUSE
(See figure 2-3.)

Index No.	Controls, Indicator or Connector	Function
1	AC PWR	AC power input connector: 3 wire with ground
2	FUSE	MDL 3/4A for 115V, 50 to 60 Hz. MDL 1/2A for 230V, 50 to 60 Hz.
3	GROUNDS, LINE, CASE and CKT	A terminal board which provides for isolation of circuit ground from case and/or power line. Normally the three terminals are connected together.
4	Blower	Provides for cooling of internal components.
5	MAIN FRAME connector, J3	Provides for connection to internal circuits. (Refer to table 2-3.)
6	PLUG-IN connector, J2	Provides for connection to internal circuits of plug-in. (Refer to table 2-4.)
7	DIG OUT (digital output) connector, J4	On Model 305B, 305C and 305D only, provides connection to the digital output for operation with a digital printer, computer, etc. Also allows for READ and HOLD on command operation. Refer to tables 2-5 and 2-6.)
8	REF (reference) input connector (Option 101 only)	Allows the reference channel input to connect to the rear panel.
9	SIG (signal) input connector (optional)	Same as in REF input connector except for the signal channel.
10	Power line nominal voltage switch	After removal of cover, allows selection of either 115 or 230 volt rms nominal power line voltages.
11	NORMAL/3009 toggle switch	Used when Model 305-PA-3009 Plug-in is installed. In "3009" position allows panel meter display to be selected by a switch on Model 305-PA-3009 Plug-in. Must be placed in NORMAL position for all other plug-ins.
12	LOCal/REMote switch (Option 102 only)	Selects operation by local control via front panel or remote control via programming inputs. (Option 102 only.)

Table 2-3. Main Frame Rear Connector J3, MAIN FRAME, all Models

Pin No.	Connections
1, 2, 3	Over-ride of automatic time constant selection is provided by connecting +24V or -24V to the pins as indicated below.

Pin	Automatic	TC = 10 MS (>5 kHz)	TC = 50 MS (0.5 - 5 kHz)	TC = 350 MS (50 - 500 Hz)	TC = 700 MS (<50 Hz)
1	Open	+24V	+24V	+24V	-24V
2	Open	+24V	+24V	-24V	-24V
3	Open	+24V	-24V	-24V	-24V

Pin No.	Connections
4	NULL OUTPUT, 1V/DEGREE NOMINAL (OPTION 104 ONLY)
5	CKT. GND.
6	PANEL READOUT } -1.800V to +3.600 vdc Internal Jumper
7	ANALOG OUTPUT } -1.800V to +3.600 vdc Internal Jumper
8	MODIFIED ANALOG OUTPUT (OPTION 107 ONLY)
9	N.C.
10	CKT. GND.
11	MODE SELECT -180° to $+180^{\circ}$ } momentarily connect -24 vdc to Select Mode, maintain connection if override of automatic circuits is desired
12	MODE SELECT 0° to 360° } momentarily connect -24 vdc to Select Mode, maintain connection if override of automatic circuits is desired
13	N.C.
14	N.C.
15	CKT. GND.
16	N.C.
17	N.C.
18	N.C.
19	N.C.
20	+24 vdc
21	N.C.
22	N.C.
23	N.C.
24	REMOTE ZERO (OPTION 105 ONLY)
25	-24 vdc

Table 2-4. Main Frame Rear Connector J2, PLUG-IN, all Models

J2 Pin No.	Plug-in Conn. No.	Connections
1	J6- 7	Remote Plug-in connections
2	J6- 8	Refer to Plug-in manual
3	J6- 9	Not used on Models 305-PA-3001 or 305-PA-3002
4	J6-10	
5		CKT. GND
6	J6-27	Remote Plug-in connections
7	J6-28	Refer to Plug-in manual
8	J6-29	Not used on Model 305-PA-3001 or 305-PA-3002
9	J6-30	
10		CKT. GND.
11	J6-11	REF. LOW — Level Limit Indicators
12	J6-12	REF. HIGH — -0.6V off
13	J6-25	SIG. HIGH — +3.2V on
14	J6-26	SIG. LOW
15		CKT. GND.
16		N.C.
17		N.C.
18		N.C.
19		N.C.
20		+24 vdc
21		N.C.
22		N.C.
23		N.C.
24		N.C.
25		-24 vdc

Table 2-5. Main Frame Rear Connector J4, DIGITAL OUTPUT, for 305B

J4 Pin No.	Digital Outputs		
1	1	BCD TENTHS	
2	2	BCD TENTHS	
3	4	BCD TENTHS	
4	8	BCD TENTHS	
5	CKT. GND.		
6	1	BCD UNITS	
7	2	BCD UNITS	
8	4	BCD UNITS	
9	8	BCD UNITS	TTL/DTL COMPATIBLE
10	CKT. GND.		$\overline{N}$ = < +0.8V at -2 ma N = > 2.4V with 3.6K ohms source
11	1	BCD TENS	
12	2	BCD TENS	
13	4	BCD TENS	
14	8	BCD TENS	
15	CKT. GND.		
16	1	BCD HUNDREDS	
17	2	BCD HUNDREDS	
18	N.C.		
19	N.C.		
20	Positive Polarity		
*21	Hold, GND for Reading, Open or High for Hold		
22	Data Ready, Low During Conversion, High when BCD Data Ready		
23	Read Rate, GND for 60 Hz Rate, Open for 4 Hz Read Rate		

*This pin is jumpered to pin 15 of J4 (GND) internally. If external control is to be used, cut this jumper.

Table 2-6. Main Frame Rear Connector J4, DIGITAL OUTPUT, for 305C

J4 Pin No.	Digital Outputs		
1	1	BCD Hundredths	TTL/DTL COMPATIBLE $\overline{N}$ = < +0.8V at 10 ma N = > 2.4V with 6K ohm source
2	2		
3	4		
4	8		
5	1	BCD Tenths	
6	2		
7	4		
8	8		
9	1	BCD Units	
10	2		
11	4		
12	8		
13	1	BCD Tens	
14	2		
15	4		
16	8		
17	1	BCD Hundreds	
18	2		
19	4		
20	8		
21	Digital ground		
22	Polarity bit, "1" for positive		
23	Sample rate adj; 4 per sec open, gnd for 30 per second		
24	READ/HOLD; open for read, gnd for hold		
25	Data Ready (0 during conversion)		

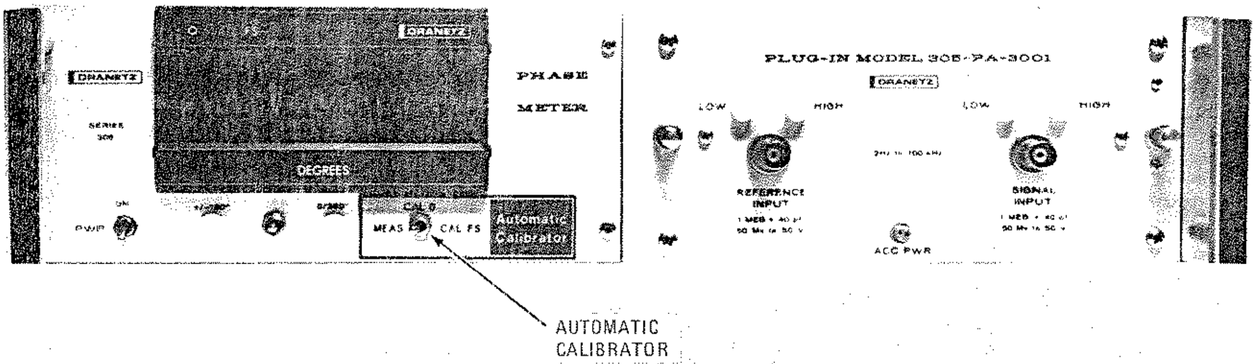


Figure 2-4. Model 305C With Option 107

2-12. OPERATION OF MODEL 305 WITH OPTION 107

2-13. In units having Option 107, the MEAS/CHECK and HIGH/LOW switches are replaced by the Automatic Calibrator switch as shown in figure 2-4. This switch is a 3-position toggle switch and is used to automatically calibrate the Model 305 panel meter for full accuracy regardless of warm-up or temperature changes. It operates a circuit installed between the phase analog output voltage and the digital panel meter input. This circuit corrects for both panel meter drifts and for changes in the signal applied to the panel meter by a digital sampling and error correction technique.

2-14. To operate a Model 305 having Option 107, turn the unit on; switch to MEAS and then to CAL 0. The panel meter display (except for decimal point and most significant digit) will blank indicating a calibration in progress. After about eight seconds, the display will light and display the zero point. It should indicate 000.00 ±0.02 degrees. Now switch to CAL F.S. The panel meter will again blank indicating a calibration in progress. After about eight seconds, the display will light and display the full scale point. It should indicate 360.00 ±0.02 degrees. Now switch to MEAS and the unit is ready to operate at full accuracy.

NOTE

Always calibrate Zero first and full scale second. Reversing this sequence may cause incorrect calibration. NEVER OPERATE ANY CONTROLS WHILE A CALIBRATION IS IN PROGRESS. This will cause incorrect calibration. If for any reason an incorrect calibration is made, simply switch back to MEAS and repeat the entire calibration procedure.

2-15. ADDITIONAL OPERATING FEATURES OF MODEL 305D

2-16. Model 305D provides a continuously adjustable angle offset which is then added to the phase angle being read. A non-linear analog null meter presents the difference between the angle being read and the preset offset angle. This feature provides a convenient means of precisely setting phase shift of filters and other networks to a desired value. The phasemeter's characteristics remain the same as those of the standard Model 305C except for the following:

a. Front Panel Analog null meter, approximately 0.2°/division near null. Sensitivity decreases off null so that a wide angle range is presented.

b. Front Panel coarse and fine offset adjustments allow setting offset angles from $+360.0^{\circ}$ to -180.0° with better than 0.1° resolution.

c. Null Output on pin 4 of connector J3 (MAIN FRAME connector) has nominal 1 volt/degree sensitivity for a minimum of $\pm 8^{\circ}$ about null.

d. Offset stability: $\pm 0.1^{\circ}$ with warm-up.

e. Offset accuracy: $\pm 0.1^{\circ}$ after warm-up (30 minutes) for either panel meter or analog output.

f. Operate/Adjust switch added to front panel.

2-17. Operation

2-18. With the OPER/ADJ switch in the OPER position the unit can be operated as a standard Series 305C Phasemeter. Details of operation are in Section II of this manual.

2.19 To use the angle offset feature proceed as follows:

a. Set the OPER/ADJ switch in the ADJ position. The offset angle is now displayed on the front panel meter.

b. Using the COARSE and FINE controls below the Null Meter, set the offset to the desired value. For example, if a network is to be adjusted to have a phase angle of -90 degrees (SIG lags REF), an offset angle of -90 degrees must be set since the null indicator zeros when the difference between offset angle and input angle is zero.

c. Set the OPER/ADJ switch in the OPER position.

d. Observing the null meter, trim the network under test for a mid-scale reading.

e. When null is reached, the network under test will have a phase angle equal in magnitude and polarity to the preset angle offset.

f. The digital panel meter displays the phase angle of the network under test and may be checked to determine the actual value after the nulling operation is completed.

SECTION III
PERFORMANCE CHECK

3-1. GENERAL

3-2. The performance check procedures enable the operator to determine if the Model 305 Phasemeter is operating properly. This check can be performed either after setting up the equipment or when a malfunction has been remedied.

3-3. TEST EQUIPMENT REQUIRED

3-4. The following test equipment is required to perform the minimum performance check:

a. Broadband AC Voltmeter, Ballantine Model 303 or equivalent.

b. Broadband (5 Hz to 500 kHz) Oscillator with low distortion, General Radio Model 1310A or equivalent.

c. Precision D.C. Voltmeter (-1.8 to +3.6 vdc with error $\leq$0.3 mv.), Fluke Model 8300A or equivalent.

d. Two shielded cables terminated in BNC connectors on each end and one BNC T-connector. The shielded cables must have lengths not in excess of 18 inches and must match each other to within 1/2 inch.

3-5. MAIN FRAME CALIBRATION

a. Obtain a voltmeter which is capable of reading between -2.0 and +4.0 volts dc with a resolution of 0.1 millivolt and an accuracy of 0.3 millivolt. Connect voltmeter to the DC Analog output of the Phasemeter (pins 7 and 5, J3, MAIN FRAME).

NOTE

If desired, the panel readout of the Model 305B, 305C or 305D can be used. The analog output accuracy, however, may suffer, since the accuracy capability of the main frame is above that of either of the panel readouts. Best over-all accuracy is obtained by using the same readout from which the data is obtained.

b. Allow a warm-up period as recommended by the manufacturer of the laboratory voltmeter and at least one-half hour for the Dranetz Model 305.

c. Place the Model 305 in the CHECK position and check range end points.

d. If range end points are in error by more than $\pm 0.02^{\circ}$, perform the adjustment shown in table 3-1. Remove the Plug-in for access to adjustments, which are located in the plug-in opening on the left wall.

e. If the digital readout is in error, it may now be adjusted by screws on the DPM. (See the digital panel meter (DPM) instruction manual for location of adjustments.)

Table 3-1. MAIN FRAME CALIBRATION FOR STANDARD 305 SERIES

Step	Phase Range	HIGH-LOW Switch	Instruction
a	$0/360^{\circ}$	LOW	Set ZERO (R1) for 0.0000 ±0.0001 Volts.
b	$0/360^{\circ}$	HIGH	Set GAIN (R3) for 3.6000 ±0.0001 Volts.
c	$+/-180^{\circ}$	LOW-HIGH	Set OFFSET (R2) for equal LOW and HIGH magnitudes. Readings should be ±1.8000 ±0.0002 Volts after adjustment.
d	--	--	Repeat Steps a, b and c readjusting if necessary.

Table 3-1A. MAIN FRAME CALIBRATION FOR PHASEMETERS HAVING OPTION 107.

Step	Phase Range	AUTO CAL Switch	Instruction
a	0/360°	CAL 0	Set ZERO (R1) for 0.0000 ±0.0001 Volts.
b	0/360°	CAL F.S.	Set GAIN (R3) for 3.6000 ±0.0001 Volts.
c	+/-180°	CAL 0-CAL F.S.	While holding the phase range switch in the +/-180° position, set OFFSET (R2) for equal CAL 0 and CAL F.S. magnitudes. Readings should be ±1.8000 ±0.0002 Volts after adjustment.
d	--	--	Repeat steps a, b and c readjusting if necessary.

NOTE

No adjustment of Digital Panel meter Zero and F.S. controls should be necessary on units with Option 107. The automatic calibration sequence in paragraph 2-14 should correct panel meter errors. If it does not, refer to Section VI of this manual for further information.

Table 3-1B. MAIN FRAME CALIBRATION FOR PHASEMETERS HAVING OPTION 103

Step	Phase Range	HIGH-LOW Switch	Instruction
a	0/360°	LOW	Set 0.0000 ±0.0001 Volts using OFFSET (R2) and, if required, ZERO (R1).
b	0/360°	HIGH	Set GAIN (R3) for 3.6000 ±0.0001 Volts.
c	+/-180°	LOW	Set ZERO (R1) for -1.8000 ±0.0001 Volts.
d	0/360°	LOW	Set OFFSET (R2) for 0.0000 ±0.0001 Volts.
e	--	--	Repeat steps c and d until both numbers remain within values specified.
f	--	--	Check 0°, 360°, -180° and 360° cal. points. If all are not within ±0.0002 Volts of correct value, repeat steps a through f.

Note: If the entire range of potentiometer adjustment cannot bring the output voltages within specification, wider range coarse controls are available on card 5 of the main frame. (See Section VIII for further information.)

3-6. MINIMUM PERFORMANCE CHECK

3-7. Prior to performing the minimum performance check in the following steps, perform the Main Frame Calibration detailed in paragraph 3-5. Adjust in accordance with the instructions if end point error exceeds ±0.02°. Make sure to set panel meter calibration points after main frame calibration.

3-8. Connect equipment as shown in figure 3-1 and proceed with the following tests.

3-9. Level Ranging Check for Model 305-PA-3001 Plug-in.

a. Set oscillator frequency to 1 kHz. Set input levels to 25 millivolts rms. Both low level indicators on the plug-in should be lit.

b. Increase input signal levels to 60 millivolts rms. Both low level indicators on the plug-in should extinguish.

c. Increase input signal levels to 1 volt rms. Each high level indicator should blink on and then extinguish, indicating up ranging.

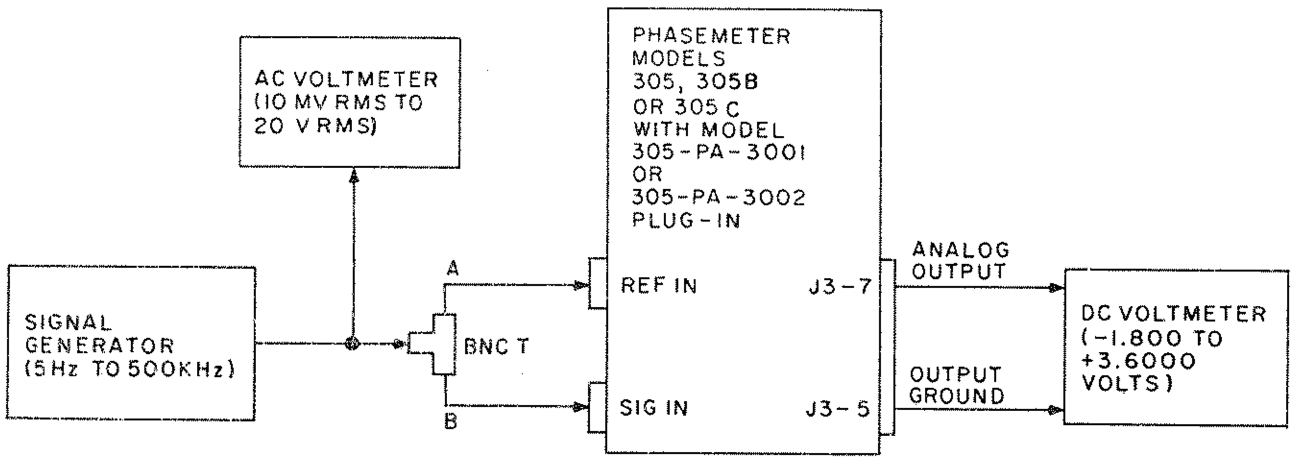
d. Increase input signal levels to 10 volts rms. Each high level indicator should light for a short time, and then extinguish, indicating a second level ranging.

3-10. Phase Error Check Over Full Frequency Range.

a. Set input levels to 200 millivolts rms. (Note: If plug-in is not a standard Model 305-PA-3001 or 305-PA-3002, refer to modification specification sheet to determine an acceptable test level.)

b. Set the various frequencies indicated in table 3-2. Record both panel meter reading and analog output voltage at each frequency.

c. If all data recorded is within the limits specified in table 3-2, the phasemeter is functioning normally. Specification limits on the analog output allow for 0.03 degrees (0.3 mv) error in the DC voltmeter used to make the measurements.



Note: A and B are matched.

Figure 3-1. Minimum Performance Test Circuit Setup

Table 3-2. PHASEMETER DATA SHEET WITH MAXIMUM TOLERANCE

Test Frequency	Panel Meter Reading in Degrees	Panel Meter Reading Tolerance (± Degrees)		Analog Output Reading in Millivolts	Analog Output Tolerance (± Millivolts)
		Model 305B	Model 305C and 305D		
5		1.1	1.00		10.3
50		0.2	0.05		0.8
100		0.2	0.05		0.8
1,000		0.2	0.05		0.8
10,000		0.2	0.05		0.3
50,000		0.2	0.05		0.8
500,000		1.1	1.00		10.3

3-11. FIELD INSTALLATION OF 305 SERIES PLUG-INS

3-12. When a different plug-in is installed in a 305 Series main frame, an adjustment to the plug-in is required to match its high frequency characteristic to that of the main frame. This does not apply for plug-ins designed for low frequency use only (below 5 kHz) or for plug-ins which have front panel zero controls, such as the 305-PA-3005, 305-PA-3008 and the 305-PA-3010. After installation of the new plug-in, perform the adjustments described in paragraph 6-15.

NOTE

A BNC "T" connector and two 12" BNC to BNC coaxial cables may be substituted for the Dranetz No. 101,573 attenuator and cables shown in the circuit of figure 6-2.

SECTION IV
THEORY OF OPERATION

4-1. GENERAL

4-2. This section provides a functional description of the Model 305. The theory of operation will be discussed by reference to the over-all block diagram (figure 4-2) augmented by several detailed block diagrams (figures 4-3 and 4-4). Before a detailed examination of the block diagrams, the basic theory of operation of the 360° type of zero crossing phase metering will be discussed using the timing diagram (figure 4-1).

4-3. BASIC OPERATION OF 360° ZERO CROSSING PHASE METERS.

4-4. The two inputs to a typical phasemeter are illustrated by lines a and b of figure 4-1. Line b, the signal input, lags line a, the reference input by approximately 90°.

4-5. Lines c and d show the waveforms obtained by amplifying the input signals by a large factor and then limiting the output level of the amplifier. Line c is then a square wave with transitions at the zero crossings on the REFERENCE sine wave while line d is a square wave with transitions at the zero crossings of the SIGNAL sine wave.

4-6. Lines e and f are obtained by differentiation of lines c and d. Line e has a narrow positive pulse at each positive going zero crossing of the REFERENCE sine wave while line f has a narrow positive pulse at each positive going zero crossing of the SIGNAL sine wave.

4-7. Application of the differentiated signals to the inputs of an R-S type flip-flop generates the waveform illustrated on line g. This signal has a duty cycle proportional to the phase angle. Its transition points correspond to selected zero crossings of the REFERENCE and SIGNAL sine waves. If the upper and lower levels of this waveform are precisely constant, its average value will be proportional to the phase angle between the input sinusoids.

4-8. The analog output of the 360° type of zero crossing phasemeter is obtained by averaging the waveform of line g after precisely setting its upper and lower levels.

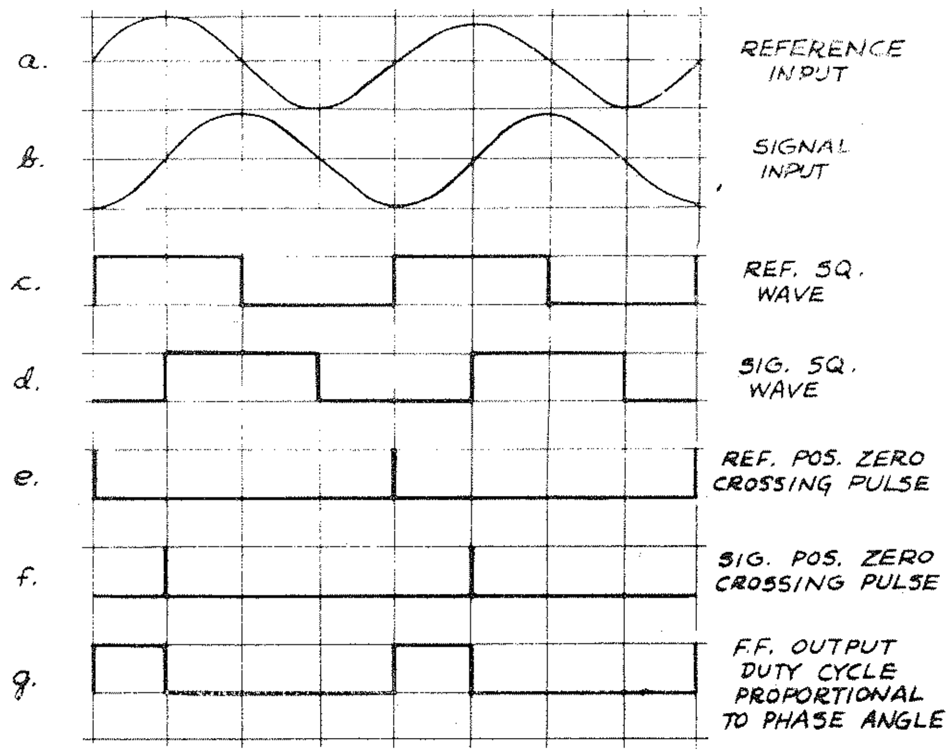


Figure 4-1. Timing Diagram for 360° Zero Crossing Phasemeters

4-9. BLOCK DIAGRAM DISCUSSION

4-10. The following sections, referenced to the block diagrams, will discuss how the Model 305C with Model 305-PA-3001 Plug-in implements the basic concepts illustrated in figure 4-2.

NOTE

> Since the other main frames and plug-in units included in this manual are similar, this discussion applies equally to Models 305, 305B, 305D and 305-PA-3002.

4-11. Sinusoidal Signal Processing

The REFERENCE and SIGNAL inputs are processed in the following manner. The input attenuator attenuates the incoming signal by 1:1, 10:1, or 100:1 as required to prevent overdrive of the input amplifier which provides a signal output level adequate to drive the squaring circuit. The level ranging circuits sample the signal level at point A and make corrections in the attenuator settings when necessary.

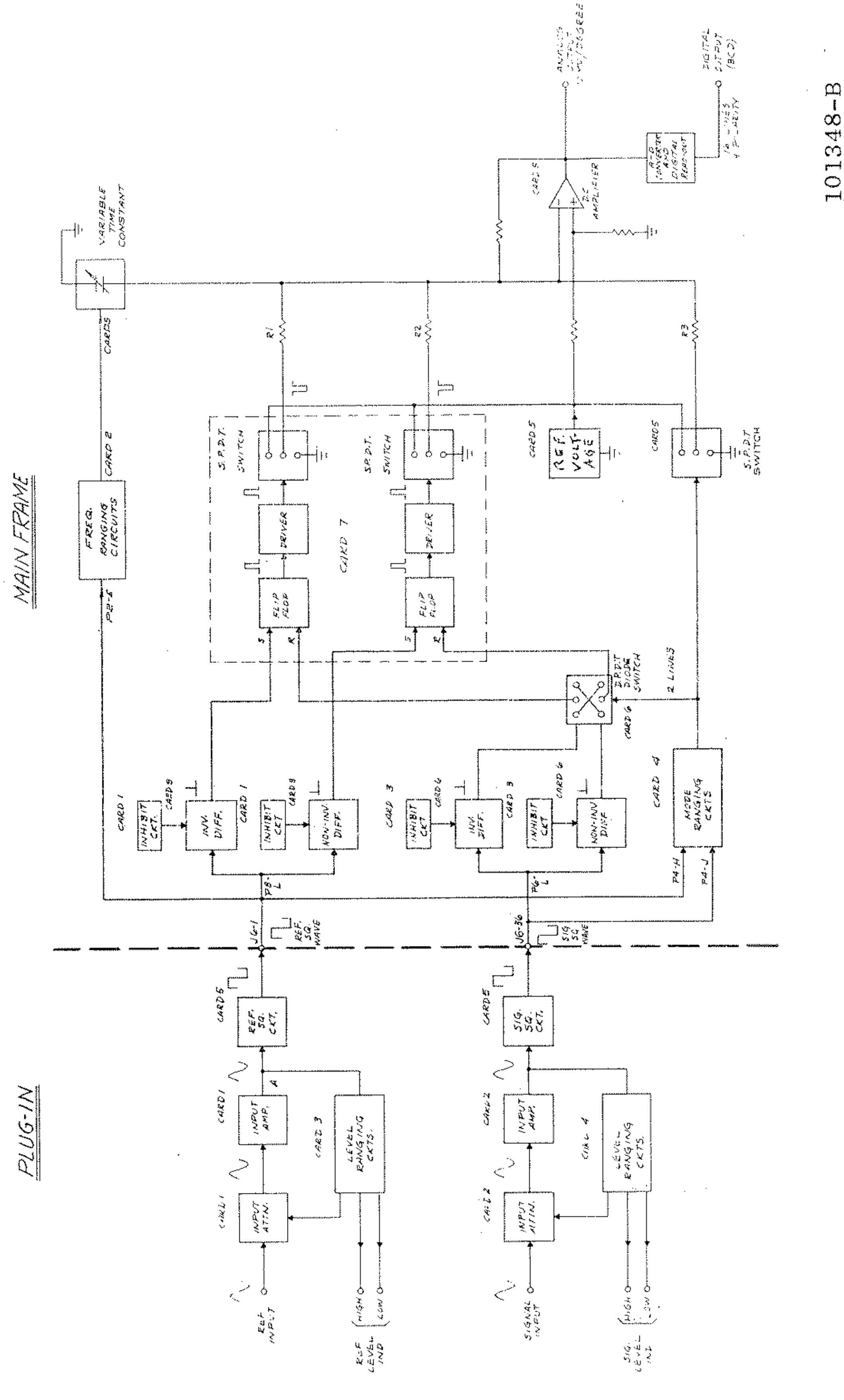


Figure 4-2 Phasemeter Model 305 Functional Block Diagram

4-12. Level Ranging Details.

The level ranging circuits are expanded in the detailed block diagram shown in figure 4-3. The amplifier provides the level necessary to drive the detector which produces a d-c output level proportional to the a-c input level. The high and low limit comparators sense when the detector output leaves the prescribed range. When a limit is passed, the appropriate driver lights the corresponding out of limit indicator lamp. If the low limit has been exceeded, the output of the low limit sense immediately resets flip flop No. 1. If this does not produce an adequate level increase, flip flop No. 2 is also reset.

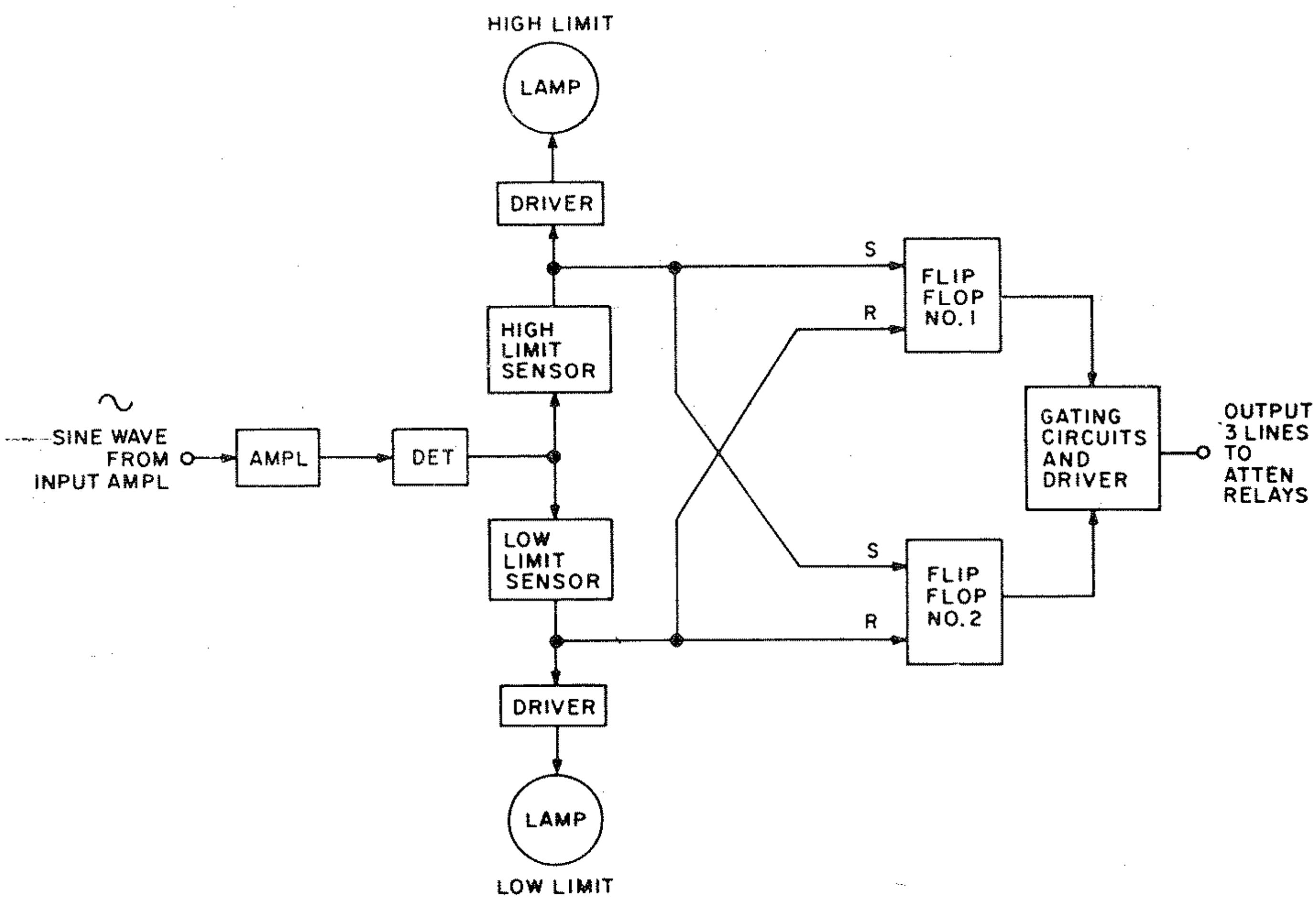


Figure 4-3. Level Ranging Circuits Detailed Block Diagram

If the high limit has been exceeded, the output of the high limit sense sets flip flop No. 2. If this does not produce an adequate level decrease, flip flop No. 1 is also set. The outputs of the two flip flops are fed to a combined gating circuit and relay driver which activates the input attenuator as follows:

Flip Flop No. 1	Flip Flop No. 2	ATTENUATOR		
		÷1	÷10	÷100
Set	Set	Out	Out	In
Re-set	Set	Out	In	Out
Re-set	Re-set	In	Out	Out
Set	Re-set	Out	In	Out

4-13. Reference Squaring Circuit.

The reference squaring circuit (figure 4-2) is an over-driven I.C. amplifier having high speed switching action which is required to precisely define the locations of the zero crossings of its sinusoidal input signal. The obtaining of this square wave completes the plug-in's function. The signal is fed to the main frame for further processing.

4-14. Differentiation.

Both positive and negative going transitions of the REFERENCE square wave are used in the operation of the Model 305 main frames. An inverting differentiator outputs a positive pulse at each negative going zero crossing of this square wave while a non-inverting differentiator outputs a positive pulse at each positive going zero crossing of this square wave. The noise inhibitor circuits act on the differentiators to limit their outputs to one and only one pulse per cycle of the reference square wave. This is necessary since a multiplicity of output pulses could cause the outputs of flip flops to assume erroneous states.

4-15. Differentiators in the SIGNAL channel function in a fashion identical to the differentiators which process the REFERENCE square wave. Inhibitors restrict the outputs of these differentiators to 1 pulse per cycle of the input frequency as is done in the REFERENCE channel.

4-16. Pulses from the differentiators are applied to the Set-Reset (R-S) flip flops. Each flip flop is set by a pulse derived from the REFERENCE square wave and is reset by a pulse derived from the SIGNAL square wave. In this way, the duty cycle of the output waveform of the flip flop becomes a direct function of the phase angle difference between the REFERENCE and SIGNAL inputs.

4-17. The outputs of the flip flops are amplified and level shifted by the switch drivers, which actuate high speed single-pole, double-throw switches. When a switch drive is high (+0.7 volt dc) the switch output is connected to a ground. When a switch drive is low (-15 volts dc) the switch output is connected to a -14 volt dc precision reference source. The duty cycle of each switch output waveform is proportional to the phase angle, as was each switch drive waveform. In addition, since its levels are precisely controlled, the average value of each switch output waveform is also proportional to the phase angle between the SIGNAL and REFERENCE inputs.

4-18. The outputs of both of the switches have an average value proportional to the phase angle. One switch derives its output from the negative going zero crossings of the input signals while the other switch derives its output from the positive going zero crossings of the input signals. The average value of each output is obtained and these are averaged by R1 and R2 together with the variable capacitor and dc amplifier.

4-19. The output of the dc amplifier is the analog output of the phasemeter and is available at a rear connector. Its sensitivity is 10 mv per degree so that the output voltage is numerically identical to the measured phase angle between REFERENCE and SIGNAL inputs. For example, an output voltage of +1.000 volts dc indicates that the SIGNAL leads the REFERENCE by an angle of 100.0°.

4-20. This analog output is also fed to a digital voltmeter (in Models 305B, 305C and 305D) which presents a readout in degrees. Additionally, the BCD coded digital outputs of the digital voltmeter are wired to a rear connector to provide a digital phase angle output.

4-21. Mode Ranging Circuits

4-22. The last phasemeter subsystem to be discussed is the angle range mode switching section. The function of these circuits is to keep the phasemeter from operating near the edge of a phase range. Two phase ranges, 0 $\pm 180^{\circ}$ and 0 to $+360^{\circ}$ are made available. An angle at the end of one of these ranges will always be in the middle of the other since the ranges are offset from each other by 180°. If the phasemeter is allowed to operate at the edge of a range, such as the 0° to 360° range, its output may be ambiguous since 0° and 360° are phase identities. Since these angles correspond to range extremes of the output, the output may randomly assume any level between the range extremes. To avoid this major error source and several lesser error sources, phase range switching in Model 305 is fully automated.

4-23. The circuits which determine the correct phase range are illustrated by the detailed block diagram shown in figure 4-4, which is an expansion of the mode ranging circuit on the overall block diagram. Both REFERENCE and SIGNAL square waves from the plug-in are applied to the inputs of a NOR gate. A truth table for this gate is as follows:

INPUT A	INPUT B	OUTPUT
High	High	Low
High	Low	Low
Low	High	Low
Low	Low	High

When the inputs at A and B are in phase, the NOR gate output will be a square wave with 50% duty cycle since the inputs are simultaneously low for 50% of the time. If the angle changes to 90°, the duty cycle of the output waveform becomes 25% since both inputs are low for only one fourth of a cycle. Note that there is no difference between the results obtained with either input leading or lagging. The output duty cycle is a function only of the magnitude of the phase difference between the two inputs. If the two inputs are 180° apart, they are never low simultaneously and the duty cycle of the NOR gate output becomes zero.

4-24. The filter averages the output of the NOR gate and the dc output of the filter is zero for a 180° difference between input signals and is at its highest level when the input signals are in phase.

4-25. High and low limit detectors are connected to the output of the filter. The low limit detector produces an output when its input signal drops below a preselected limit indicating phase angles near 180°. The high limit detector produces an output when its input goes above a preselected limit indicating phase angles near zero degrees. An output from the high limit detector (near 0°) sets the flip flop providing a negative output at point C. This signal actuates the phase range switches to select the 0 ±180° mode and, through the driver actuates the 0 ±180° indicator lamp. An output from the low limit detector (near 180°) resets the flip flop providing a negative output at point D. This signal actuates the phase range switches to select the 0/360° mode and, through the driver actuates the 0°/360° indicator lamp.

4-26. Output signals from the mode ranging circuits are fed to solid state switches, shown on the over-all block diagram. The double-pole double-throw diode switch acts upon the pulse outputs of the differentiators which process the SIGNAL square wave. Since these pulses are normally 180° out of phase, the switch substitutes one for the other in the 0 ±180° mode and causes the subsequent circuits to act as if the phase angle at the SIGNAL input were shifted by 180°. In order to eliminate the need for an operator to manually subtract this 180° offset from all measurements made in the 0 ±180° mode, a single pole double throw transistor switch is used to subtract through R3 a dc signal equivalent to the 180° offset previously introduced. This corrects the dc output so that it always reads directly in degrees regardless of the operating mode in use.

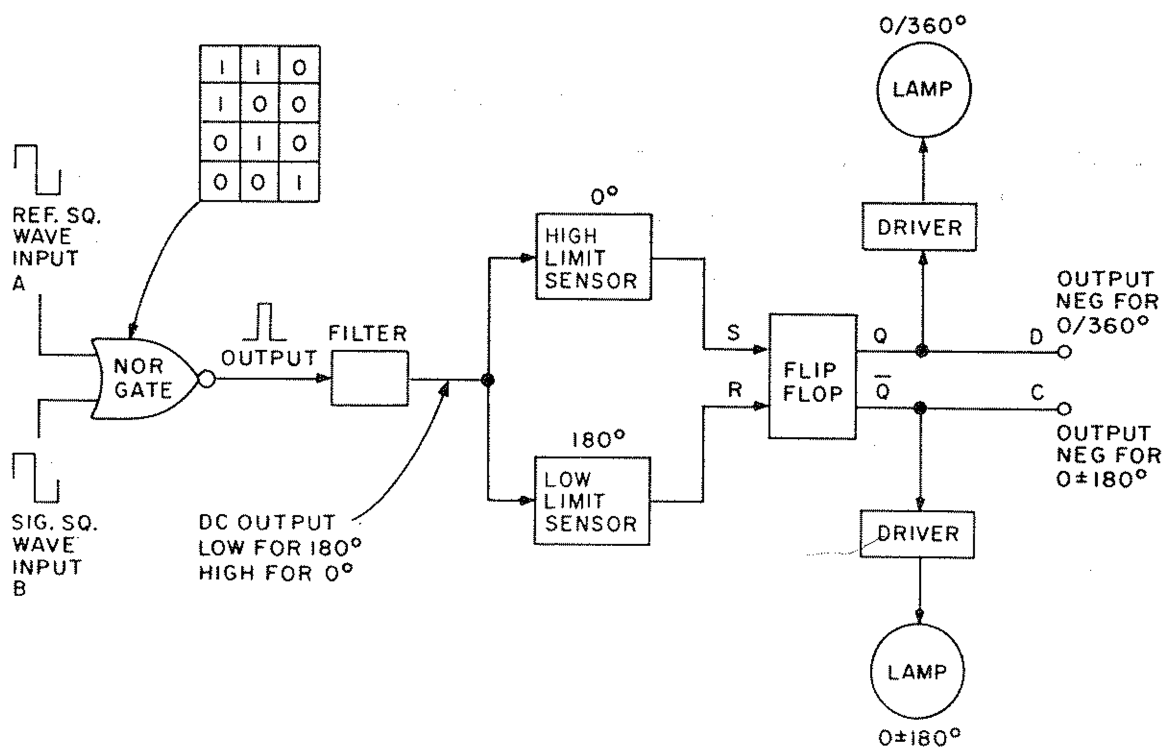


Figure 4-4. Model 305 Block Diagram Detail
Mode Ranging Circuits

SECTION V

MAINTENANCE

5-1. GENERAL

5-2. This section describes the periodic testing recommended for Model 305 Phasemeter and provides the information necessary to locate and correct any malfunctions. Section VI provides detailed calibration procedures if operation is out of tolerance due to component replacements or component aging.

5-3. Three levels of periodic testing are recommended.

a. In-place Main Frame self-check and Calibration (per para. 3-5)

b. Performance Check. (Perform all steps listed in Section III.)

c. Full Calibration (per Section VI) as required.

A simple self check and calibration of Model 305 main frames in operating location is recommended once each month. This test is accomplished using front panel controls only. If adjustment is required, the necessary trim potentiometers are available by removal of the plug-in section (para. 3-5).

5-4. A more extensive test should be performed at intervals. Details of this test are provided in Section III of this manual entitled Performance Check. This test should be performed on new equipment upon arrival to assure that no damage occurred during shipment.

5-5. If a malfunction is observed during the Performance Check or during normal use, the malfunction may be located and the defective component repaired by using the information provided in the following paragraphs. This information is basically a circuit function discussion referenced to the schematic diagrams of the Model 305C main frame and Model 305-PA-3001 plug-in.

NOTE

> Since the other main frames and plug-in units included in this manual are similar, this discussion applies equally to Models 305, 305B, 305D and 305-PA-3002.

If a malfunction is traced to the digital panel meter on either the 305B, 305C or 305D, refer to the instruction manual of the panel meter used. These manuals are supplied with all Model 305's which use digital panel meters.

5-6. MECHANICAL DISASSEMBLY PROCEDURE

5-7. The Model 305 may be removed from its case by removing two screws A (figure 5-1) at the lower rear of the unit. The unit then slides out of the front of the case.

IMPORTANT: FOR PERFORMING FULL CALIBRATION (SECTION VI), DO NOT DISASSEMBLE THE UNIT FURTHER. THE FOLLOWING DISASSEMBLY INSTRUCTIONS ARE ONLY FOR THE PURPOSE OF TROUBLESHOOTING AND REPAIR. AFTER REPAIR, THE UNIT SHOULD BE ASSEMBLED TO THIS POINT FOR CALIBRATION.

a. Main Frame Monitoring

Voltages and waveforms on the plug-in cards (in the main frame) may be observed by removal of screws B (figure 5-1) which fasten the card retainer and reinsertion of the card using the right angle extender C supplied with each main frame. Make certain that the card faces in the proper direction before reinsertion into the main frame.

CAUTION

POWER SHOULD BE OFF WHEN CARDS ARE BEING REMOVED OR INSERTED.

b. Plug-in Monitoring

For troubleshooting, the plug-in may be withdrawn from the main frame after first turning the front panel captive screws counterclockwise. An extender cable is provided for electrical connection of the plug-in to the main frame after removal, as shown in figure 5-2. (It is intended only for use during troubleshooting, and not during performance check or calibration).

c. Plug-in Disassembly

Access may be obtained to the cards on the plug-in as follows: (See figure 5-1.)

(1) Remove shields D by removing screws E.

(2) Remove screws F in order to raise cards 1 and 2 on hinges at G. This gives access to card.

(3) Do not attempt any adjustment of variable capacitors except as detailed in Section VI.

(4) Access to plug-in card 5 may be obtained by removal of shield J with associated hardware.

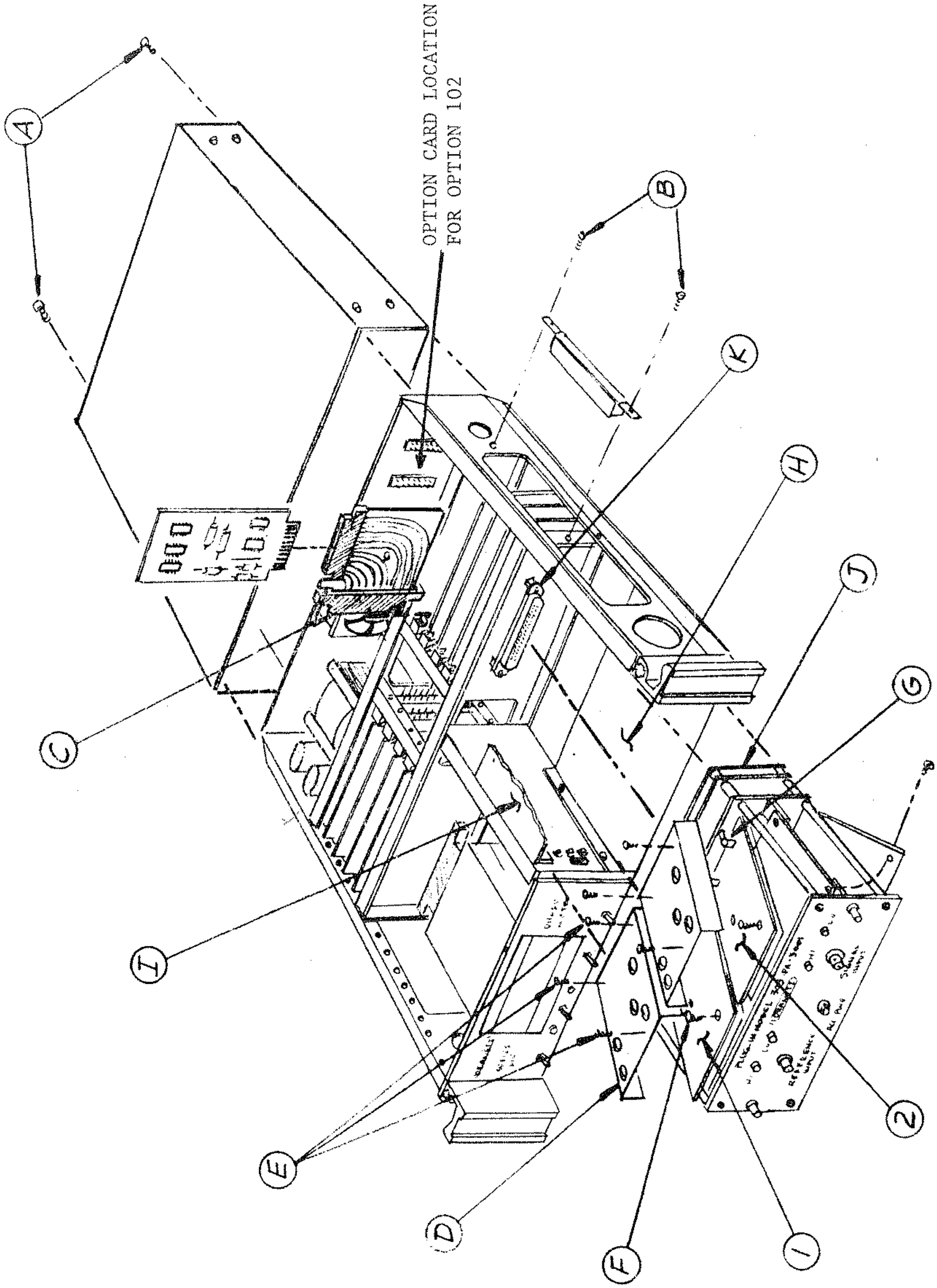


Figure 5-1. Disassembly Illustration

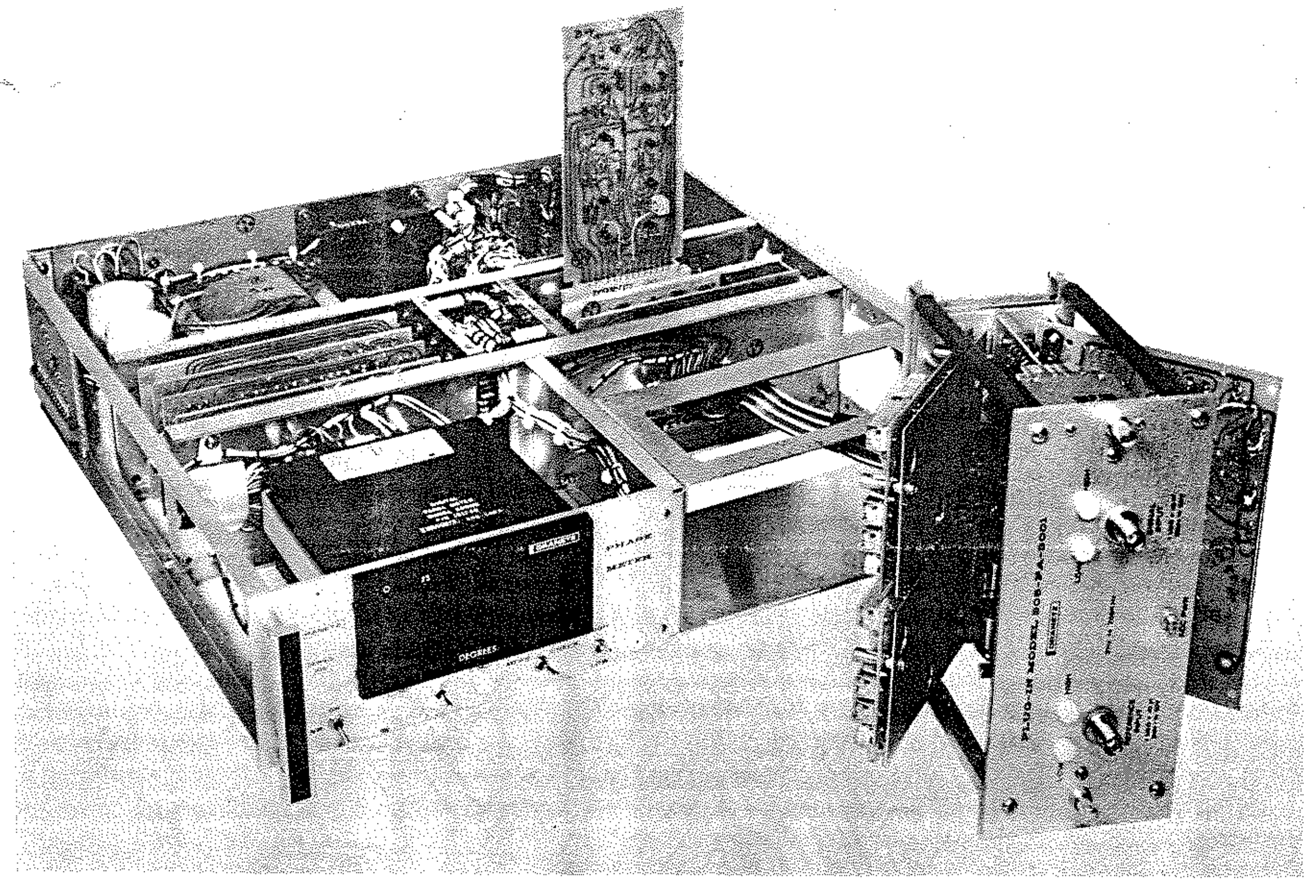


Figure 5-2. Main Frame Showing Extender Cable and Access to Circuit Boards

5-8. CIRCUIT DESCRIPTION

5-9. The following paragraphs provide circuit operation description at the component level. All discussion is referenced to the schematic diagrams in this manual. The schematic diagrams also contain significant signal and bias level information to aid in establishing the source of a malfunction. These discussions will not attempt to relate the functions of various components to the instrument as a whole; rather, each circuit board will be considered as an entity. The actual interconnections between boards is shown in the interconnection diagram (figure 5-3), while the function of each circuit with regard to the operation of the phasemeter as a whole is derived from the block diagrams contained in Section IV Theory of Operation. Each block in the diagrams of Section IV has a card number which aids to correlate the basic information with the detailed discussions of this section. A thorough understanding of the theory of operation explained in Section IV is necessary before the following detail information may be used effectively.

5-10. MODEL 305-PA-3001 WIDE RANGE PLUG-IN

5-11. Card A1 and Card A2 (See figures 5-23 and 5-24.) - The circuit diagram of Cards A1 and A2 is shown in figure 5-23. A sinusoidal input signal is applied to pin 1. If the level is below 500 mv rms, it is applied through relays K1 and K2 to the input of the amplifier without any attenuation. If the level at pin 1 is between 0.5 and 5.0 volts, relays K3 and K4 are closed and the signal is divided by 10 before it is applied to the amplifier. If the level at pin 1 is greater than 5 volts rms, relays K5 and K6 are closed and the signal is divided by 100 before it is applied to the amplifier.

5-12. Diodes CR1 and CR2 are clamps which protect Q1 from an application of excess voltage. The input level is limited to approximately 22 volts p-p.

5-13. Transistors Q1, Q2 and Q3 are used in a feedback amplifier circuit to provide gain while maintaining a 100-megohm input impedance and a low output impedance. This amplifier is designed to be run in an overdriven mode without excessive phase error.

NOTE

Model 305-PA-3002 uses Cards A1 and A2 (figures 5-29 and 5-30 in lieu of figures 5-23 and 5-24).

5-14. Card 5 Comparator (See figure 5-27 and 5-28.) - The outputs of Cards 1 and 2 are connected to Card 5 on which are two squaring circuits. U2 and U4 are differential comparators and are essentially high gain amplifiers with carefully controlled characteristics. The outputs of these devices are square waves with transitions at the zero crossings of the input sine waves. These outputs are the Reference and Signal square waves applied to the main frame.

NOTE

Cards A3 and A4 are used with Plug-in 305-PA-3001 only.

5-15. Cards 3 and 4 (See figures 5-25 and 5-26.) - These cards are the level detecting and switching circuits which operate the attenuators on Cards 1 and 2. The output of Card 1 (Reference) is connected to pin 7 of Card 3 while the output of Card 2 is applied to pin 7 of Card 4. The signal from pin 7 is applied through a frequency compensating network (C4, R36 and R37) to transistor Q8 which together with transistors Q9 and Q10 form a voltage-to-current converter section. The output of this stage is fed into a diode detector (CR8 and CR10) and filter (C8, R47, and C10). In this way a dc level proportional to the ac input level is obtained.

5-16. The dc level is fed to operational amplifiers A1 and A2 which serve as limit sensors. Since the amplifiers have differential inputs, a reference signal may be applied to the second input for comparison to the dc signal. If the input level is too high, the dc level into pin 5 of A1 becomes greater than the reference level set at pin 4. The output of A1 then becomes negative and causes Q11 to conduct. Q11 then produces the high limit output signal at pin 3 of the card and also lights the high limit lamp connected from pin 4 of the card to -24 volt power. If the input signal level becomes too low, the dc level into pin 4 of A2 becomes less than the reference level set at pin 5. The output of A2 becomes negative and causes Q12 to conduct. Q12 then produces the low limit output signal at pin 5 of the card and also lights the low limit lamp connected from pin 6 of the card to -24 volt power.

5-17. The high and low limit lines, A and B, drive two flip flops. The states of the flip flop outputs through the resistor-diode gating circuits determine which of the relay drivers (Q1, Q2, Q3) will conduct as follows:

Point C	Point D	Relay Drivers		
		Q1	Q2	Q3
High	High	On	Off	Off
High	Low	Off	On	Off
Low	Low	Off	Off	On

The relay drivers then actuate the desired relays on Cards 1 and 2.

5-18. MODEL 305 MAIN FRAME SIGNAL CIRCUITS

5-19. Card A8, Dual Differentiator -(See figures 5-17 and 5-18.) The reference square wave from pin 8 of Card 5 (figure 5-27 is applied to pin L of Card 8. This waveform is fed through isolating resistors R3 and R6 to pins M and N for use by other circuits in the main frame.

5-20. In the Inverting Differentiator, emitter follower Q1 prevents loading of the input signal. Q3 is a switching stage, while Q5 functions only as an inverter. Q7 is the output driver. The collector of Q7 (point A) switches between the negative supply (-24 vdc) and its emitter voltage of -5 vdc. The positive-going transition at point A is differentiated by capacitor C1 and fed through diode CR4 to its load on card 7.

5-21. In the Non-Inverting Differentiator emitter follower Q2 prevents loading of the input signal. Q4 is a switching gain stage adjustable by a 200-ohm potentiometer in series with R12. This potentiometer provides high frequency phase adjustment.

5-22. Transistor Q6 is the output driver. Point B switches between +19 vdc and ground. The positive transition is differentiated by capacitor C2 and is fed through diode CR5 to its load on card 7.

5-23. <u>Card A6 Dual Differentiators with DPDT Diode Switch. (See figures 5-13 and 5-14.)</u>- The signal square wave from pin 5 of card 5 (figure 5-27) is applied to pin L of Card 6. This waveform is fed through isolating resistors R3 and R6 to pins M and N for use by other circuits in the main frame.

5-24. The inverting and non-inverting differentiators function exactly as those on Card 8 described above.

5-25. The differentiator outputs are connected to the card output terminals through a diode switching circuit. When the switch drive at pin B is negative, it turns on transistors Q8 and Q11 which raises points 3 and 4 to a nominal -7 vdc bias level. Diodes CR4 and CR7 can now conduct and transfer the peaks of their positive going pulses to the flip flops on Card 7. Diodes CR5 and CR6 do not conduct because they are reverse biased by holding points 5 and 6 at a -24 vdc bias level. This is the case for the 0/+360° mode of operation. For 0/±180° operation, a 180° phase shift is accomplished by exchanging the signals at pins C and S of the card. Drive point R is held negative and B is positive. This turns transistors Q9 and Q10 on while Q8 and Q11 are off. Points 3 and 4 drop to -24 vdc biasing CR4 and CR7 off while points 5 and 6 are raised to -7 vdc allowing the positive pulses to transfer through CR5 and CR6.

5-26. <u>Card A7, Flip Flops and Switches</u>. (See figures 5-15 and 5-16.) - Card 7 has two identical circuit groups. Each consists of a flip flop, a switch driver and a switch module. Only one circuit group will be discussed.

5-27. Inputs to flip flop #1 are positive pulses applied to pins C and F. Pins D and E provide means for dc inputs which hold the flip flop in either state regardless of pulse inputs.

These are used for calibration purposes only. Q1 and Q2 constitute the flip flop.

5-28. Q5 is driven by the collector of Q1 and emitter coupled to Q7. The output of Q7 is clamped at +0.7 vdc and -15 vdc.

5-29. Integrated circuit U1 is a dual single pole, double throw solid state switch. When the input at pin 7 is low (-15 vdc), pins 2 and 4 are connected to pin 8 (-14 vdc). When pin 7 is high (+0.7 vdc), pins 2 and 4 are connected to pin 1 (ground).

5-30. The outputs from the card are the average currents through resistors R35 and R36 connected to pins K and S respectively.

5-31. Card A5 DC Amplifier Circuits. (See figures 5-11 and 5-12.) - This card contains a number of circuits related to obtaining the average value of the input waveforms at pins K and L; and also, with presenting this as a dc output level of -1.800 vdc to +3.600 vdc at pin S.

5-32. Integrated circuit U5 is a dc amplifier connected in a summing configuration. Its output is proportional to the sum of the current inputs at pins K and L of this card and is -1.8 to +3.6 volts dc corresponding to -180^{o} to +360 degree phase angle.

5-33. Averaging of the input is accomplished by capacitor C3 and C4 connected in series between the summing junction and ground. Transistor Q3 connects an additional capacitor C2 at frequencies below 5 kHz. Below 500 Hz, Q2 connects capacitor C5 and below 50 Hz, Q1 connects capacitor C6.

5-34. Integrated circuits U1 and U2 apply an input to the dc amplifier which provides a 1.800 vdc (180^{o}) shift in its output voltage.

5-35. The -14 vdc reference is established by temperature compensated diodes CR4 and U4. A +14 volt dc reference is established equal in amplitude but opposite in polarity to the -14 volt dc reference established by U3. This +14 volt dc reference is fed to U2.

5-36. MODEL 305 MAIN FRAME CONTROL CIRCUITS

5-37. Paragraph 5-18 described the main frame circuits which directly process incoming signals to derive phase information. This paragraph will be concerned with control and auxiliary circuits which in some way aid or modify the operation of the signal processing circuits.

5-38. Mode Selection Circuits Card A4.- (See figures 5-9 and 5-10. This circuit detects when the phase angle being measured nears the end of a range. Detection points are set at approximately +15° and +345° on the 0/360° range and at ±165° on the 0 ±180° range.

5-39. The reference square wave from pin J drives switch Q4 through emitter follower Q3. The signal square wave from pin H drives switch Q2 through emitter follower Q1. The collectors of Q2 and Q4 are both connected to point 1 where they drive a common load resistor R11. The maximum voltage at point 1 is limited to approximately +8 vdc by CR3 clamping to zener diode CR2.

5-40. When the input angle is zero degrees, a square wave is present at point 1. If the inputs are 180° apart, point 1 remains in its low state since either Q2 or Q4 is always conducting. Therefore, the average value of the voltage at point 1 changes from an approximate +4 vdc at zero degrees to an approximately 0 vdc for 180° phase difference between the signals at pins H and J.

5-41. The dc level obtained is sent to the front panel CAL switch through pin N. In the MEAS (measure) position, the CAL switch returns this signal to pin P. In the CAL position, the CAL switch substitutes a dc level from pin K. This allows either mode to be selected for calibration.

5-42. The signal from pin P is applied to differential amplifiers A1 and A2. When the signal is lower than the voltage at A1 pin 4, the output of A1 becomes negative and sets a flip flop (Q5 and Q6) through CR6. When the signal is higher than the voltage at A2 pin 5, the output of A2 becomes negative and resets the flip flop through CR7.

5-43. The state of the flip flop (Q5 and Q6) determines the operating mode (0 ±180° or 0/360°). Outputs taken from the collectors are applied to pins C and D. The collectors also drive transistors Q7 and Q8 which light front panel lamps to indicate which mode the unit is in. Pins R and S are used to introduce external set and reset signals to the flip flop. A -24 vdc signal at either pin R or S will override signals from A1 and A2.

5-44. <u>Frequency Detection Circuits Card A2</u> (See figure 5-7 and 5-8.) - The Reference Square wave is applied through pin E to emitter follower Q1, which drives switch Q2 without heavily loading the input. For calibration, +24 vdc applied at pin P overrides the signal at pin E and holds Q2 "on" continuously. This causes all outputs to indicate frequency above switch points for calibration using the fastest output time constant.

5-45. When Q2 is "on" its collector is very nearly at ground and when it is "off" its collector is clamped by diode CR1 to zener CR2. In this way, a square wave is then applied to the four frequency detecting circuits which form the balance of Card 2.

5-46. Since all four frequency detectors operate in a similar fashion, only one will be discussed in detail. Frequency switch points are at 50 Hz, 500 Hz, 5 kHz, and 50 kHz. Switching should be within ±10% of these values.

5-47. The square wave at the collector of Q2 is applied to the 5 kHz detector through R28. While the positive (+8 dc) polarity remains, C3 is charged at a rate determined by C3 and R28. When the square wave returns to the ground portion of its cycle, capacitor C3 is discharged through CR5 and R26. The peak voltage on C3 is transferred through emitter follower Q3 and diode CR3 to storage capacitor C1. The voltage on C1 is applied to the inverting input of operational amplifier A1. If it exceeds the voltage at pin 5 of A1, the output of A1 becomes negative.

5-48. The other three frequency detectors operate similarly. The input shunt capacitors are different to provide different charging times and thereby are active at different frequencies.

5-49. MODEL 305D OFFSET AND NULL CIRCUITS (Figures 5-19 and 5-20)

5-50. The circuits on Card A10, along with additional front panel components, provide the user a means of setting an angular offset and reading the difference between that offset and a measured phase angle on an analog meter.

5-51. A stable reference voltage of either -6 volts or -14 volts is applied to pin C. Resistors R1, R2, R3 and R4 together with front panel controls R10 and R11 scale the reference voltage and apply it to both inputs of amplifier U1 which provides buffer and level shift functions so that the output at U1 pin 10 may be adjusted to any value between -3.6000 and +1.8000 volts DC.

5-52. Resistor R12, R13 and R14 are a summing network which adds this offset voltage to the analog output from Card A5 (-1.8000 to +3.6000 volts). The difference between the two signals is applied to null amplifier U2 pin 4. Diode Network CR1, CR2, CR3, CR4 and VR1 reduce the gain of the amplifier at large output levels.

5-53. The output of amplifier U2 (pin 10) is applied to the input of amplifier U3 (pin 4) for further amplification. The gain of U3 is made progressively lower with increasing output level by diode networks CR5, CR6, CR7, CR8 and VR4 as well as CR9, CR10, CR11, CR12 and VR5. The voltage developed across the feedback network of U3 is applied through R23 via pins R and 14 to the front panel analog null meter M2 which indicates null when the measured phase angle is equal to the offset angle selected using front panel potentiometer R10 and R11.

5-54. SERIES 305 DUAL POWER SUPPLY (Figures 5-21 and 5-22)

5-55. The dual power supply circuits provide + and -24 volt DC regulated power to all the phasemeter main frame and plug-in circuitry.

5-56. The AC power line voltage is stepped down by transformer T1 and rectified by diodes CR1 and CR2 to produce approximately +40 volts DC across capacitor C1.

5-57. Amplifier U1 senses a portion of the positive output voltage (+E) and compares it to reference Zener diode CR11. The output of U1 (pin 10) is amplified by transistor Q2 and applied to the base of pass transistor Q1 causing it to conduct to maintain the positive output voltage (+E) at a +24 volt DC level. Potentiometer R16 is used to set this output voltage to +24 ±0.3 volts.

5-58. Amplifier U2 senses the sum of the plus (+E) and minus (-E) output voltages and compares this sum to ground (0 volts). The output of U2 (pin 10) is amplified by Q3 and applied to pass transistor Q4 causing it to conduct as required to maintain the minus (-E) output voltage magnitude equal to the plus (+E) output voltage magnitude.

5-59. Current limiting in pass transistor Q1 is provided by transistor Q5 which begins to conduct when the voltage across current sensing resistor R5 exceeds approximately 1 volt. Transistor Q5 then reduces the base current available to Q1 and limits its output current.

5-60. Current limiting in pass transistor Q4 is provided by Q6 which begins to conduct when the voltage across current sensing resistor R7 exceeds approximately 1 volt. Transistor Q6 then reduces base current available to Q4 and limits its output current.

5-61. SELECTED COMPONENTS

5-62. General

5-63. This section covers the procedure for selecting several specific components on cards 3 and 4 of the plug-ins and cards 2 and 4 of the Main Frames. These selected components may require replacement due to component failure, but will not require change during routine calibration. To avoid accidental changes in these values, fixed selected components have been installed at the factory. For convenience in repair, all selected resistors may be replaced by equivalent variable resistors (see parts list).

5-63. Cards A3 and A4 of Plug-In 305-PA-3001 (Figure 5-25)

5-64. Selection of R49 may be necessary after replacement of any of the following parts on the same card: R36, R37, R38, R43, R44 or R46. Set up the equipment as shown in figure 3-1, and proceed as follows:

a. Set oscillator output to zero. Increase oscillator output level slowly and note point at which the High Limit lamp blinks. This indicates upranging from ÷ 1 range to ÷ 10 range.

b. Select R49 (nominal 470K) so that up ranging takes place between 480 and 500 mv rms. Down ranging must occur between 450 and 360 mv rms. (This is the point at which the LOW LIMIT light blinks with decreasing amplitude.

5-65: Card A2 of Main Frame (Figure 5-7)

Selection of R28, R29, R30 or R31 may be required after respective replacement of C3, C4, C5 or C6. Set up equipment as shown in figure 3-1 with the addition of an oscilloscope, and proceed as follows:

a. Set the oscillator output to 1V rms.

b. Put Card 2 on an extender.

c. Connect an oscilloscope (dc, 10V per Division) to Pin A and sweep the frequency through 50 kHz. The voltage at Pin A should change from approximately -13V dc to +13V dc as the frequency is increased.

d. Select R30 (30K ohms nominal) so that switching occurs between 45 and 48 kHz.

e. Connect scope to Pin B and sweep frequency through 5 kHz. The voltage should switch from -13V dc to +13V dc as the frequency is increased.

f. Select R28 so that switching occurs between 4.8 and 5.2 kHz.

g. Connect oscilloscope to Pin S and repeat at 500 Hz setting R31 for switching between 480 and 520 Hz.

h. Connect oscilloscope to Pin M and repeat at 50 Hz selecting R29 to set switching between 46 and 49 Hz.

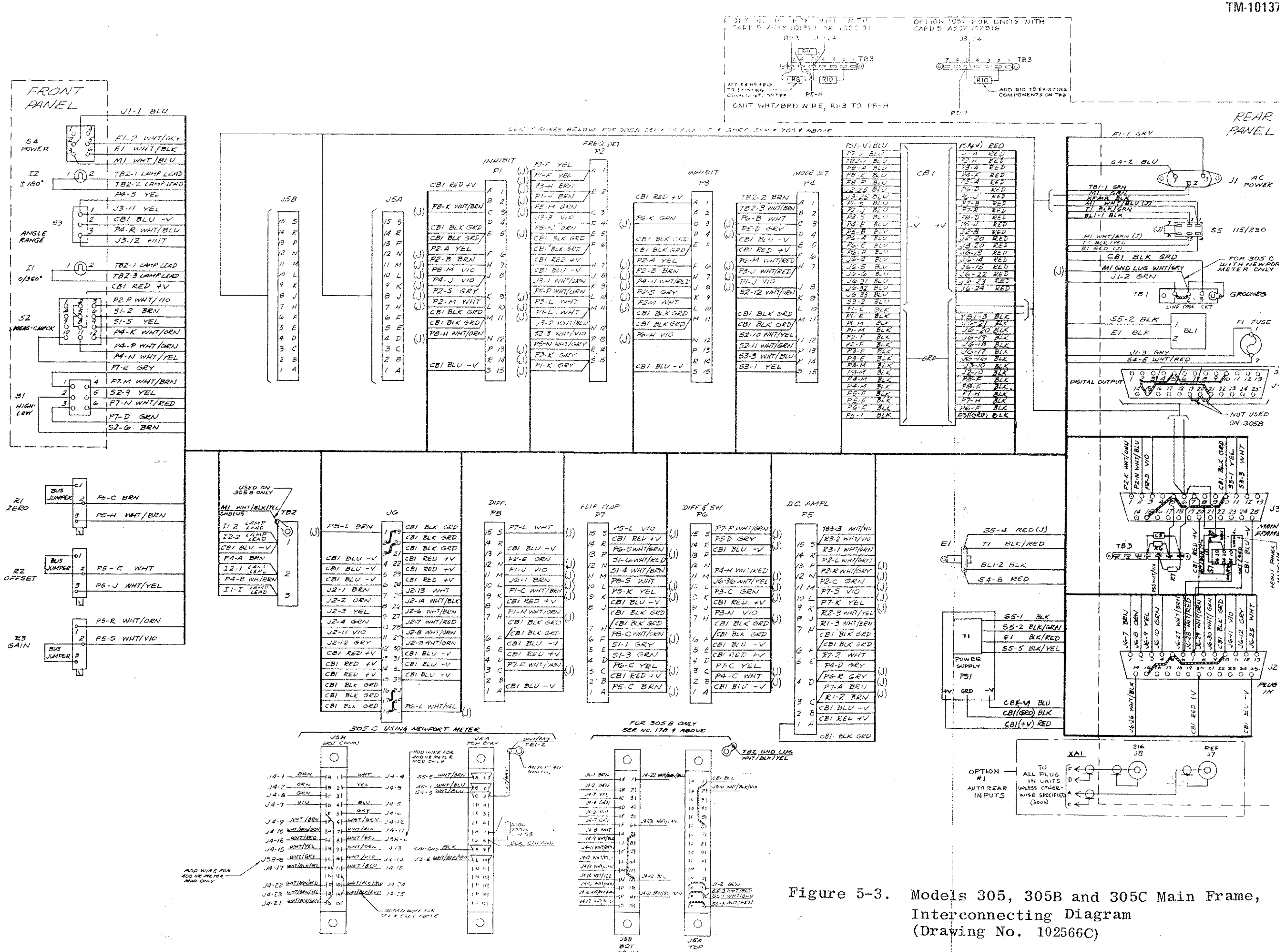


Figure 5-3. Models 305, 305B and 305C Main Frame, Interconnecting Diagram (Drawing No. 102566C)

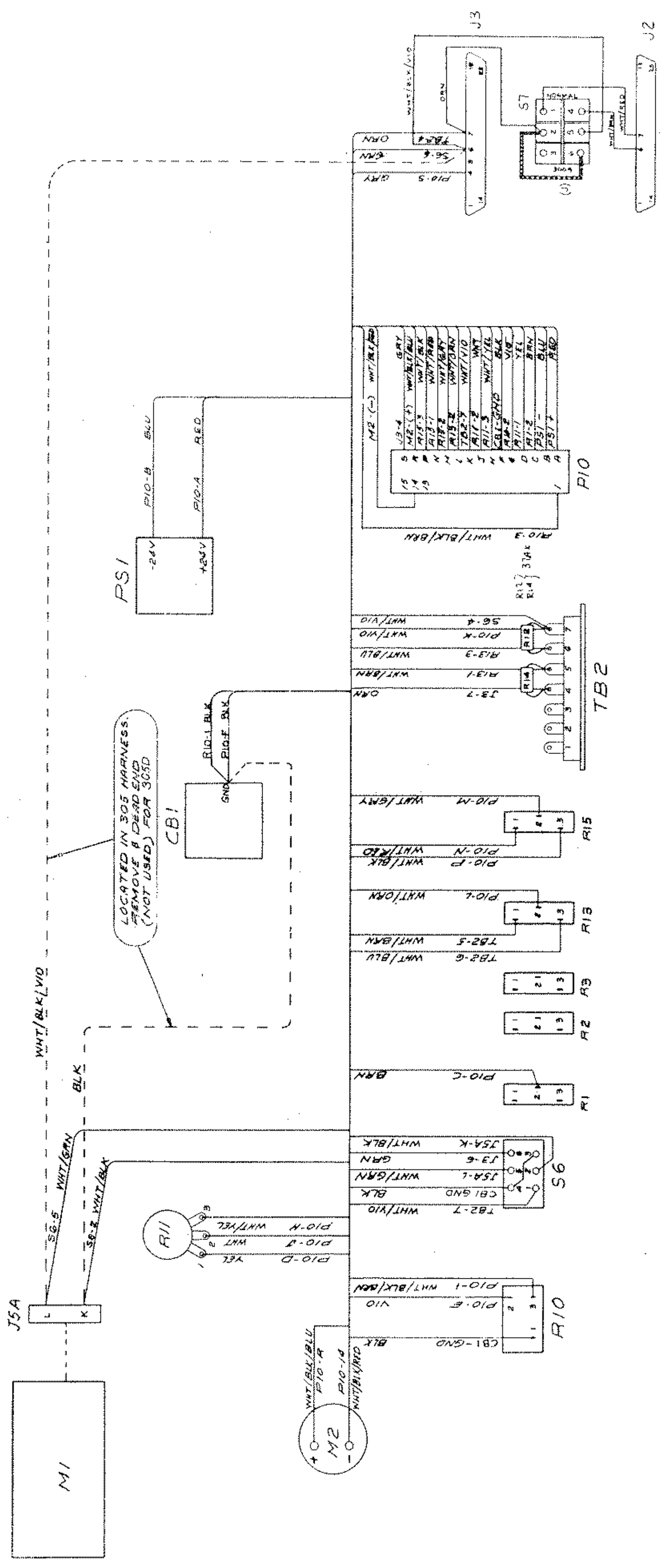


Figure 5-4. Model 305D Main Frame, Interconnecting Diagram (Drawing No. 102216F)

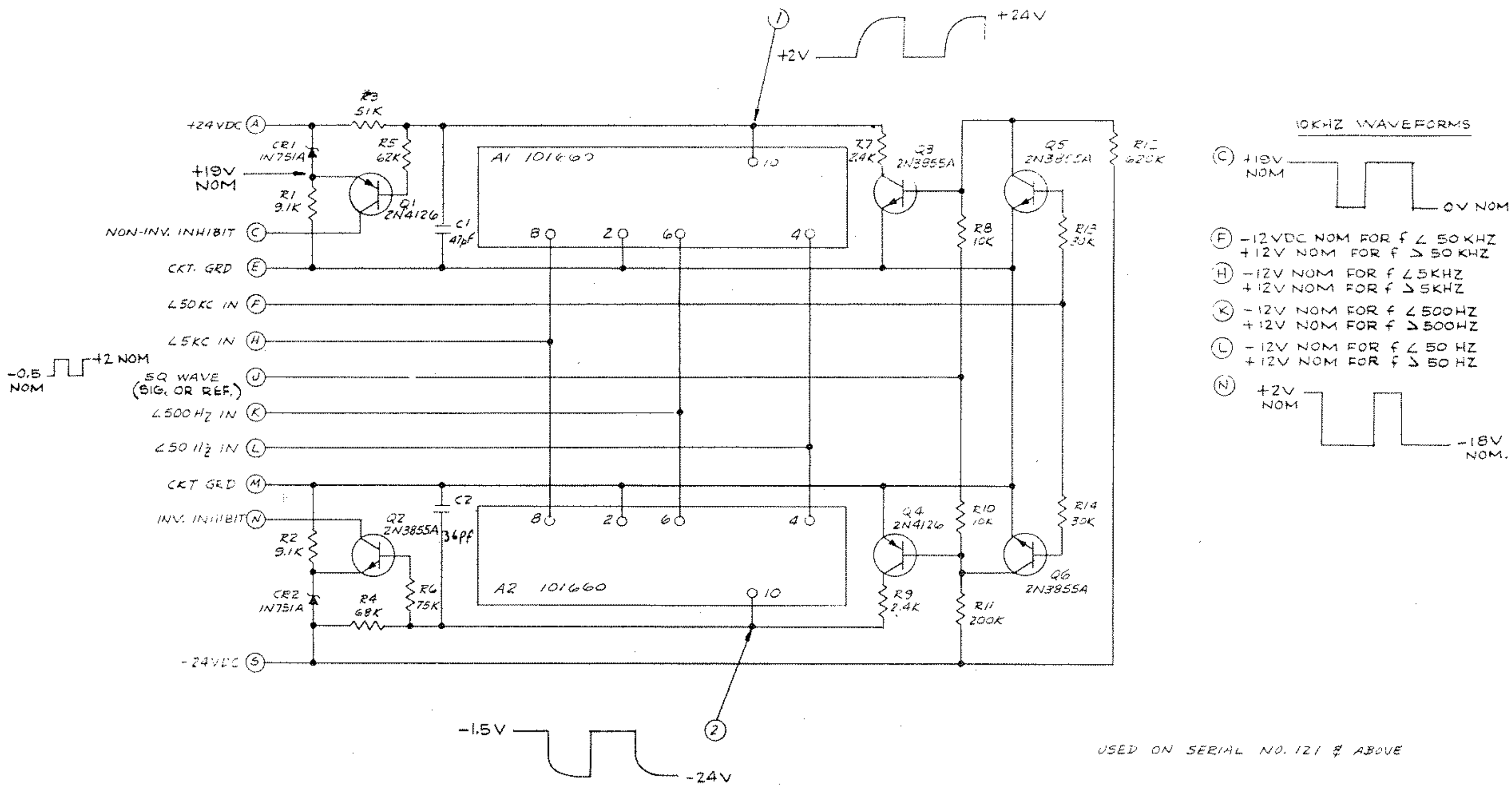


Figure 5-5. Main Frame Card A1 and A3 Inhibit Circuits, Schematic Diagram (Drawing No. 101669C)

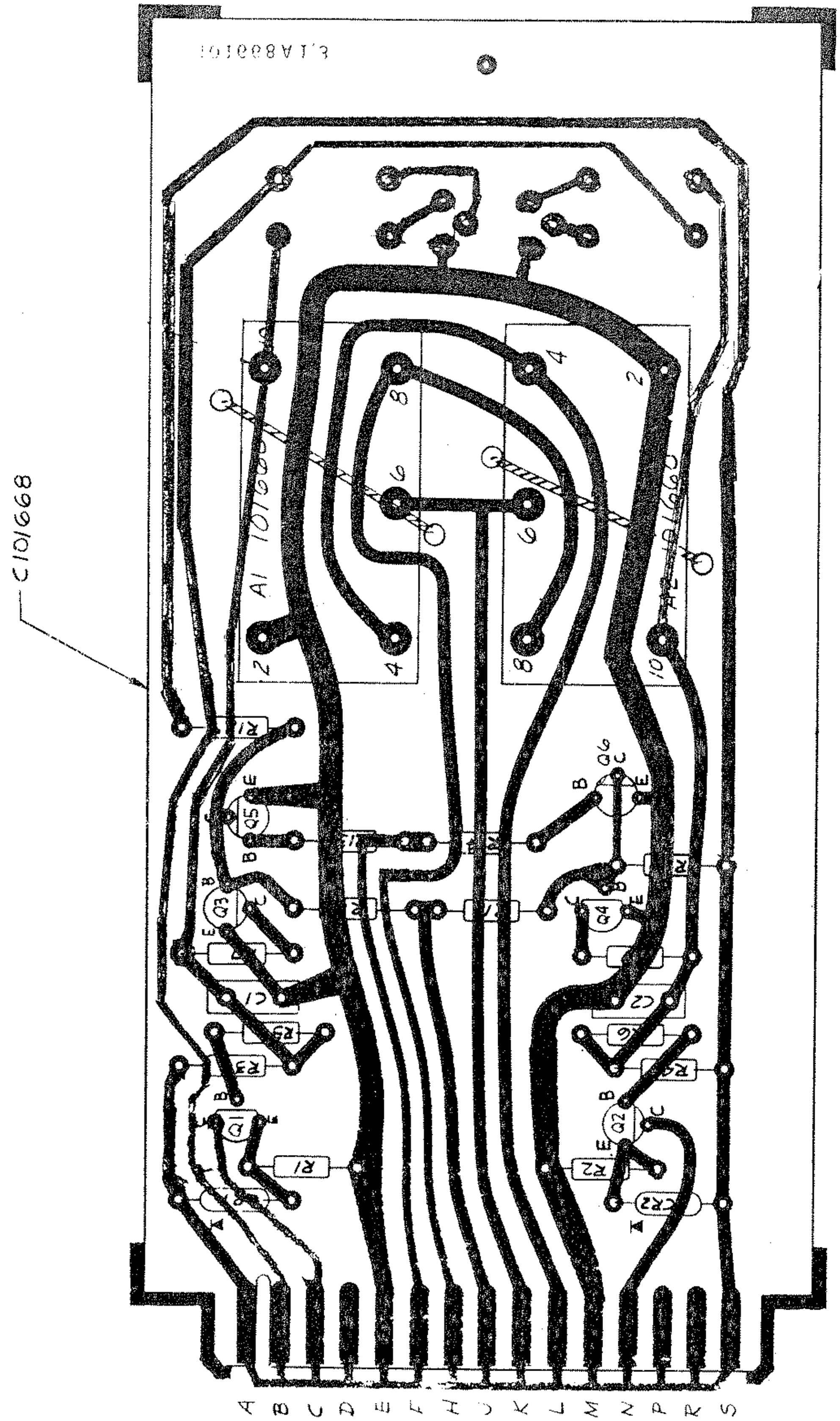


Figure 5-6. Main Frame Card A1 and A3 Inhibit Circuits, Parts Location (Drawing No. 101668B)

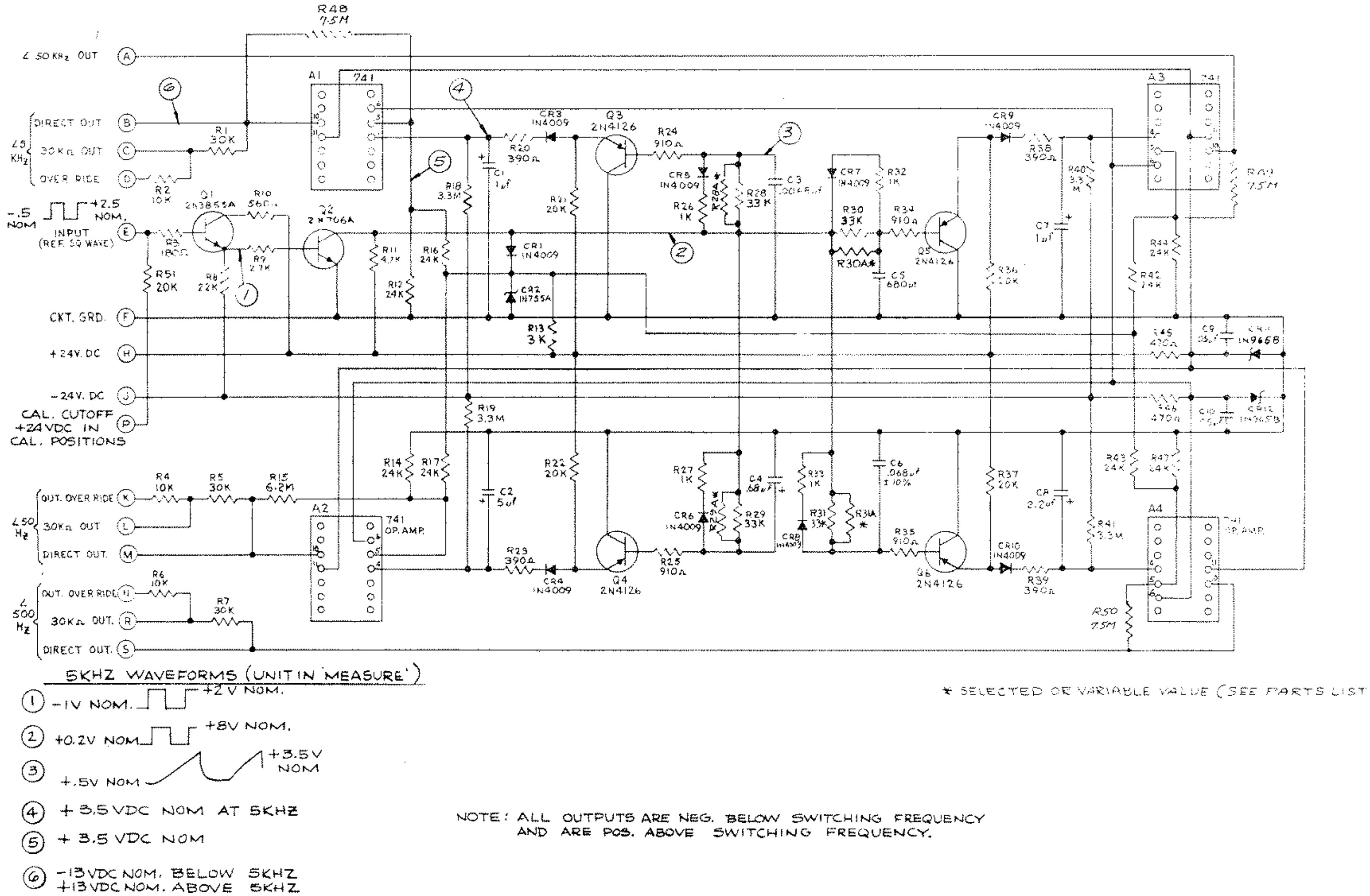


Figure 5-7. Main Frame Card A2 Frequency Ranging Circuits, Schematic Diagram (Drawing No. 101326K)

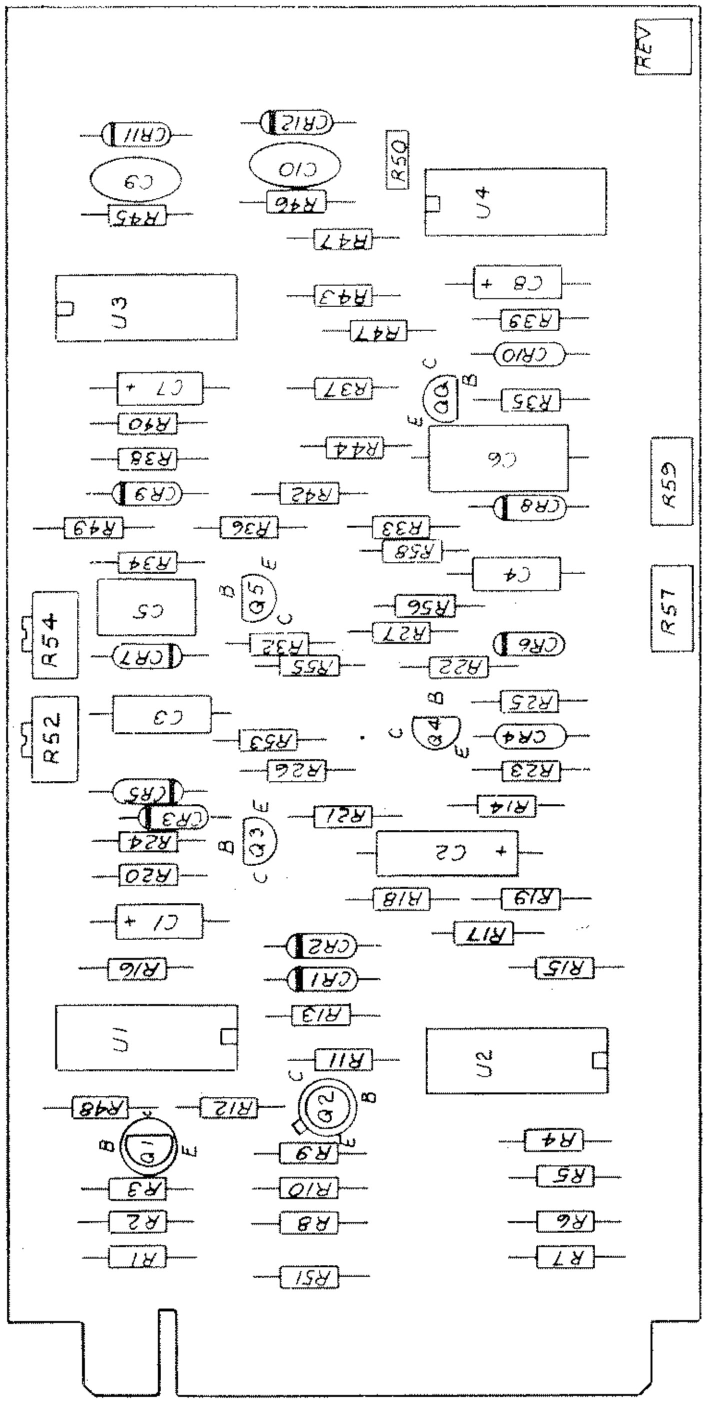


Figure 5-8. Main Frame Card A2 Frequency Ranging Circuits, Parts Location (Drawing No. 101319L)

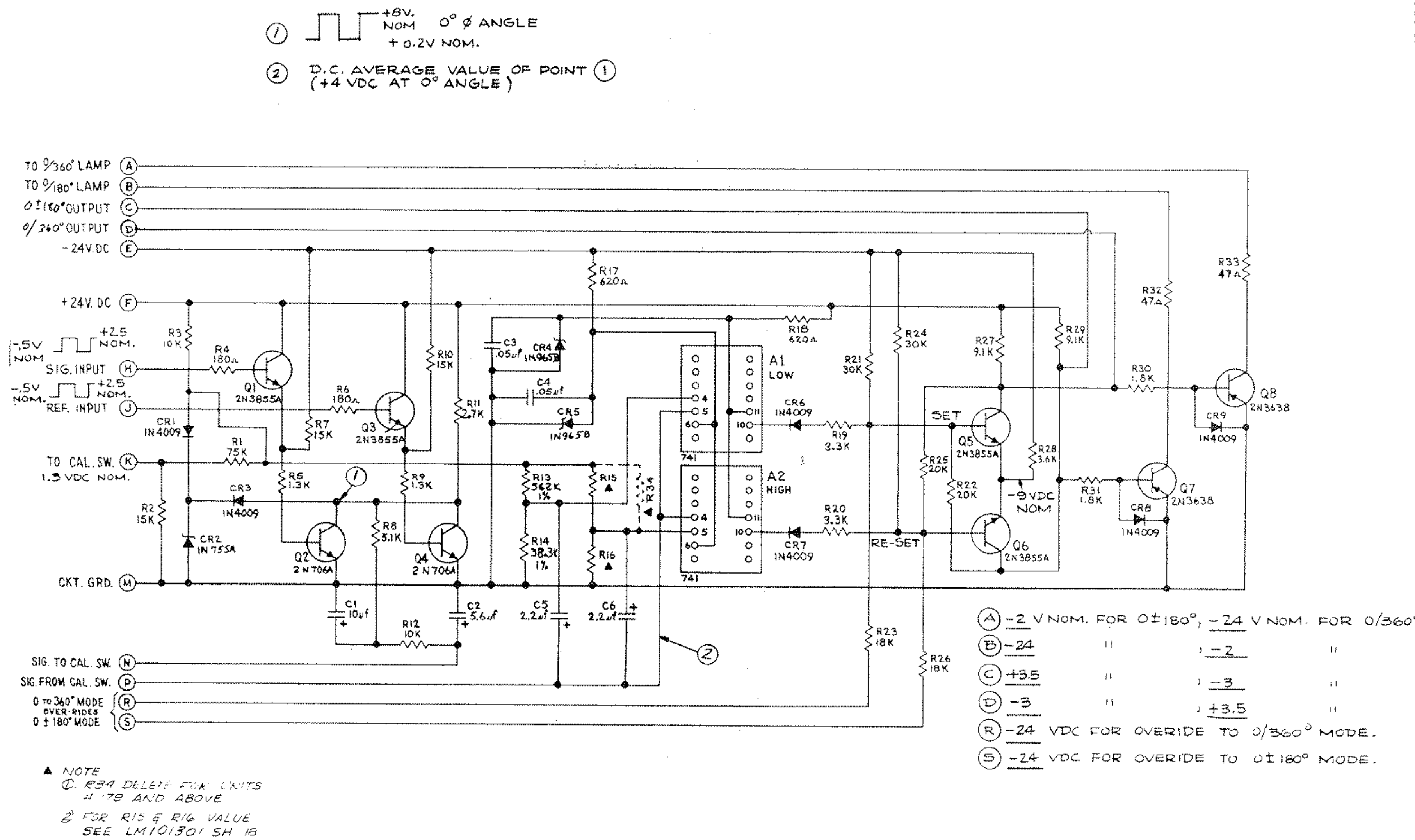


Figure 5-9. Main Frame Card A4 Mode Selection Circuits, Schematic Diagram (Drawing No. 101327H)

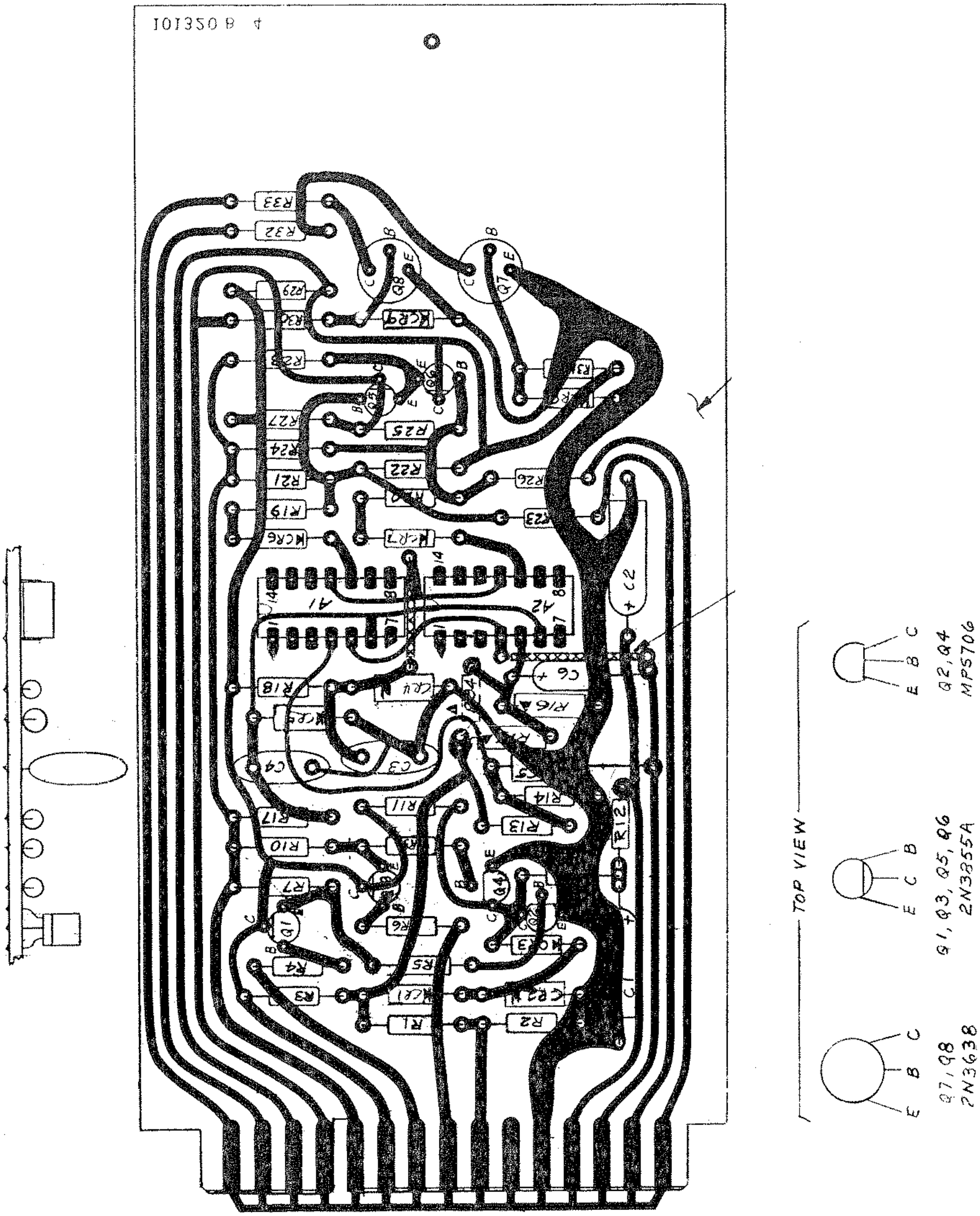


Figure 5-10. Main Frame Card A4 Mode Selection Circuits, Parts Location (Drawing No. 101320D)

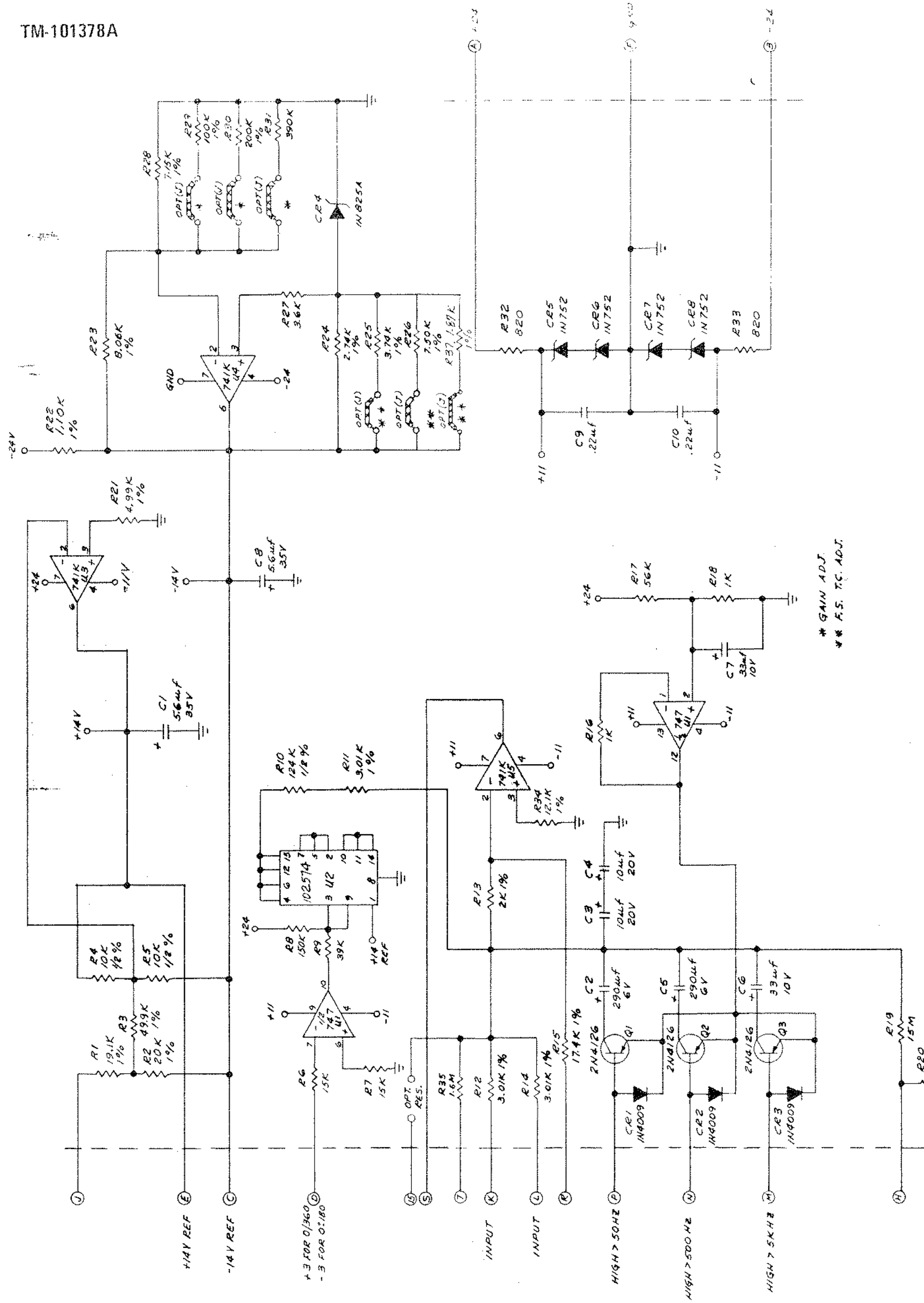


Figure 5-11. Main Frame Card A5 DC Amplifier Circuits, Schematic Diagram (Drawing No. 102518D)

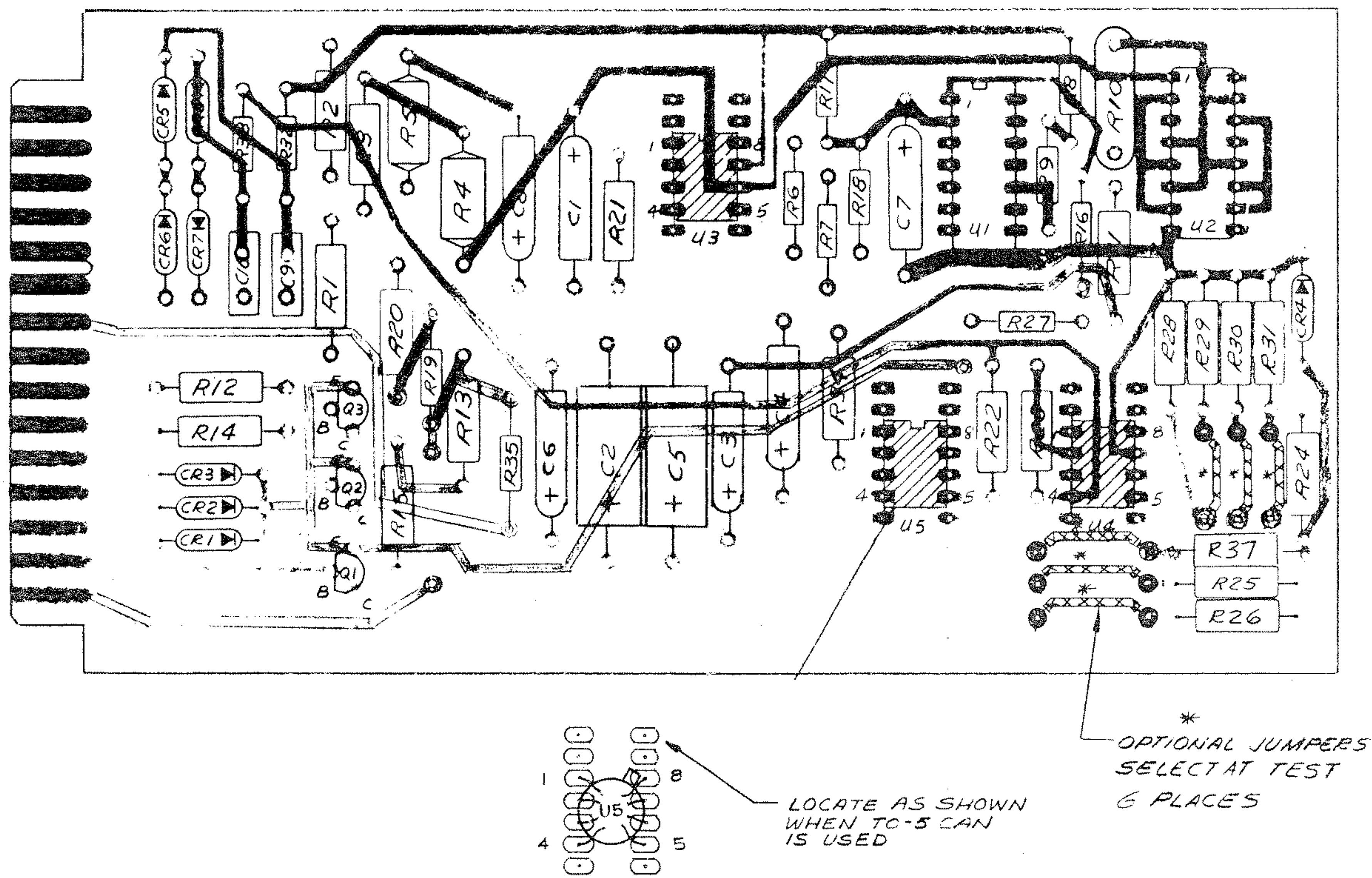


Figure 5-12. Main Frame Card A5 DC Amplifier Circuits, Parts Location (Drawing No. 102516E)

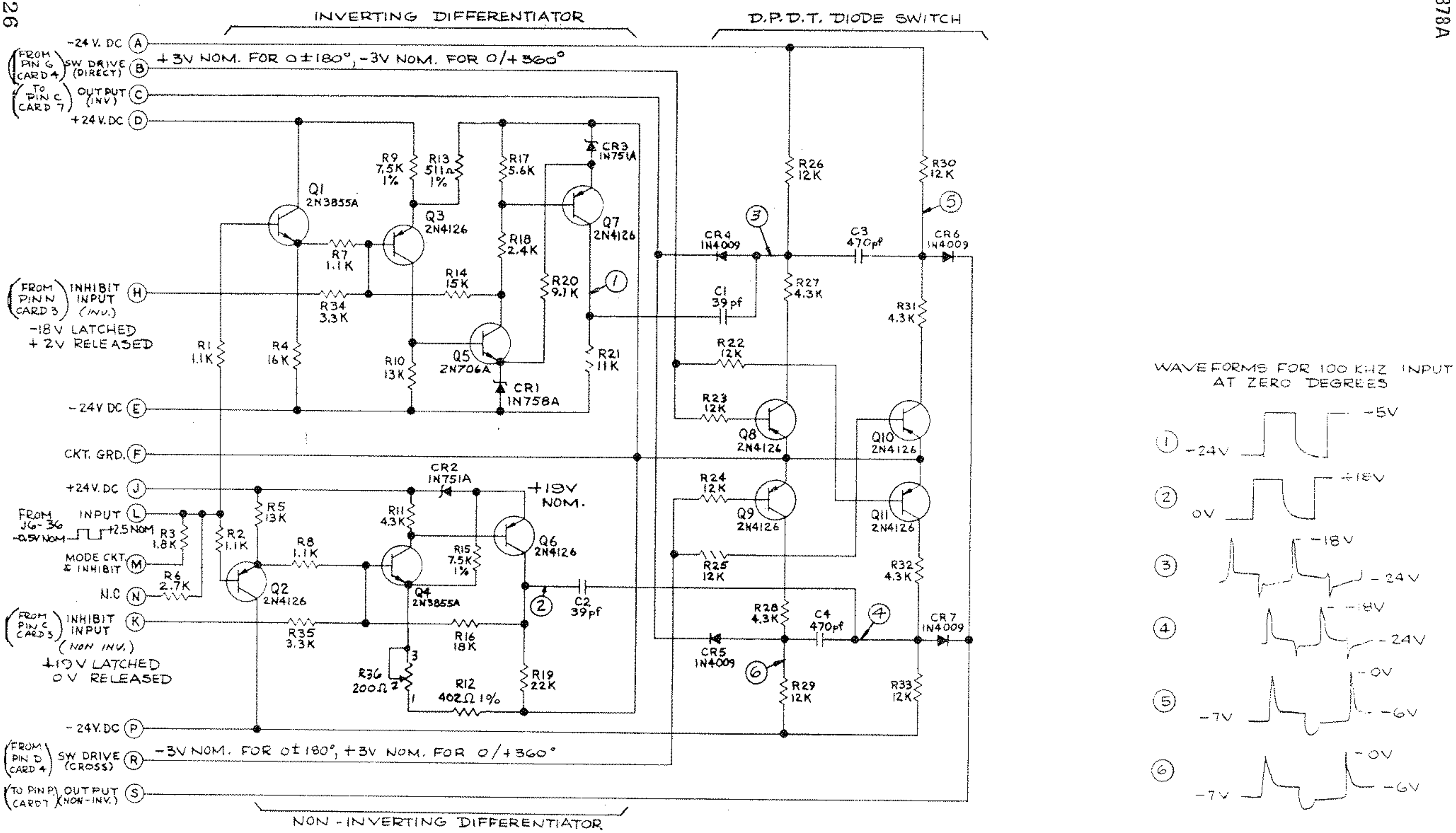


Figure 5-13. Main Frame Card A6 Differentiator and Switch Circuits, Schematic Diagram (Drawing No. 101329F)

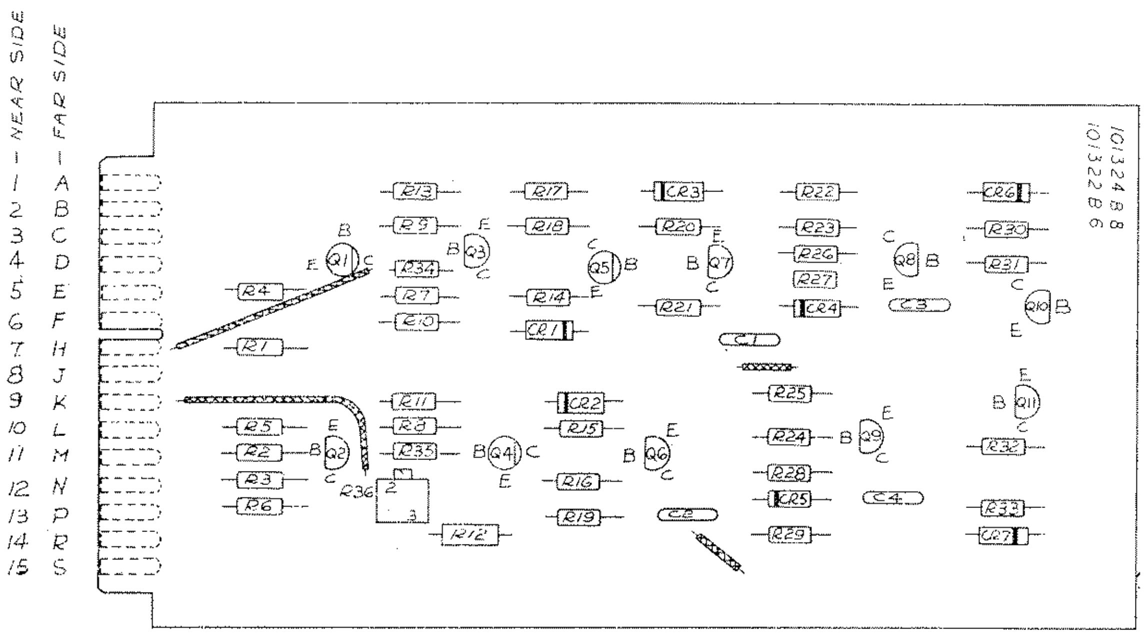


Figure 5-14. Main Frame Card A6 Differentiator and Switch Circuits, Parts Location (Drawing No. 101322C)

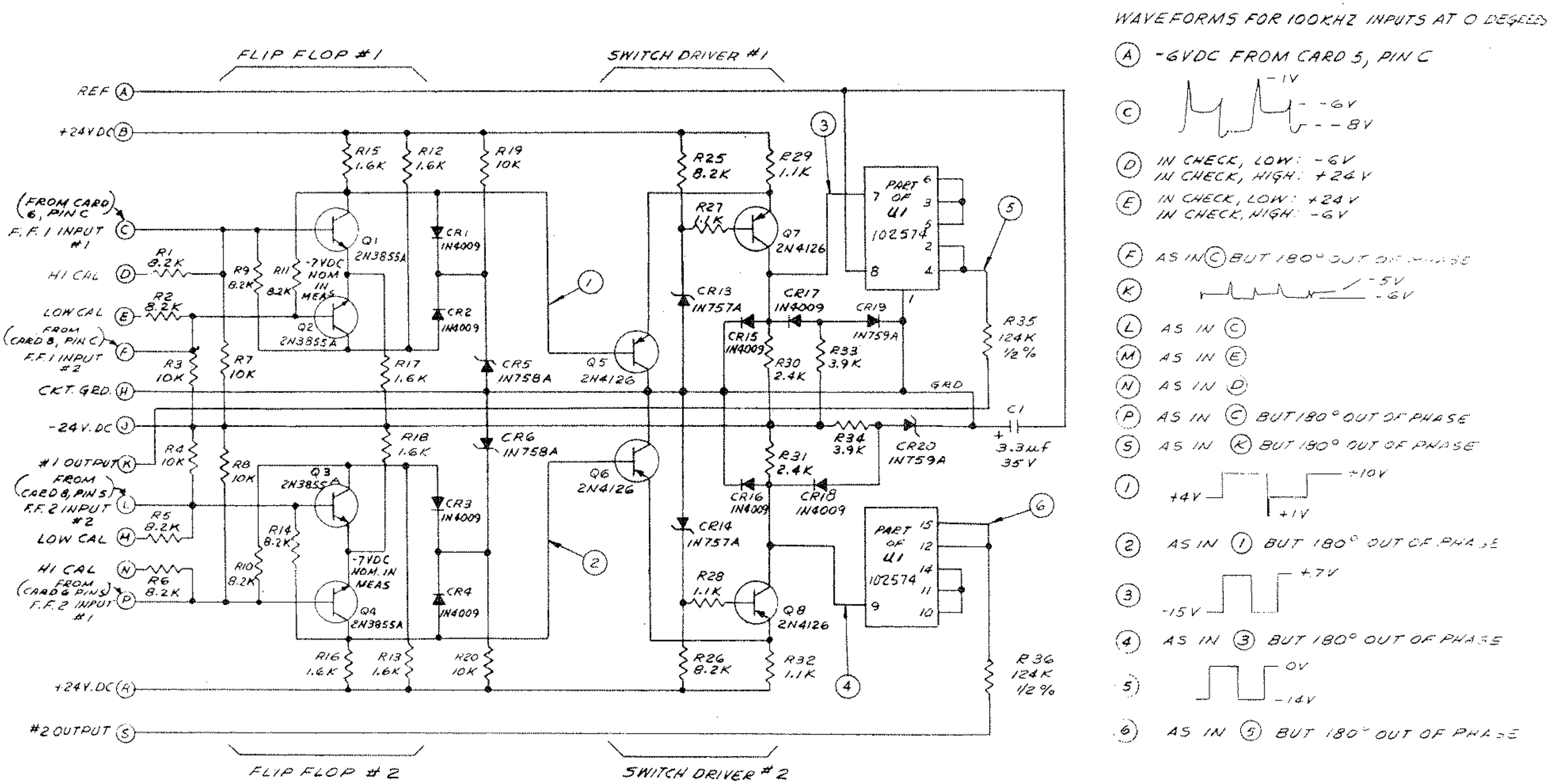


Figure 5-15. Main Frame Card A7 Flip-Flops and Switches, Schematic Diagram (Drawing No. 102522B)

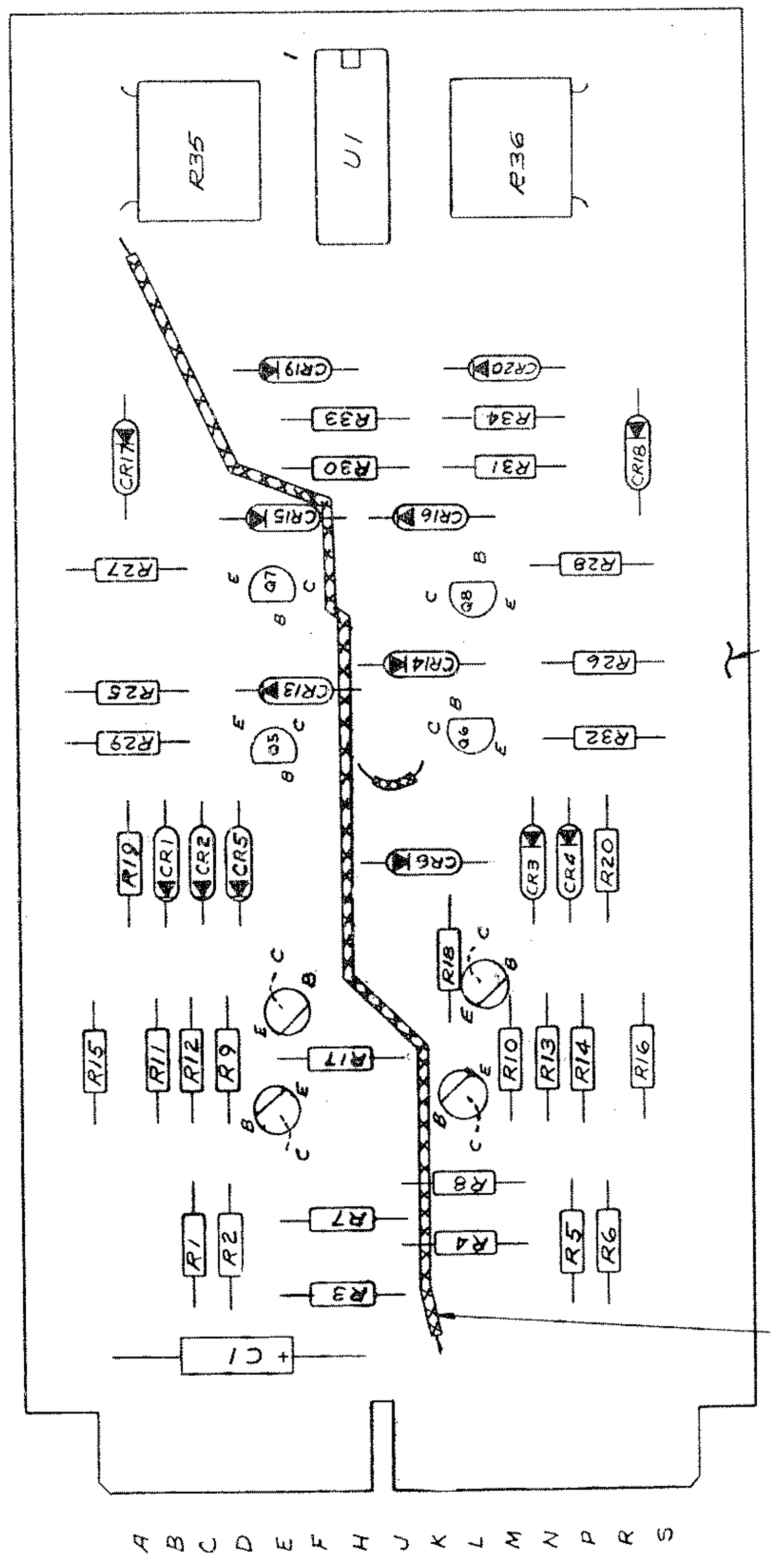


Figure 5-16. Main Frame Card A7 Flip-Flops and Switches, Parts Location (Drawing No. 102520A)

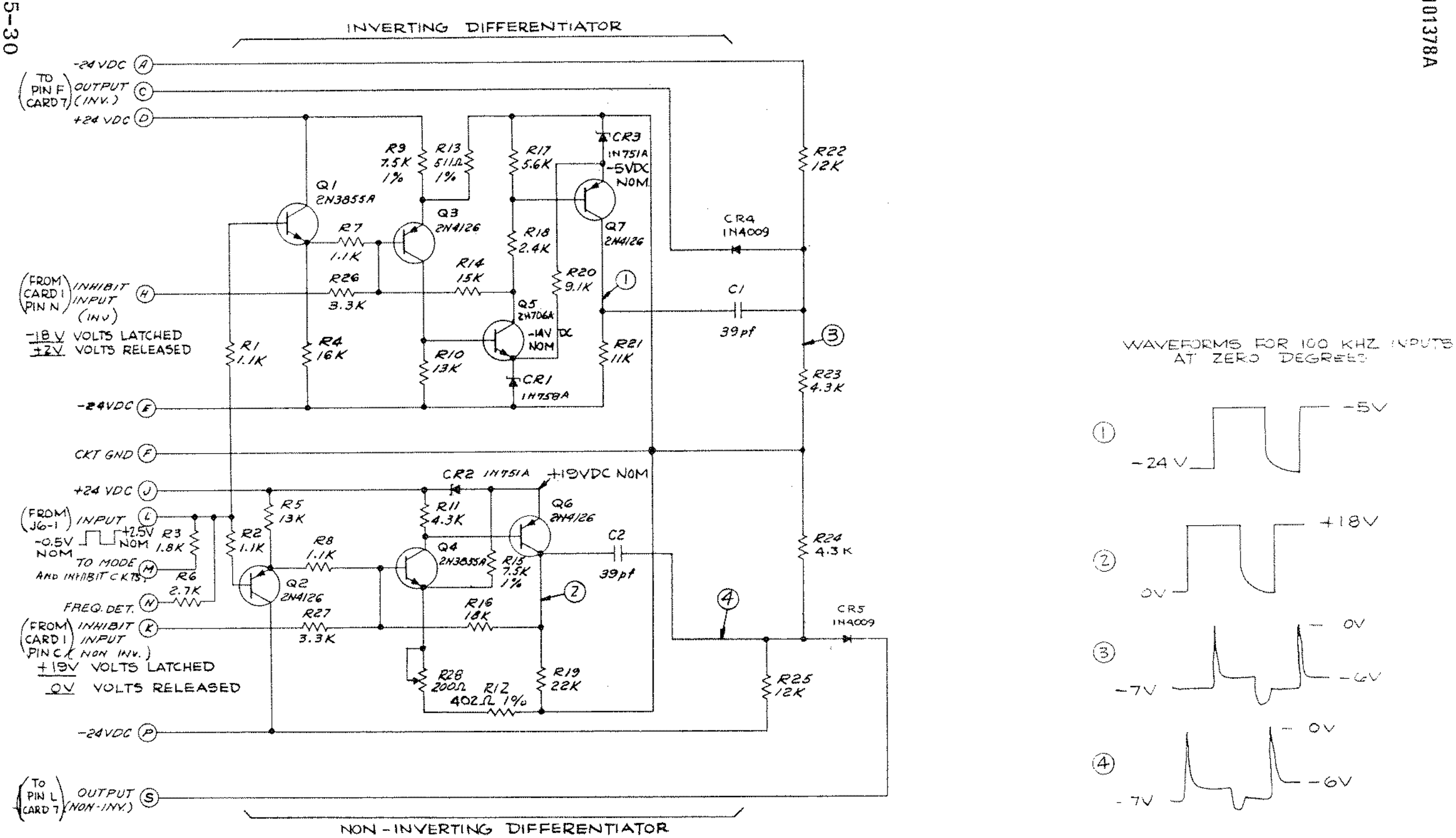


Figure 5-17. Main Frame Card A8 Differentiator Circuits, Schematic Diagram (Drawing No. 101331G)

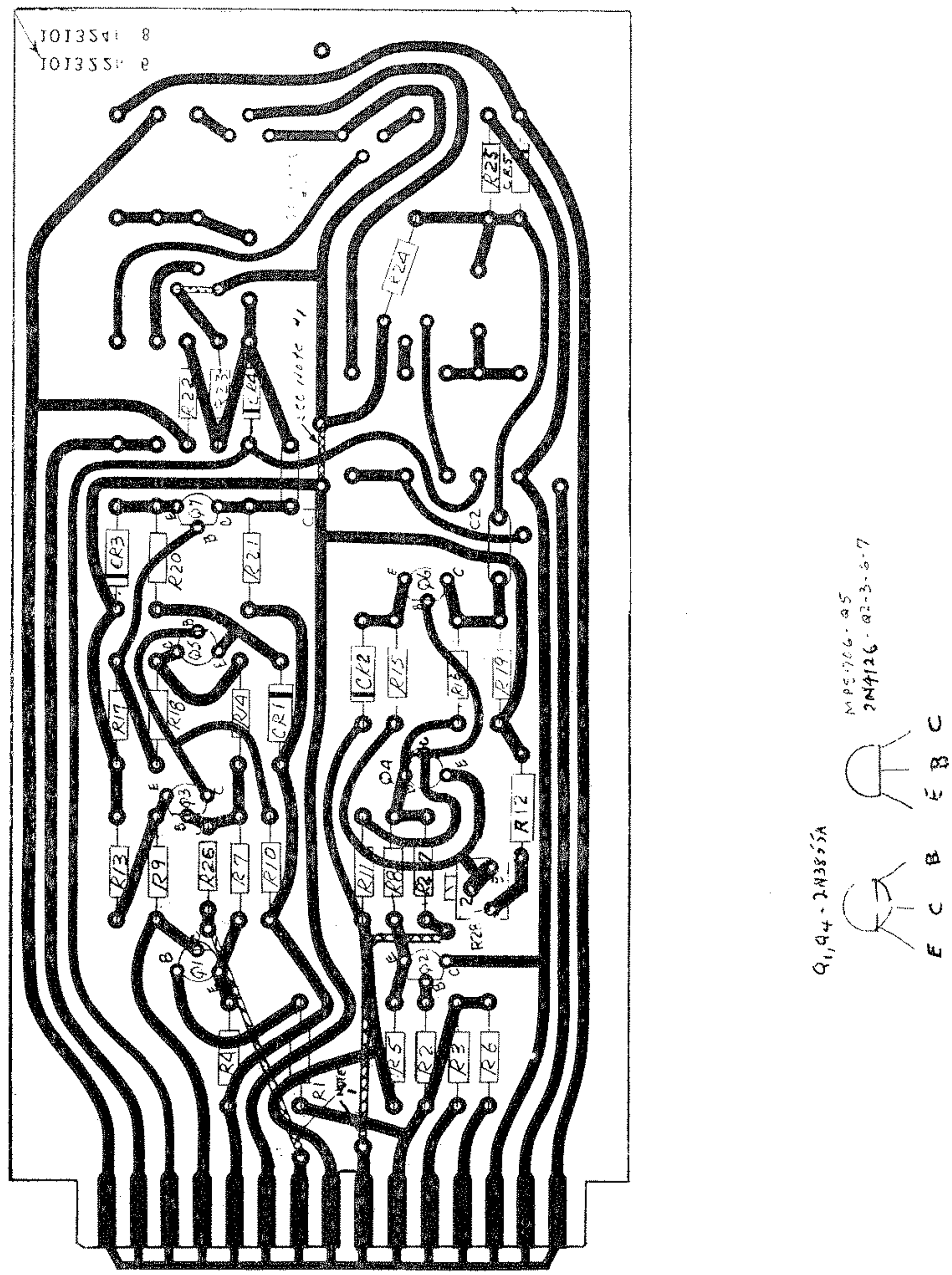


Figure 5-18. Main Frame Card A8 Differentiator Circuits, Parts Location (Drawing No. 101324C)

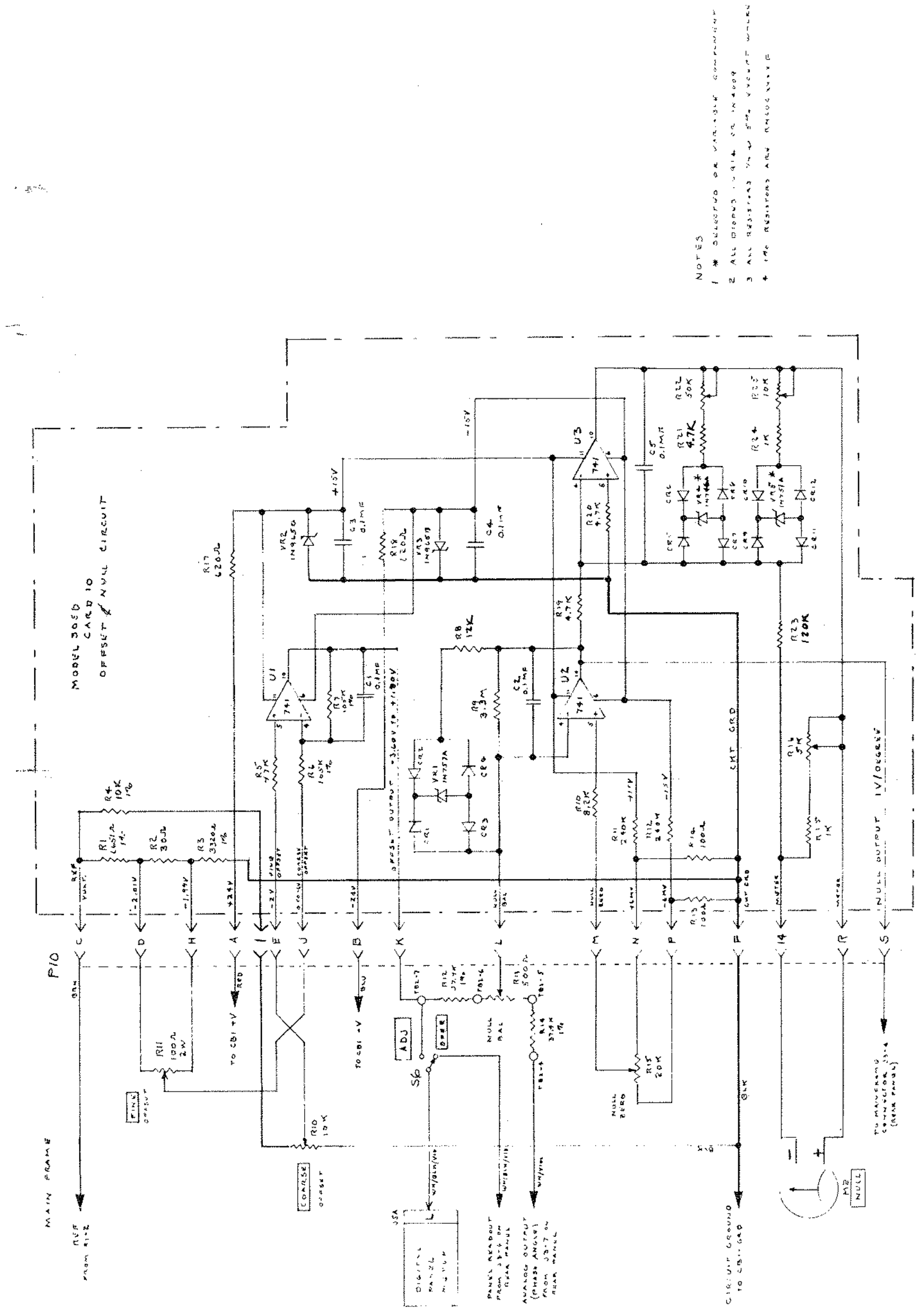


Figure 5-19. Main Frame Card A10 Offset and Null Circuits, Schematic Diagram (Drawing No. 102224C)

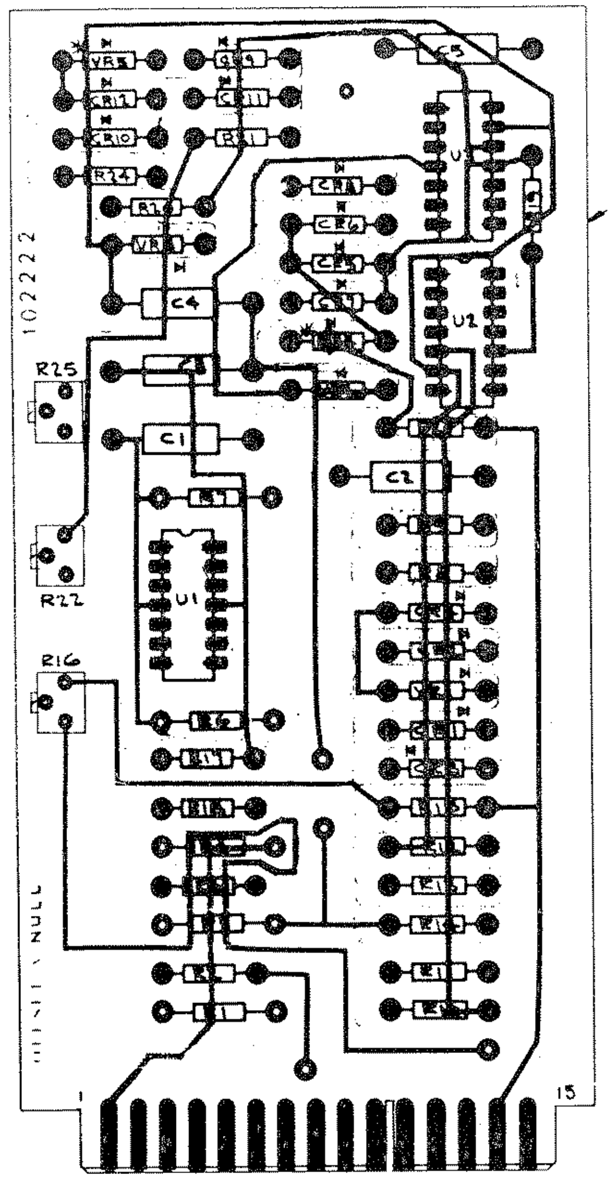


Figure 5-20. Main Frame Card A10 Offset and Null Circuits, Parts Location (Drawing No. 102222C)

NOTE #1

VOLTAGE -E-	R15 RES VALUE
22V - 28V	10K 1% 1/8W
18V - 22V	8.66K 1% 1/8W
15V - 18V	6.49K 1% 1/8W
12V - 15V	4.75K 1% 1/8W

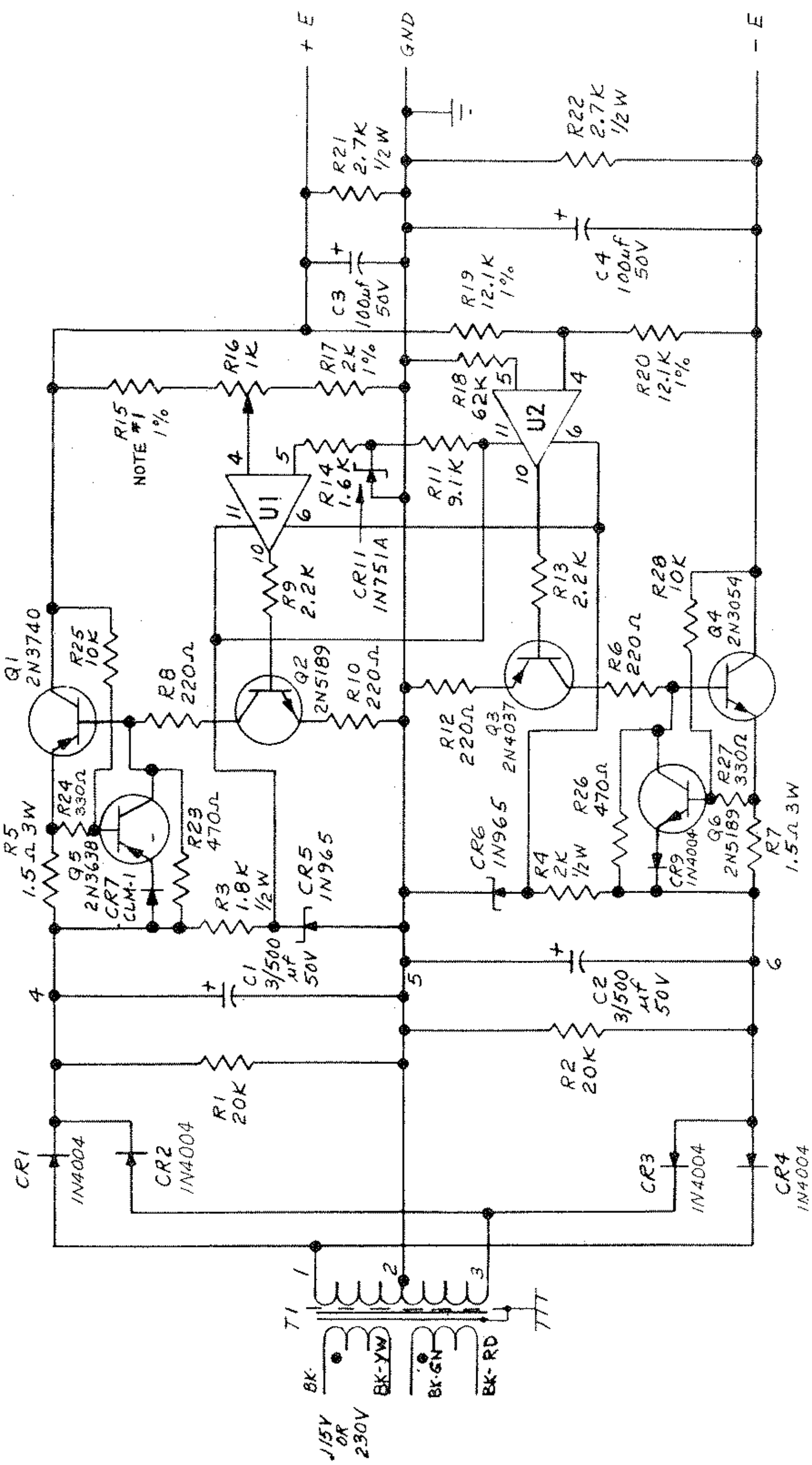


Figure 5-21. Dual Power Supply, Schematic Diagram (Drawing No. 101215M)

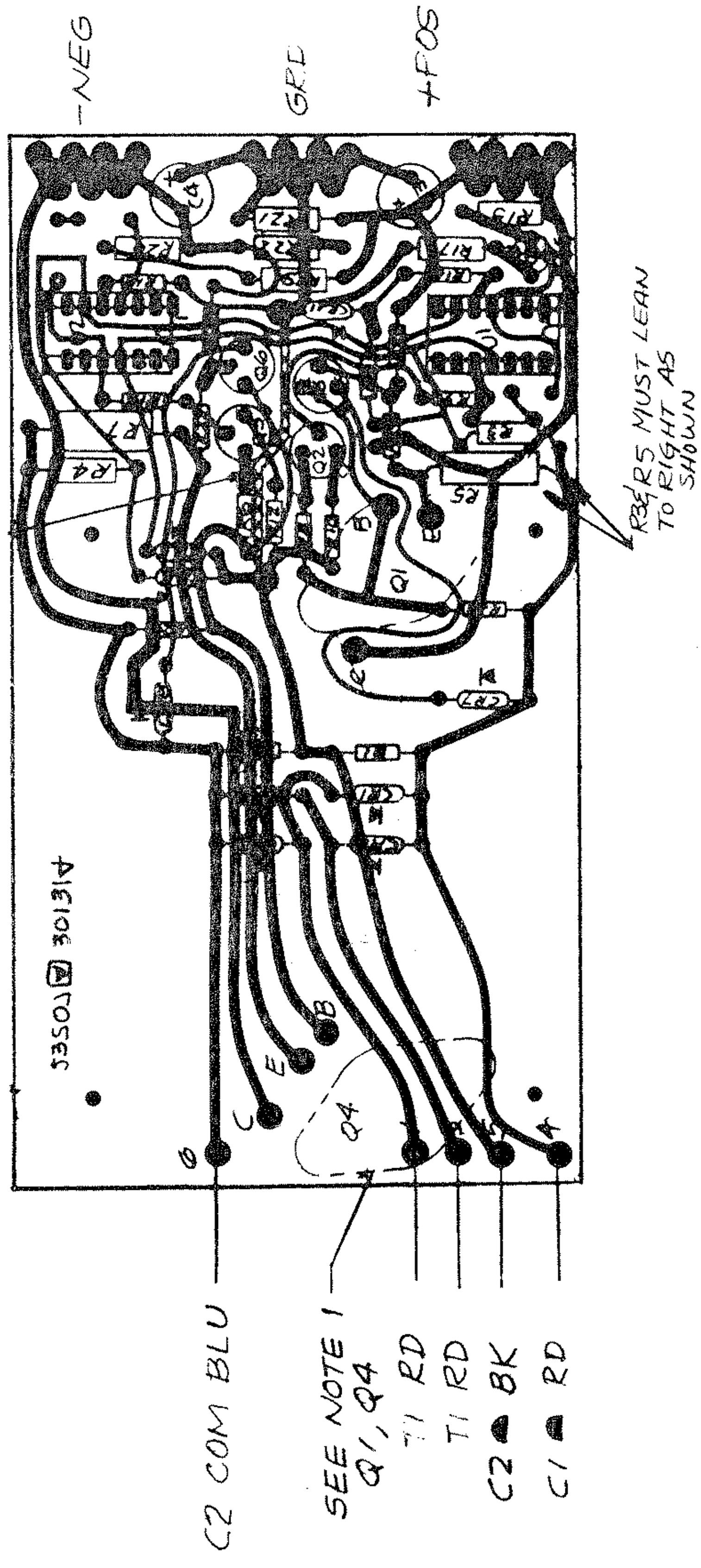


Figure 5-22. Dual Power Supply, Parts Location (Drawing No. 301314F)

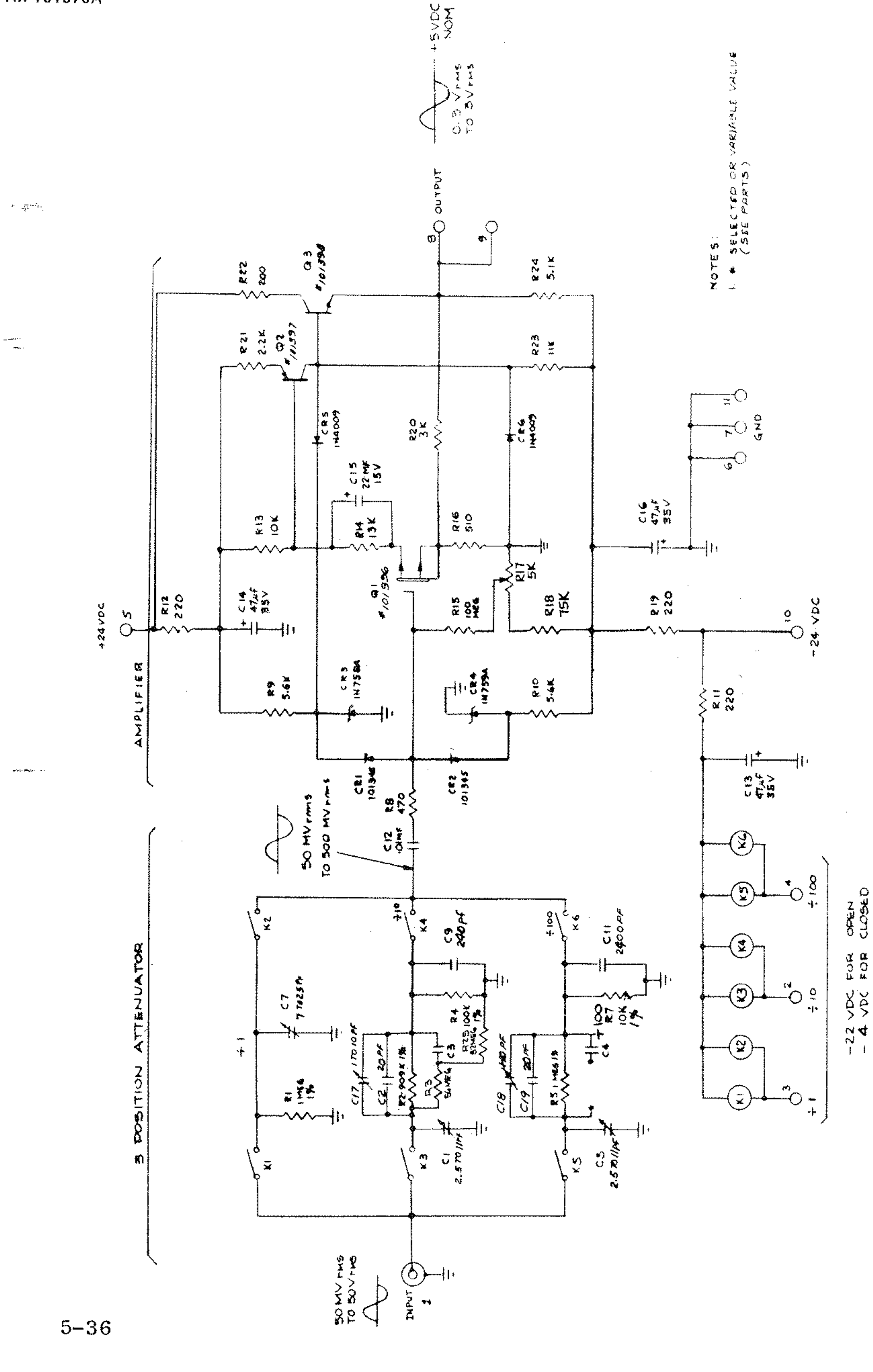


Figure 5-23. Plug-In Model 305-PA-3001 Cards A1 and A2 Input Amplifier, Schematic Diagram (Drawing No. 102619D)

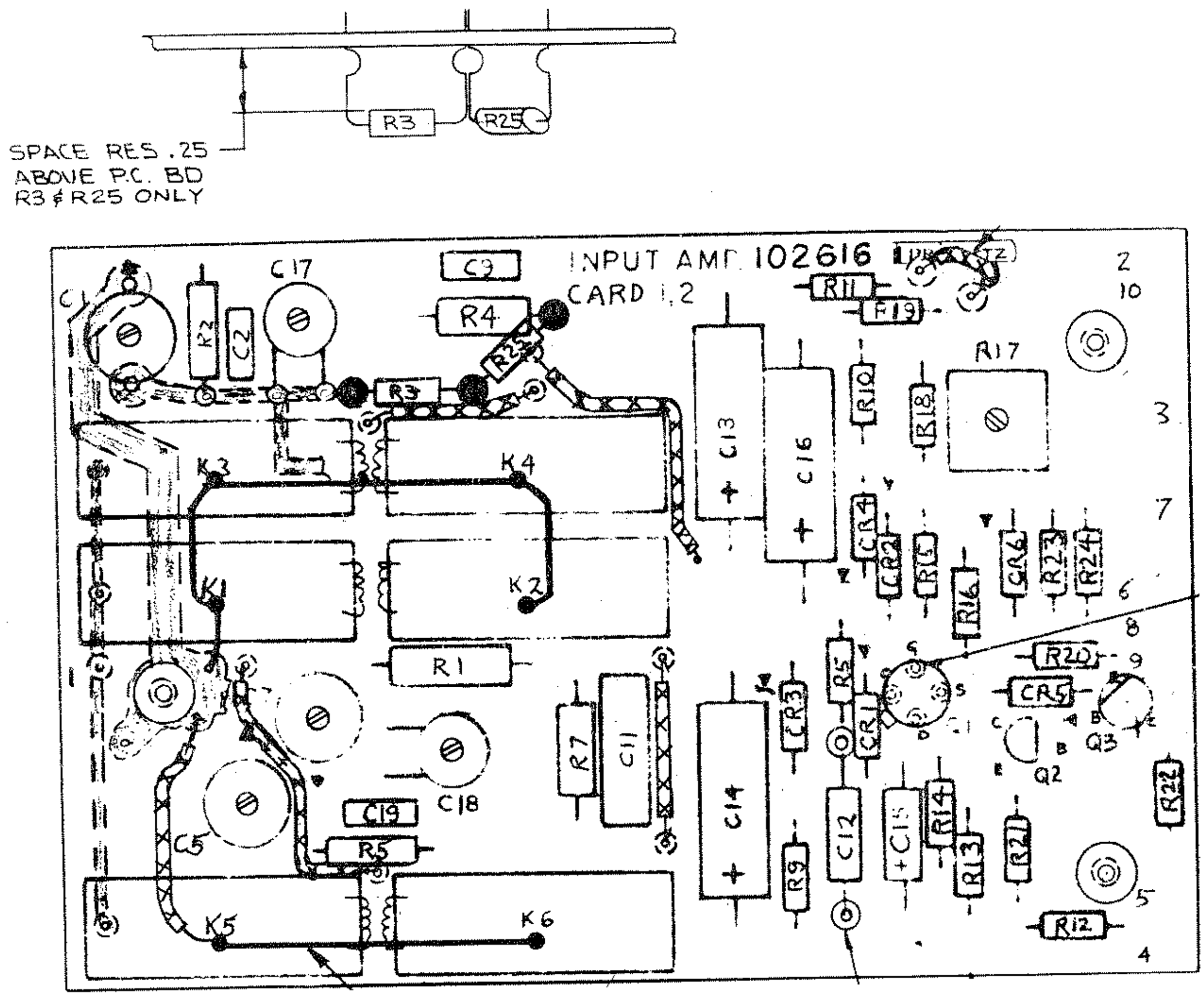


Figure 5-24. Plug-In Model 305-PA-3001 Cards A1 and A2 Input Amplifier, Parts Location (Drawing No. 102616E)

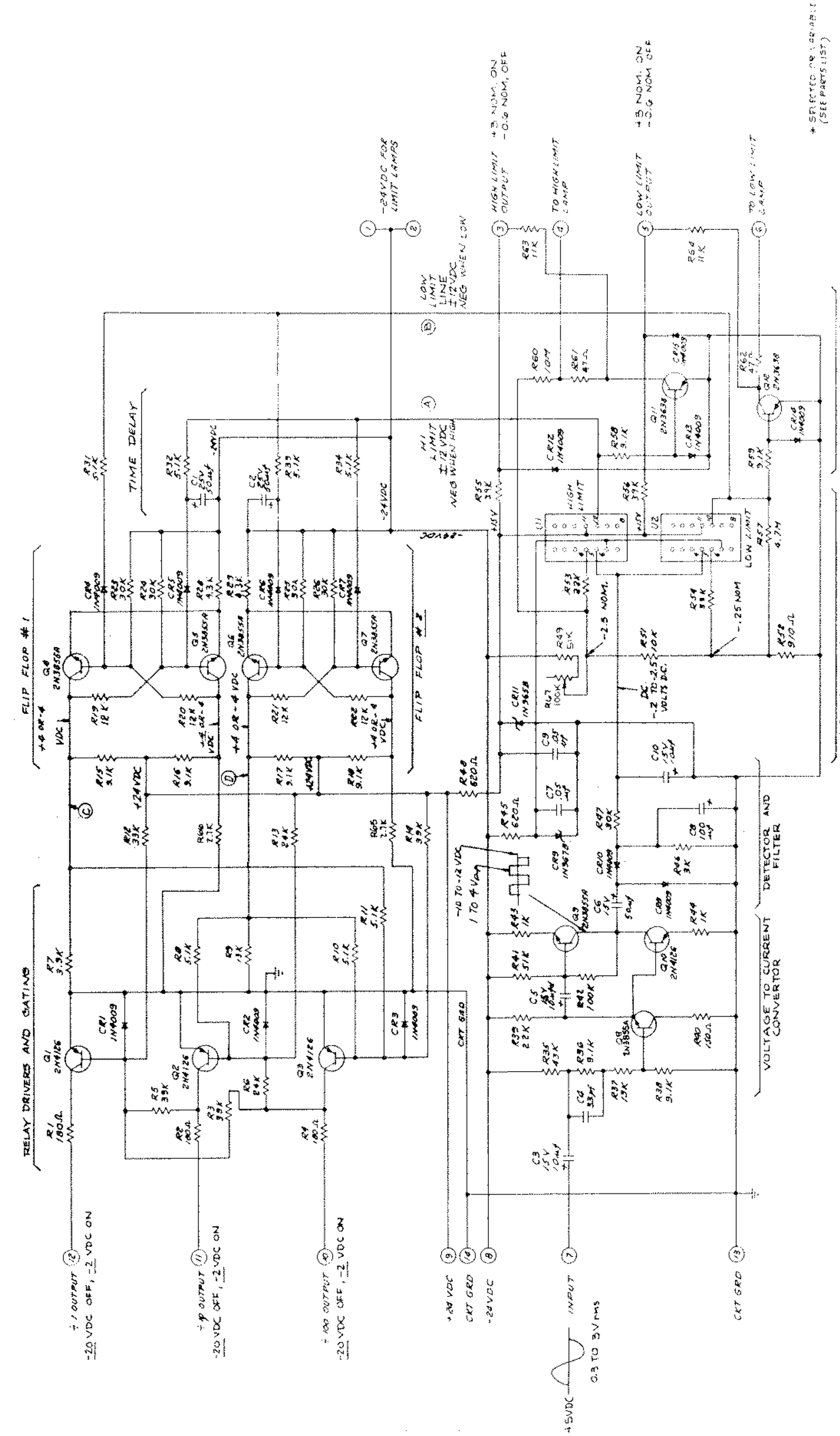


Figure 5-25. Plug-In Model 305-PA-3001 Cards A3 and A4 Auto Level Board, Schematic Diagram (Drawing No. 101358W)

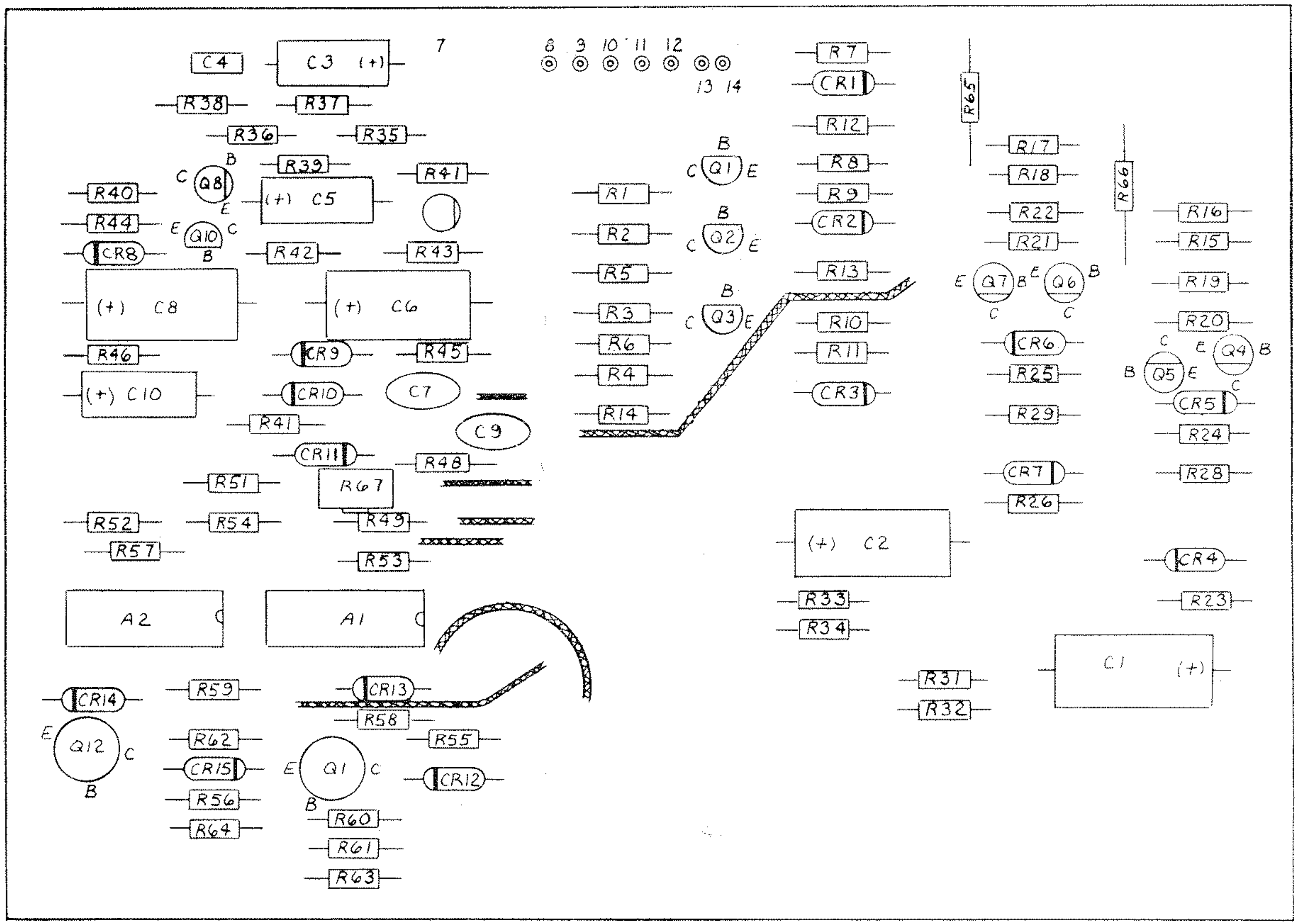


Figure 5-26. Plug-In Model 305-PA-3001 Cards A3 and A4 Auto Level Board, Parts Location (Drawing No. 101359W)

NOTES:
1. ALL RESISTANCE VALUES ARE IN OHMS, ¼W, 5%, UNLESS OTHERWISE NOTED.
2. ALL CAPACITOR VALUES ARE IN MICROFARADS UNLESS OTHERWISE NOTED.
3. * SELECT AT TEST

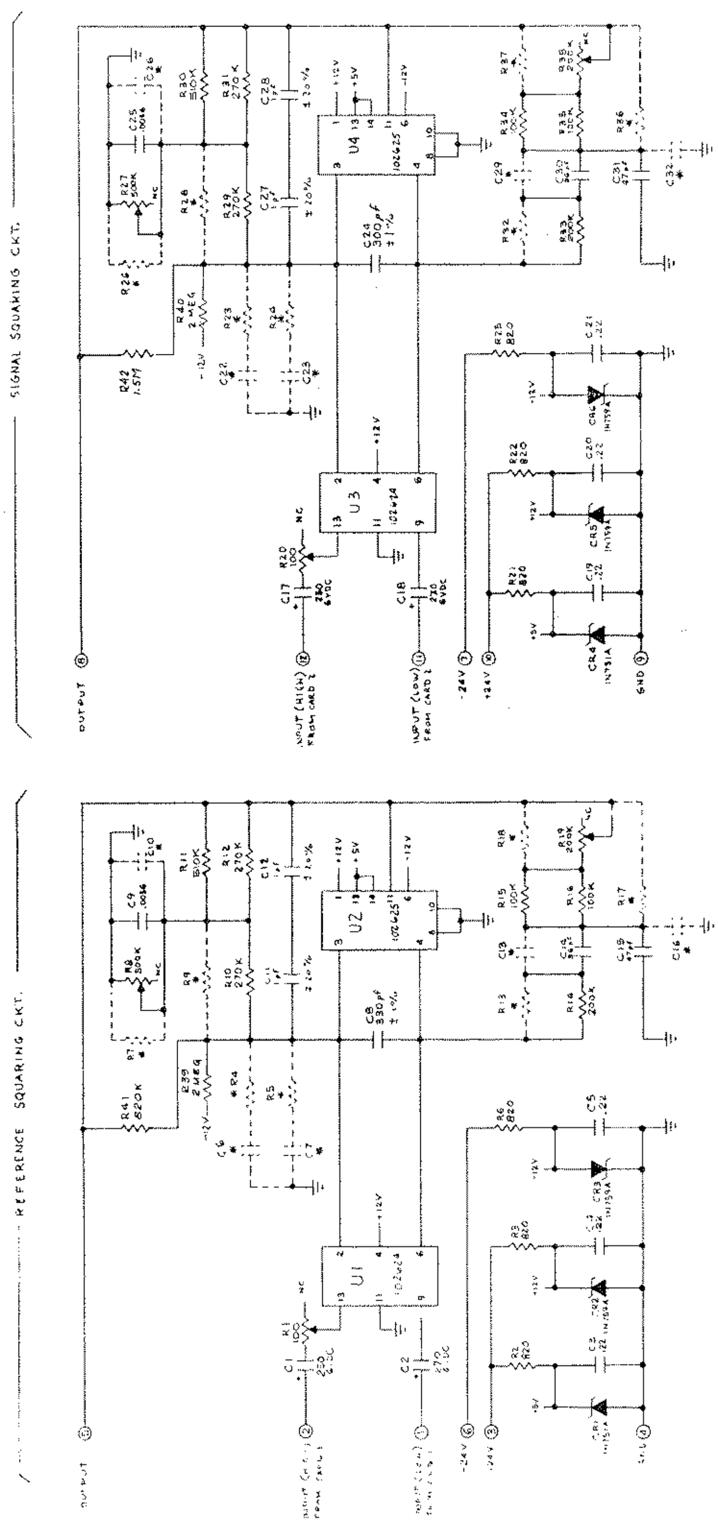


Figure 5-27. Plug-In Models 305-PA-3001 and 305-PA-3002 Card A5 Comparator, Schematic Diagram (Drawing No. 102623E)

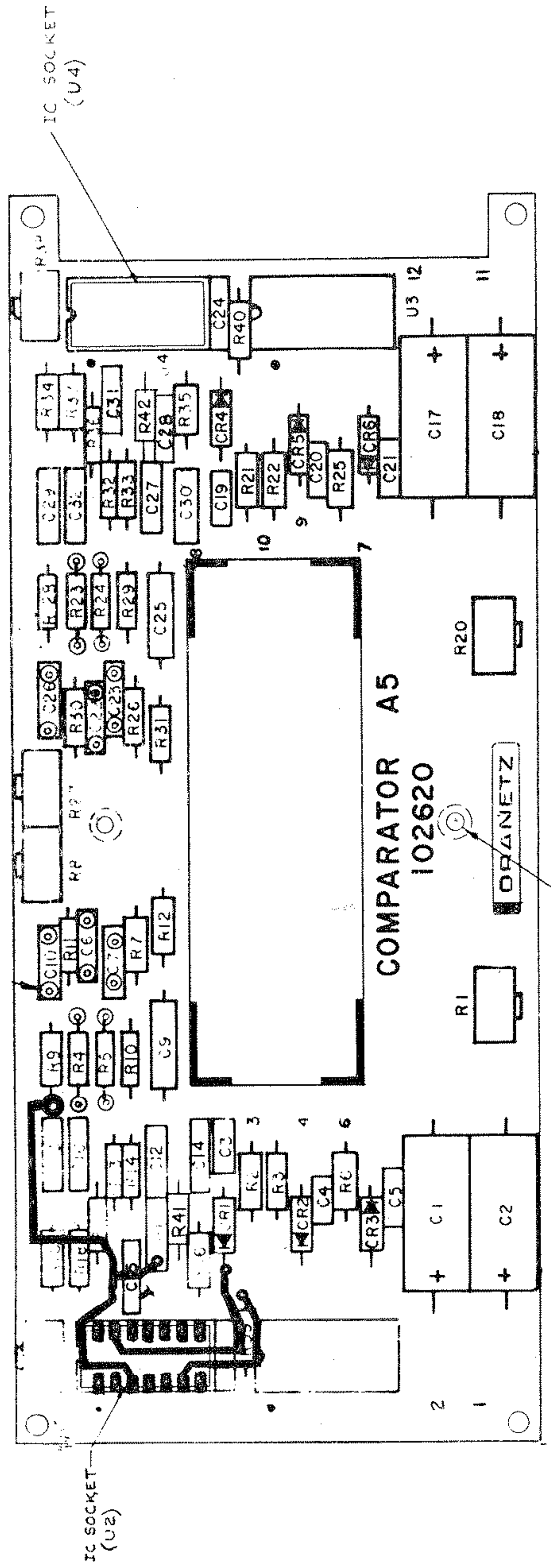


Figure 5-28. Plug-In Models 305-PA-3001 and 305-PA-3002 Card A5 Input Amplifier, Parts Location (Drawing No. 102620D)

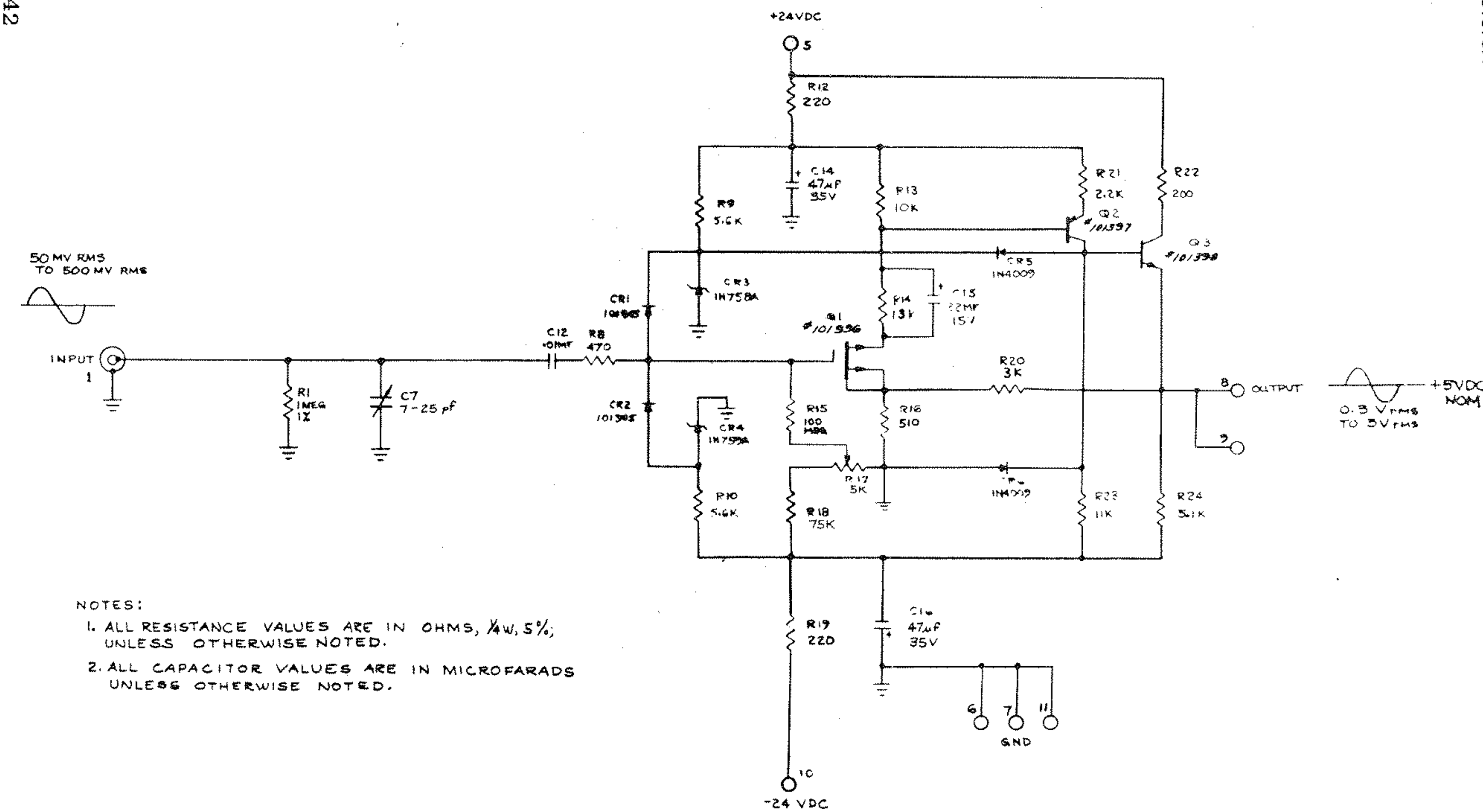


Figure 5-29. Plug-In Model 305-PA-3002 Cards A1 and A2 Input Amplifier, Schematic Diagram (Drawing No. 102842B)

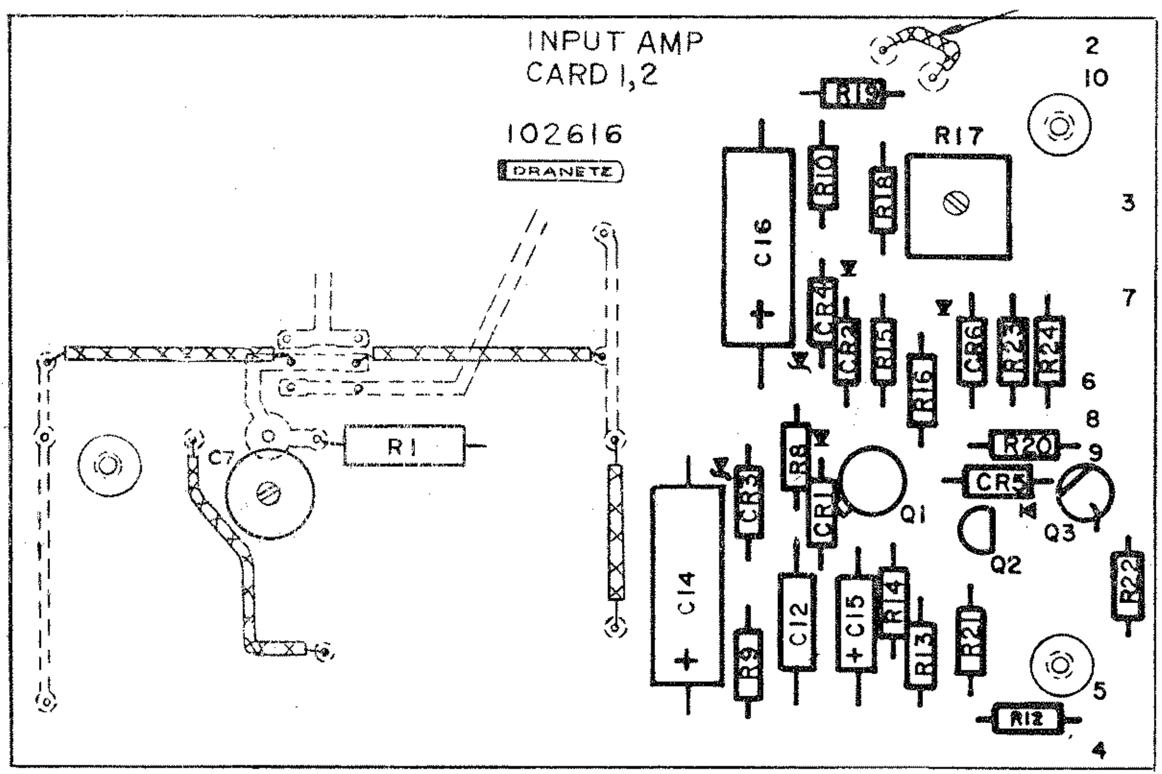


Figure 5-30. Plug-In Model 305-PA-3002 Cards A1 and A2 Input Amplifier, Parts Location (Drawing No. 102841A)

SECTION VI
FULL CALIBRATION PROCEDURE

6-1. GENERAL

6-2. This section describes the calibration adjustments which may be made by the Calibration Laboratory. Note that the sequence of adjustments must be maintained in order that proper alignment be attained. The plug-in should be in place throughout the calibration procedure unless otherwise noted.

6-3. All or part of the calibration procedure may be necessitated by repairs or component replacement in the main frame or plug-in circuits which directly process the phasemeter's two input signals. These circuits are located on Cards 6 (figure 5-14), Card 7 (figure 5-16) and Card 8 (figure 5-18) of the main frame and on Cards 1 and 2 (figure 5-24) and Card 5 (figure 5-28) of the plug-in section.

6-4. EQUIPMENT REQUIRED

a. Broadband Oscillator with low distortion (5 Hz to 500 kHz), General Radio Model 1310A or equivalent.

b. Broadband AC Voltmeter, Ballantine Model 303 or equivalent.

c. Precision dc voltmeter (-1.8 to +3.6 vdc with error ≤ 0.3 mv.) Fluke Model 8300A or equivalent.

d. High Frequency attenuator (100 ohms Z out, 600 ohms Z in; 0, 14, 20, and 40 dB). (See figure 6-2.)

e. 2 Matched Cables (0.04"D pins to BNC, 15 to 20 pf capacity).

f. 1 K ohm ±1% resistor with 0.04"D pin on one end and 40-mil socket on other end.

g. Two-inch calibration adapter wired so both main frame inputs are driven from the Reference Channel.

NOTE

Items d,e,f and g may be purchased as Dranetz Assembly #101,573.

6-5. EQUIPMENT SETUP

a. Connect the equipment as shown in figure 6-1.

b. If the complete procedure is to be performed, it should be done in the order listed below.

6-6. TEST PROCEDURE

6-7. Perform the Main Frame Calibration in accordance with paragraph 3-5.

6-8. Perform the tests in accordance with table 6-1 of this section. If all readings are within specification limits, further calibration is not necessary, and the unit can be placed into operation. If the readings are not within specification limits, remove Main Frame (with Plug-in) from its case to expose top of plug-in and proceed with the steps detailed in the following paragraphs.

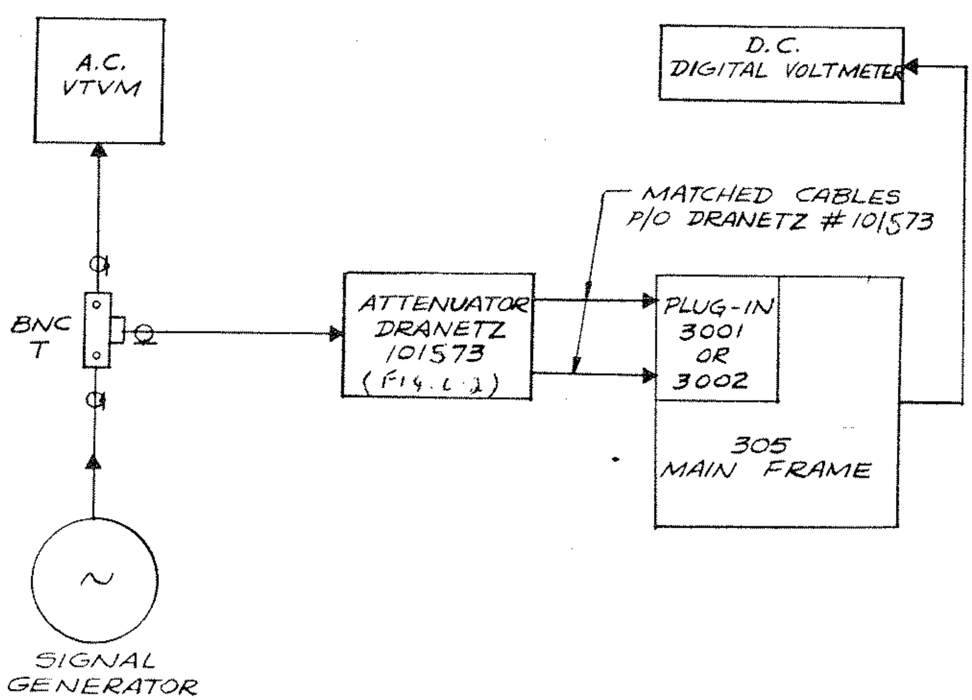


Figure 6-1. Test Circuit

Table 6-1. MAIN FRAME CALIBRATION

Main Frame Type	Plug-in Type	Data Required			
		Figure 6-5	6-6	6-7	6-8
305	305-PA-3001	✓			
305	305-PA-3002			✓	
305B	305-PA-3001	✓	✓		
305B	305-PA-3002			✓	✓
305C	305-PA-3001	✓	✓		
305C	305-PA-3002			✓	✓
305D	305-PA-3001	✓	✓		
305D	305-PA-3002			✓	✓

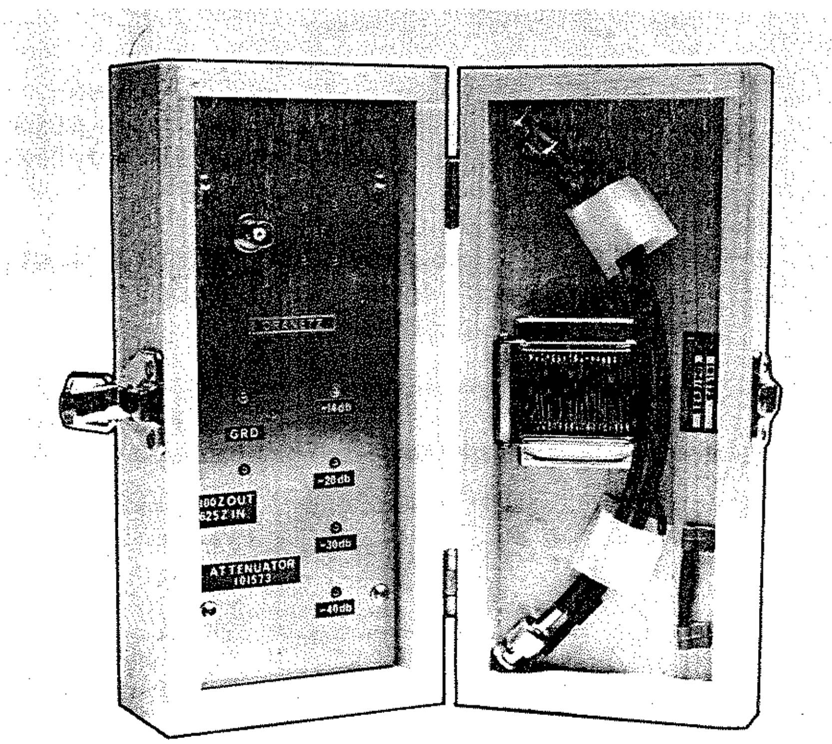


Figure 6-2. High Frequency Attenuator
Dranetz Assembly #101,573

6-9. ADJUSTMENT PROCEDURE FOR OPTION 107 (Card A11)

6-10. If a phasemeter is found to need adjustment according to paragraph 6-8, adjust the auto calibrate circuits of Card A11 as follows before proceding to paragraph 6-11.

a. Install jumper wire or clip lead between two terminals on Card A11 near capacitor C5. See figure 6-3 for terminal locations. Note that main frame calibration must be performed prior to the following adjustments.

b. Install jumper wire or clip lead between two terminals on Card A11 near resistor R67.

c. Set the Automatic Calibration switch to the CAL 0 position and adjust potentiometer R49 for +0.0020 ±0.0001 Vdc on pin 11 of the Card 11 connector. Measure this voltage with the Fluke DVM. Refer to figure 6-3 for potentiometer locations.

d. Set the digital panel meter zero (0) potentiometer for an indication of +000.20 ±0.01 degrees.

e. Set the Automatic Calibrator switch to the CAL F.S. position and adjust potentiometer R47 for 3.6040 ±0.0001 Vdc at pin 11 of the Card 11 connector.

f. Set the digital panel meter full scale (F.S.) potentiometer for an indication of 360.40 ±0.01 degrees.

g. Remove jumpers installed in steps a and b, and perform the automatic calibration sequence described in paragraph 2-14.

6-11. ADJUSTMENT PROCEDURE FOR 305D OFFSET CIRCUITS.

6-12. A calibration of the angle offset circuits is recommended whenever excess error is noted. Perform the calibration as follows:

a. Perform the Main Frame calibration procedure of paragraph 3-5.

b. Set zero and gain on the digital panel meter at zero and +360^{o} calibration points.

c. Place the phasemeter in the Zero Degree check position.

d. With the OPER/ADJ switch in the ADJ position, set COARSE and FINE offset controls for a panel meter reading of 0.00 ±0.02 degrees.

e. Switch to the OPER position. Set null zero potentiometer R15 for a null reading (center scale) on the analog null meter.

NOTE

Remove plug-in for access, potentiometer R15 is on inside surface of opening.

f. Switch to the ADJ position. Set COARSE and FINE offset controls for a panel meter reading of -360.000 ±0.02 degrees.

g. Switch to the OPER position and set the phasemeter in the +360 degree check position.

h. Set null balance potentiometer R13 (located next to R15) for a null reading (center scale) on the analog null meter. This completes the calibration of the Option 104 circuits. Other potentiometers are factory set and should not require resetting.

6-13. ADJUSTMENT PROCEDURE (Model 305-PA-3001 In Main Frame).

Adjust input amplifier bias levels as follows:

a. Connect SIGNAL INPUT to one 0 dB output.

b. Connect REFERENCE INPUT to other 0 dB output.

c. Set oscillator to 1 kHz and signal level to zero.

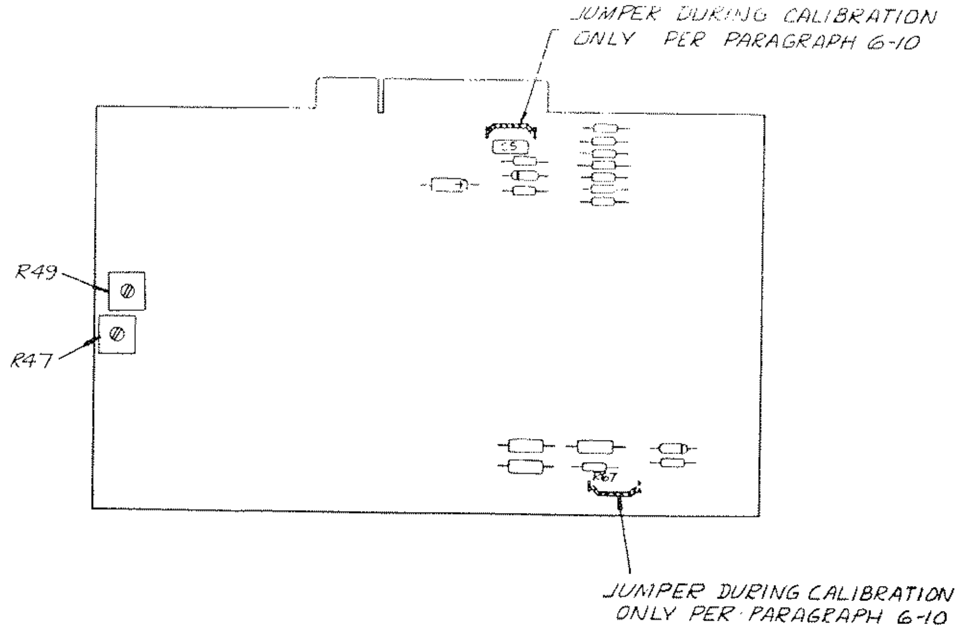
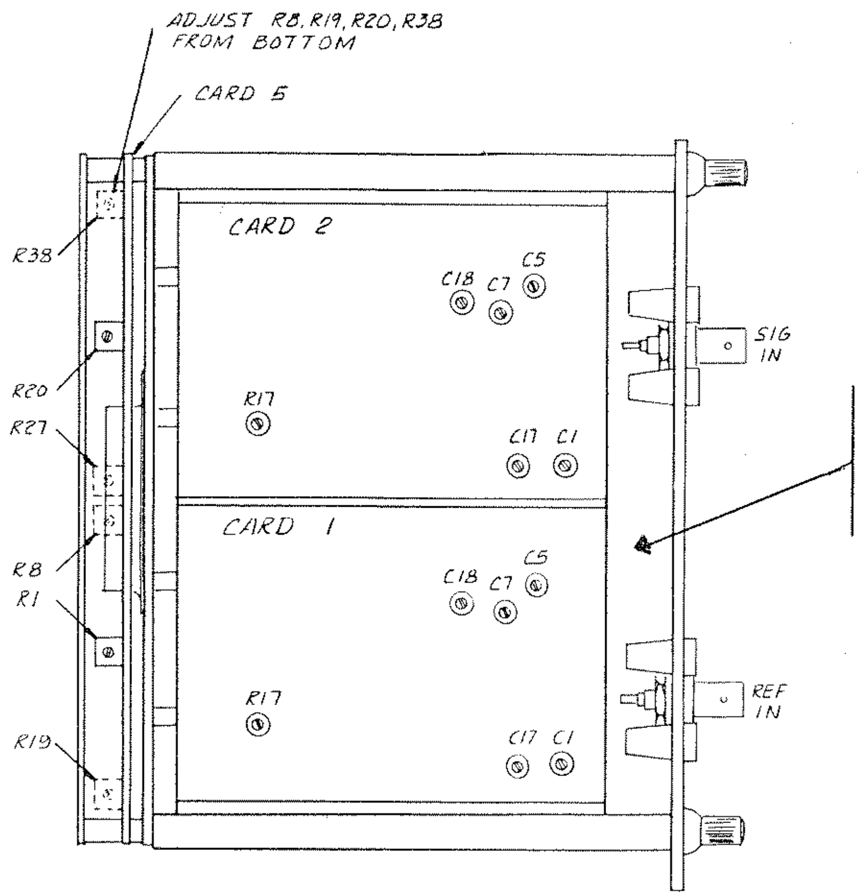


Figure 6-3. Adjustment and Terminal Identification for Assembly No. 102524



CARDS 3 & 4 ARE LOCATED BELOW CARDS 1 & 2. CARD 3 IS UPPER, CARD 4 IS LOWER.

Figure 6-4. Plug-in Adjustment Identification

Note

See figure 6-4 for Plug-in adjustment identification.

d. Disconnect pin 8 on cards 1 and 2. The low limit lamps should light. Increase input level until clipping on the outputs (pin 8) is observed.

e. Adjust bias potentiometers R17 on cards 1 and 2 for symmetrical clipping.

f. Reduce input level to the point just below clipping (maximum undistorted output). The level read on the VTVM should be greater than 550 mv.

g. Replace wires to pin 8 on cards 1 and 2.

6-14. Adjust Auto Level Switching Point as follows:

a. Connect SIGNAL INPUT to one 0 dB output.

b. Connect REFERENCE INPUT to other 0 dB output.

c. Set oscillator to 1 kHz and signal level to zero.

d. Increase oscillator output level slowly and note points at which the high limit lamps blink. This indicates upranging from the ÷1 attenuator range to the ÷10 range. Adjust R67 potentiometer on plug-in card A3 so that up ranging takes place between 470 and 490 mv RMS on the REFERENCE channel. Adjust R67 potentiometer on card A4 so that up ranging takes place between 470 and 490 mv RMS on the SIGNAL channel.

6-15. Adjust plug-in input capacitance as follows:

a. Connect SIGNAL INPUT to one 0 dB output.

b. Connect REFERENCE INPUT to other 0 dB output.

c. Set oscillator output to 100 mv rms at 500 kHz.

d. Note phase reading (dc meter reading).

e. Add 1K ohm resistor in series with the signal input (between cable and assembly no. 101573).

f. Adjust signal channel (C7 on card 2) input capacitor for a phase difference of 12.0 ±0.1 degrees (120 mv ±1 mv) from the value noted in step d.

NOTE

If it is not possible to set 12.0 degrees in any step, change the oscillator frequency until it is possible and repeat all steps starting with step f. Units having option 101 are set to 20.0 (200 mv) degrees due to the increased input capacitance inherent with this option.

g. Change the 1K ohm resistor to the REFERENCE INPUT.

h. Adjust reference channel input capacitor (C7 on card 1) for a phase difference of 12.0 ±0.1 degrees from the value noted in step d. Remove 1K ohm series resistor.

i. Connect SIGNAL INPUT to one 0 dB output and REFERENCE INPUT to other 0 dB output.

j. Set oscillator output to 1.0 volt rms at 500 kHz.

k. Note phase reading.

l. Add 1K ohm resistor in series with the signal input.

m. Adjust signal channel 20 dB attenuator input capacitor (C1 on card 2) for a phase difference of 12.0 ±0.1 degrees from the value noted in step k.

n. Change the 1K ohm resistor to the reference input.

o. Adjust reference channel 20 dB attenuator input capacitor (C1 on card 1) for a phase difference of 12.0 ±0.1 degrees from the value noted in step k. Remove 1K ohm series resistor.

p. Set oscillator output to 10 volts rms at 500 kHz.

q. Note phase reading.

r. Add 1K ohm resistor in series with the signal input.

s. Adjust signal channel 40 dB attenuator input capacitor (C5 on card 2) for a phase difference of 12.0 ±0.1 degrees from the value noted in step q.

t. Change the 1K ohm resistor to the reference input.

u. Adjust reference channel 40 dB attenuator input capacitor (C5 on card 1) for a phase difference of 12.0 ±0.1 degrees from the value noted in step q. Remove 1K ohm series resistor.

6-16. Set main frame high frequency response as follows:

a. Connect calibration adapter between main frame and plug-in.

b. Connect both inputs to the 0 dB attenuator outputs.

c. Set oscillator output to 250 mv rms at 100 kHz.

d. Set both R36 on card 6 and R28 on card 8 of the main frame fully counterclockwise.

e. Adjust either R36 on card 6 or R28 on card 8 for a zero degree phase reading. Remove calibration adapter.

6-17. Set plug-in frequency response to match main frame as follows:

NOTE

This adjustment should be performed when a new plug-in is installed in the main frame.

a. Connect both inputs to the 0 dB attenuator outputs.

b. Set oscillator output to 100 mv rms at 50 kHz.

c. Adjust either R1 or R20 on card 5 for a zero degree phase reading.

6-18. Adjust for level sensitivity as follows:

a. Set oscillator output to 250 mv rms.

b. Connect one 0 dB output of the attenuator to the SIGNAL INPUT.

c. Connect -14 dB output to the REFERENCE INPUT.

d. Adjust R19 on card 5 of plug-in for minimum phase error in the 10 kHz to 50 kHz frequency range.

e. Adjust R8 on card 5 of plug-in for minimum phase error in the 50 Hz to 250 Hz frequency range.

f. Connect the REFERENCE INPUT to the 0 dB output and the SIGNAL INPUT to the -14 dB output.

g. Adjust R38 on card 5 of plug-in for minimum phase error in the 10 kHz to 50 kHz frequency range.

h. Adjust R27 on card 5 of plug-in for minimum phase error in the 50 Hz to 250 Hz frequency range.

6-19. Phase match plug-in input attenuators as follows:

a. Run line #1 on data sheets of figures 6-5 and 6-6. This data will be used as a standard for attenuator phase adjustments which follow. When setting the attenuator phase shifts, they should be matched to the numbers on line #1 rather than set to the ideal value of zero degrees. This method assures that the attenuators will match each other as well as matching the direct input run of line #1.

b. Set oscillator and connect attenuator in accordance with line #2 of data sheets.

c. Set phase shift of reference channel 20 dB attenuator by adjusting C17 on card 1 for minimum deviation from line #1 at 5 kHz.

d. Run line #2 on data sheets of figure 6-5 and 6-6 (dc output and digital panel meter reading).

LINE #	OSCILLATOR OUTPUT LEVEL	ATTENUATOR CONNECTORS		Ø ERROR IN DEGREES AT TEST FREQUENCIES OF (DC METER READING)					
	V RMS	REFERENCE	SIGNAL	5 Hz	50 Hz	500 Hz	5 kHz	50 kHz	500 kHz
1	0.1	0 dB	0 dB	1.5	.8	-.1	-.4	-3.6	-22.8
2	1.0	0 dB	-20 dB	-6.9	-2.6	-2.4	-.3	-2.8	-11.2
3	1.0	-20 dB	0 dB				-4.2		
4	1.0	0 dB	0 dB						
5	10.0	0 dB	-40 dB						
6	10.0	-40 dB	0 dB						
7	10.0	0 dB	0 dB						
8	TOLERANCE LIMITS* →			±1.03°	±0.08°	±0.08°	±0.08°	±0.08°	±1.03°

*TOLERANCE LIMITS INCLUDE ±0.03° (±0.3 MV) FOR D.C. DIGITAL VOLTMETER. IF ACCURACY OF VOLTMETER IS SIGNIFICANTLY BETTER THAN ±0.3 MV. THIS EXTRA ±0.03° SHOULD BE SUBTRACTED FROM EACH TOLERANCE LISTED.

Figure 6-5. Test Data Sheet With DC Meter Readings

e. Set up for data sheets lines #3.

f. Set phase shift of signal channel 20 dB attenuator by adjusting C17 on card 2 for minimum deviation from line #1 at 5 kHz.

g. Run line #3 on data sheets of figure 6-5 and 6-6.

h. Run line #4 on data sheets. If any points are out of tolerance, slightly change the setting of C17 on either card 1 or 2. If any adjustment is required in this step, tests of lines 2 and 3 must be repeated.

i. Set up for line #5 of data sheets.

j. Set phase shift of reference channel 40 dB attenuator by adjusting C18 on card 1 to match line #1 at 5 kHz.

k. Run line #5 on data sheets.

l. Set up for data sheets lines #6.

LINE #	OSCILLATOR OUTPUT LEVEL	ATTENUATOR CONNECTOR		Ø ERROR IN DEGREES AT TEST FREQUENCIES OF (DIGITAL PANEL METER)					
	V RMS	REFERENCE	SIGNAL	5 Hz	50 Hz	500 Hz	5 kHz	50 kHz	500 kHz
1	0.1	0 dB	0 dB						
2	1.0	0 dB	-20 dB						
3	1.0	-20 dB	0 dB						
4	1.0	0 dB	0 dB						
5	10.0	0 dB	-40 dB						
6	10.0	-40 dB	0 dB						
7	10.0	0 dB	0 dB						
8	TOLERANCE LIMITS								
	305B			$\pm 1.2^{\circ}$	$\pm 0.2^{\circ}$	$\pm 0.2^{\circ}$	$\pm 0.2^{\circ}$	$\pm 0.2^{\circ}$	$\pm 1.2^{\circ}$
	305C AND 305D			$\pm 1.00^{\circ}$	$\pm 0.05^{\circ}$	$\pm 0.05^{\circ}$	$\pm 0.05^{\circ}$	$\pm 0.5^{\circ}$	$\pm 1.00^{\circ}$

Figure 6-6. Test Data Sheet With Digital Panel Meter Readings

m. Set phase shift of signal channel 40 dB attenuator by adjusting C18 on card 2 to match line #1 at 5 kHz.

n. Run line #6 on data sheets.

o. Run data sheets lines #7. If any points are out of tolerance, slightly change the setting of C18 on either card 1 or 2. If any adjustment is required in this step, tests of lines 5 and 6 must be repeated.

6-20. ADJUSTMENT PROCEDURE (305-PA-3002 In Main Frame).

Adjust input amplifier bias levels as follows:

a. Connect SIGNAL INPUT to one 0 dB output.

b. Connect REFERENCE INPUT to other 0 dB output.

c. Set oscillator to 1 kHz and signal level to zero.

d. Increase input level until clipping on the outputs (pin 8) is observed.

e. Adjust bias potentiometers R17 on cards 1 and 2 for symmetrical clipping.

f. Reduce input level to the point just below clipping (maximum undistroted output). The level read on the VTVM should be greater than 550 mv.

6-21. Adjust plug-in input capacitance as follows:

a. Connect SIGNAL INPUT to one 0 dB output.

b. Connect REFERENCE INPUT to other 0 dB output.

c. Set oscillator output to 100 mv rms at 500 kHz.

d. Note phase reading (dc meter reading).

e. Add 1K ohm resistor in series with the signal input (between cable and assembly no. 101573).

f. Adjust signal channel (C7 on card 2) input capacitor for a phase difference of 12.0 ±0.1 degrees (120 mv ±1 mv) from the value noted in step d.

NOTE

If it is not possible to set 12.0 degrees in any step, change the oscillator frequency until it is possible and repeat all steps starting with step f. Units having option 101 are set to 20.0 (200 mv) degrees due to the increased input capacitance inherent with this option.

g. Change the 1K ohm resistor to the REFERENCE INPUT.

h. Adjust reference channel input capacitor (C7 on card 1) for a phase difference of 12.0 ±0.1 degrees from the value noted in step d. Remove 1K ohm series resistor.

6-22. Set main frame high frequency response as follows:

a. Connect calibration adapter between main frame and plug-in.

b. Connect both inputs to the 0 dB attenuator outputs.

c. Set oscillator output to 250 mv rms at 100 kHz.

d. Set both R36 on card 6 and R28 on card 8 of the main frame fully counterclockwise.

e. Adjust either R36 on card 6 or R28 on card 8 for a zero degree phase reading. Remove calibration adapter.

6-23. Set plug-in frequency response to match main frame as follows:

NOTE

This adjustment should be performed when a new plug-in is installed in the main frame.

a. Connect both inputs to the 0 dB attenuator outputs.

b. Set oscillator output to 100 mv rms at 50 kHz.

c. Adjust either R1 or R20 on card 5 for a zero degree phase reading.

6-24. Adjust for level sensitivity as follows:

a. Set oscillator output to 250 mv rms.

b. Connect one 0 dB output of the attenuator to the SIGNAL INPUT.

c. Connect -14 dB output to the REFERENCE INPUT.

d. Adjust R19 on card 5 of plug-in for minimum phase error in the 10 kHz to 50 kHz frequency range.

e. Adjust R8 on card 5 of plug-in for minimum phase error in the 50 Hz to 250 Hz frequency range.

f. Connect the REFERENCE INPUT to the 0 dB output and the SIGNAL INPUT to the -14 dB output.

g. Adjust R38 on card 5 of plug-in for minimum phase error in the 10 kHz to 50 kHz frequency range.

h. Adjust R27 on card 5 of plug-in for minimum phase error in the 50 Hz to 250 Hz frequency range.

6-25. If unit under calibration is in a Model 305 Main Frame, run data sheet of figure 6-7. If unit under calibration is in a Model 305B, C or D Main Frame, run data sheets of figures 6-7 and 6-8. All data should be within limits specified.

LINE #	OSCILLATOR OUTPUT LEVEL	ATTENUATOR CONNECTORS		Ø ERROR IN DEGREES AT TEST FREQUENCIES OF (DC METER READING)					
	V RMS	REFERENCE	SIGNAL	5 Hz	50 Hz	500 Hz	5 kHz	50 kHz	500 kHz
1	0.1	0 dB	0 dB						
2	0.5	0 dB	0 dB						
3	0.25	-14 dB	0 dB						
4	0.25	0 dB	-14 dB						
5									
6									
7									
8	TOLERANCE LIMITS*			±1.03°	±0.08°	±0.08°	±0.08°	±0.08°	±1.03°

*TOLERANCE LIMITS INCLUDE ±0.03° (±0.3 MV) FOR D.C. DIGITAL VOLTMETER. IF ACCURACY OF VOLTMETER IS SIGNIFICANTLY BETTER THAN ±0.3 MV. THIS EXTRA ±0.03° SHOULD BE SUBTRACTED FROM EACH TOLERANCE LISTED.

Figure 6-7. Test Data Sheet with DC Meter Reading

LINE #	OSCILLATOR OUTPUT LEVEL	ATTENUATOR CONNECTOR		Ø ERROR IN DEGREES AT TEST FREQUENCIES OF (DIGITAL PANEL METER)					
	V RMS	REFERENCE	SIGNAL	5 Hz	50 Hz	500 Hz	5 kHz	50 kHz	500 kHz
1	0.1	0 dB	0 dB						
2	0.5	0 dB	0 dB						
3	0.25	-14 dB	0 dB						
4	0.25	0 dB	-14 dB						
5									
6									
7									
8	TOLERANCE LIMITS								
	305B			±1.2°	±0.2°	±0.2°	±0.2°	±0.2°	±1.2°
	305C AND 305D			±1.00°	±0.05°	±0.05°	±0.05°	±0.05°	±1.00°

Figure 6-8. Test Data Sheet with Digital Panel Meter Reading

SECTION VII

REPLACEABLE PARTS LIST

7-1. GENERAL

7-2. This section contains the maintenance parts list for Phasemeter Model 305, 305B, 305C, and 305D with Plug-In Models 305-PA-3001 and 305-PA-3002. The list provides the part number, description, reference designator, and manufacturer. The following table identifies the manufacturer by the manufacturer's code list

CODE	MANUFACTURER'S NAME AND ADDRESS
00779	AMP, Incorporated P.O. Box 3608 Harrisburg, Penna. 17105
01002	General Electric Company Industrial and Power Capacitor Dept. Hudson Falls, New York
01295	Texas Instrument, Inc. Semicoductor Components Division 13500 North Central Expressway Dallas, Texas 72531
02660	Amphenol Connector Division Chicago, Illinois
03508	General Electric Semiconductor Syracuse, N.Y. 13201
04713	Motorola Semiconductor Products 5805 East McDowell Road Phoenix, Arizona 85008
07263	Fairchild Semiconductor 464 Ellis Street Mountain View, Calif. 94040
09023	Cornell Dubilier Electronics Div. Federal Pacific Electric Company 2562 Dalrymple Sanford, N.C. 27330
09353	C & K Components, Inc. 163 Morse Street Westrum, Mass. 02172

CODE	MANUFACTURER'S NAME AND ADDRESS
12040	National Semiconductor Corp. P.O. Box 443 Danbury, Connecticut 06810
18736	Voltronics Corp. Hanover, New Jersey 07936
23207	Dranetz Engineering Laboratories, Inc. 2385 South Clinton Avenue South Plainfield, N.J. 07080
23936	Pamotor Inc. Burligame, Calif.
32539	Mura Corporation 355 Great Neck Road Great Neck, N.Y. 11021
44655	Ohmite Mfg. Company 3601 West Howard Street Skokie, Ill. 60076
54453	Sullins San Marcos, Calif.
70903	Belden Manufacturing Co. Chicago, Ill. 60644
71400	Busmann Mfg. Division of McGraw Edison Company 2536 West University Street St. Louis, Missouri 63017
71468	ITT Cannon Electric Company 655 East Dyer Road Santa Ana, Calif. 92702
71590	Centralab Electronics Division of Globe-Union Inc. 5757 North Greenbay Avenue Milwaukee, Wisconsin 53201
73138	Beckman Instruments Inc. Helipot Division 2500 Harbor Blvd. Fullerton, Calif. 92634
78290	Struthers-Dunn Inc. Pitman, N.J. 08071
80183	Sprague Products Company North Adams, Mass.

CODE	MANUFACTURER'S NAME AND ADDRESS
80294	Bourns, Inc. 1200 Columbia Avenue Riverside, Calif. 92507
81312	Winchester Electronics Division of Litton Industries Oakville, Conn.
81349	On MIL Spec List. Manufactured to meet Military Specifications. Available from a variety of suppliers.
81413	Elmenco-Arco Electronics Community Drive Great Neck, N.Y. 11022
82389	Switchcraft, Inc. 5555 North Elston Avenue Chicago, Ill. 60630
83330	Herman H. Smith, Inc. 812 Snediker Avenue Brooklyn, N.Y. 11207
86694	RCA Electronic Components 415 South 5th Street Harrison, N.J. 07029
87930	Tower Manufacturing Corporation 158 Pine Street Providence, R.I. 92903
94145	Raytheon Co. Quincy, Mass.

REPLACEABLE PARTS LIST

MAIN FRAME		PHASEMETER MODELS 305, 305B, AND 305C	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
BL1	SU2A5	23936	FAN
C5	192P22292	80183	CAPACITOR, 0.0022 uF ±10%, 200V
F1 (230V)	103282-G4	23207	FUSE, 1/2 AMP
F1 (115V)	103282-G5	23207	FUSE, 3/4 AMP
XA1-XA8	67054-4	00779	CONNECTOR, PC DUAL 15 PIN
XF1	HKP	71400	FUSE HOLDER
I1, I2	L-28/40 RLCW	32539	LAMP WITH ROUND WHITE LENS CAP
J1	H1061	87930	RECEPTACLE, AC
J2,J3	DB25S	71468	CONNECTOR
J6	57-10-360	00779	CONNECTOR
J7,J8	31-102-1050	00779	CONNECTOR, BNC
R1	78SR500KBW	73138	POTENTIOMETER, 500K
R2	78SR2KBW	73138	POTENTIOMETER, 2K
R3	785R500Ω BW	73138	POTENTIOMETER, 500 OHMS
R6	RCR07G110J	81349	RESISTOR, 11 OHMS ±5%, 1/4W
R7	RCR07G910J	81349	RESISTOR, 91 OHMS ±5%, 1/4W
S1,S4,S7	7201	09353	SWITCH, DPDT
S2	7401	09353	SWITCH, 4PDT
S3	7105	09353	SWITCH, SPDT
S5	46206LFR	82389	SWITCH, SLIDE
	17258	70903	LINE CORD, POWER
	CB1 PC BOARD (ASSY NO. 101317)		
C1,C4	CS13F226K	81349	CAPACITOR, FIXED, TANTALUM, 22 uF ±10%, 35V
C2,C3	TGS-50	80183	CAPACITOR, DISC, CERAMIC, .05 uF, 100V

REPLACEABLE PARTS LIST

MAIN FRAME		PHASEMETER MODELS 305, 305B, AND 305C	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
	MODEL 305B ONLY		
J4	DB25S	71468	CONNECTOR
J5A,J5B	ISM15DREH	54453	CONNECTOR, PC, DUAL 15 PIN
M1	101373	23207	DIGITAL PANEL METER
	MODEL 305C ONLY		
J4	DB25S	71468	CONNECTOR
J5A	ISM10DREH	54453	CONNECTOR, PC, DUAL 15 PIN
J5B	ISM15DREH	54453	CONNECTOR, PC
M1	101749	23207	DIGITAL PANEL METER
R100	RCR07G271J	81349	RESISTOR, CARBON, 270 OHMS, 1/4W

REPLACEABLE PARTS LIST

MAIN FRAME	PHASEMETER MODEL 305D		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
	NOTE THE REPLACEABLE PARTS INCLUDE MODEL 305C PLUS THE FOLLOWING:		
A10	102222	23207	PC BOARD, OFFSET NULL
M2	103246	23207	METER, 100-0-100 MICROAMP (DIAL FROM MMI-NULL-A)
P10	BDJ15S0	81312	CONNECTOR, PC
R10	7276R10K-L.5	73138	POTENTIOMETER, 10K
R11	RV4SAYSD101A	73138	POTENTIOMETER, 100 OHMS
R12	RN60C3742F	81349	RESISTOR, PRECISION, 37.4K
R13	78SR500	73138	POTENTIOMETER, 500 OHMS
R14	RN60C3742F	81349	RESISTOR, PRECISION, 37.4K
R15	78SR20K	73138	POTENTIOMETER, 20K
S5	7201	09353	SWITCH, TOGGLE
	70-2-2G	94145	KNOB

REPLACEABLE PARTS LIST

A1 AND A3 MAIN FRAME	INHIBIT CIRCUITS (ASSY NO. 101668)		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
A1,A2	101660	23207	MODULE, DELAY SELECTOR
C1	DM15-470J	81413	CAPACITOR, 47 pF ±5%, 500V
C2	DM15-360J	81413	CAPACITOR, 36 pF ±5%, 500V
CR1,CR2	1N751A	81349	DIODE
Q1,Q4	103285	23207	TRANSISTOR
Q2,Q3,Q5,Q6	2N3855A	03508	TRANSISTOR
			NOTE: UNLESS OTHERWISE NOTED, ALL RESISTORS ARE ±5%, 1/4W
R1,R2	RCR07G912J	81349	RESISTOR, 9.1K
R3	RCR07G513J	81349	RESISTOR, 51K
R4	RCR07G683J	81349	RESISTOR, 68K
R5	RCR07G623J	81349	RESISTOR, 62K
R6	RCR07G753J	81349	RESISTOR, 75K
R7,R9	RCR07G242J	81349	RESISTOR, 2.4K
R8,R10	RCR07G103J	81349	RESISTOR, 10K
R11	RCR07G204J	81349	RESISTOR, 200K
R12	RCR07G624J	81349	RESISTOR, 620K
R13,R14	RCR07G303J	81349	RESISTOR, 30K
	MOD 14, ASSY NO. 102572		
	SAME AS ASSY 101668, EXCEPT FOR THE FOLLOWING:		
C3,C4	CS13F394K	81349	CAPACITOR, .39 uF ±10%, 35V
Q7,Q8	103285	23207	TRANSISTOR
R15,R16	RCR07G103J	81349	RESISTOR, 10K, 5%, 1/4W

REPLACEABLE PARTS LIST

A2 MAIN FRAME		FREQUENCY RANGING CIRCUITS (ASSY NO. 101319-G1)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
U1-U4	SN72741J	01295	INTEGRATED CKT
C1,C7	CS13F105K	81349	CAPACITOR, 1 uF ±10%, 35V
C2	CS13F565K	81349	CAPACITOR, 5.6 uF ±10%, 35V
C3	192P68292	80183	CAPACITOR, 0.0068 uF ±10%, 200V
C4	CS13F684K	81349	CAPACITOR, 0.68 uF ±10%, 35V
C5	DM15-681J	81413	CAPACITOR, 680 pF, 100V
C6	192P68392	80183	CAPACITOR, .0680 uF ±10%, 200V
C8	CS13E225K	81349	CAPACITOR, 2.2 uF ±10%, 20V
C9,C10	TGS-50	80183	CAPACITOR, 0.05 uF ±20%, 100V
CR1,CR3-CR10	1N4009	81349	DIODE
CR2	1N755A	81349	ZENER DIODE, 7.5V
CR11,CR12	1N965B	81349	ZENER DIODE, 15V
R1,R5,R7	RCR07G303J	81349	RESISTOR, 30K
R2,R4,R6	RCR07G103J	81349	RESISTOR, 10K
R3	RCR07G181J	81349	RESISTOR, 180 OHMS
R8	RCR07G223J	81349	RESISTOR, 22K
R9	RCR07G272J	81349	RESISTOR, 2.7K
R10	RCR07G561J	81349	RESISTOR, 560 OHMS
R11	RCR07G472J	81349	RESISTOR, 4.7K
R12,R14,R16,R17, R42-R44,R47	RCR07G243J	81349	RESISTOR, 24K

REPLACEABLE PARTS LIST

A2 MAIN FRAME	FREQUENCY RANGING CIRCUITS (ASSY NO. 101319-G1)		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R13	RCR07G302J	81349	RESISTOR, 3K
R15	RCR07G625J	81349	RESISTOR, 6.2 MEGOHMS
R18,R19,R40,R41	RCR07G335J	81349	RESISTOR, 3.3 MEGOHMS
R20,R23,R38,R39	RCR07G391J	81349	RESISTOR, 390 OHMS
R21,R22,R36,R37, R51	RCR07G203J	81349	RESISTOR, 20K
R24,R25,R34,R35	RCR07G911J	81349	RESISTOR, 910 OHMS
R26,R27,R32,R33	RCR07G102J	81349	RESISTOR, 1K
R28 THRU R31	RCR07G333J	81349	RESISTOR, 33K (SELECTED COMPONENT)
R28 THRU R31 (ALTERNATE)	62PR50K	73138	POTENTIOMETER
R45,R46	RCR07G471J	81349	RESISTOR, 470 OHMS
R48-R50	RCR07G755J	81349	RESISTOR, 7.5 MEGOHMS
Q1	2N3855A	81349	TRANSISTOR
Q2	103286	23207	TRANSISTOR
Q3-Q6	103285	23207	TRANSISTOR
	MOD 14, ASSY NO. 101319-G2		
C1,C7,C8	CS13F565K	81349	CAPACITOR, 5.6 uF ±10%, 35V

REPLACEABLE PARTS LIST

A4 MAIN FRAME	MODE SELECTOR CIRCUITS (ASSY NO. 101320-G1)		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
U1-U2	SN72741J	01295	INTEGRATED CIRCUIT
C1	CS13E106K	81349	CAPACITOR, 10 uF ±10%, 20V
C2	CS13F565K	81349	CAPACITOR, 5.6 uF ±10%, 35V
C3,C4	TGS-50	80183	CAPACITOR, 0.05 uF ±10%, 100V
C5,C6	CS13E225K	81349	CAPACITOR, 2.2 uF ±10%, 20V
CR1,CR3,CR6-CR9	1N4009	81349	DIODE
CR2	1N755A	81349	DIODE, ZENER
CR4,CR5	1N965B	81349	DIODE, ZENER
Q1,Q3,Q5,Q6	2N3855A	03508	TRANSISTOR
Q2,Q4	103286	23207	TRANSISTOR
Q7,Q8	2N3638	07263	TRANSISTOR
R1	RCR07G753J	81349	RESISTOR, 75K ±5%, 1/4W
R2,R7,R10	RCR07G153J	81349	RESISTOR, 15K ±5%, 1/4W
R3,R12	RCR07G103J	81349	RESISTOR, 10K ±5%, 1/4W
R4,R6	RCR07G181J	81349	RESISTOR, 180 OHMS ±5%, 1/4W
R5,R9	RCR07G132J	81349	RESISTOR, 1.3K ±5%, 1/4W
R8	RCR07G512J	81349	RESISTOR, 5.1K ±5%, 1/4W
R11	RCR07G272J	81349	RESISTOR, 2.7K ±5%, 1/4W
R13	RN60C5623F	81349	RESISTOR, 562K ±1%, 1/8W
R14	RN60C3832F	81349	RESISTOR, 38.3K ±1%, 1/8W
R15	RN50C6192D	81349	RESISTOR, FILM 61.9K ±1/2%, 1/8W
R16	RN60C5622D	81349	RESISTOR, FILM 56.2K ±1/2%, 1/8W

REPLACEABLE PARTS LIST

A4 MAIN FRAME	MODE SELECTOR CIRCUITS (ASSY NO. 101320-G1)		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R17,R18	RCR07G621J	81349	RESISTOR, 620 OHMS ±5%, 1/4W
R19,R20	RCR07G332J	81349	RESISTOR, 3.3K ±5%, 1/4W
R21,R24	RCR07G303J	81349	RESISTOR, 30K ±5%, 1/4W
R22,R25	RCR07G203J	81349	RESISTOR, 20K ±5%, 1/4W
R23,R26	RCR07G183J	81349	RESISTOR, 18K ±5%, 1/4W
R27,R29	RCR07G912J	81349	RESISTOR, 9.1K ±5%, 1/4W
R28	RCR07G362J	81349	RESISTOR, 3.6K ±5%, 1/4W
R30,R31	RCR07G182J	81349	RESISTOR, 1.8K ±5%, 1/4W
R32,R33	RCR07G470J	81349	RESISTOR, 47 OHMS ±5%, 1/4W
	MOD 14, ASSY NO. 101320-G2		
C1	CS13E686K	81349	CAPACITOR, 68 uF ±10%, 20V
C2	CS13D226K	81349	CAPACITOR, 22 uF ±10%, 15V
C5,C6	CS13E106K	81349	CAPACITOR, 10 uF ±10%, 20V

REPLACEABLE PARTS LIST

A5 MAIN FRAME	DC AMPLIFIER CIRCUIT (ASSY NO. 102516)		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C1,C8	CS13F565K	80183	CAPACITOR, 5.6 uF, 35V
C2,C5	103206-G1	23207	CAPACITOR, 290 uF, 6V
C3,C4	CS13E106K	81349	CAPACITOR, 10 uF, 20V
C6,C7	CS13C336K	81349	CAPACITOR, 33 uF, 10V
C9,C10	103209-G2	23207	CAPACITOR, 0.22 uF, 50V
CR1-CR3	1N4009	81349	DIODE
CR4	103295	23207	DIODE
CR5-CR8	1N752A	81349	DIODE
Q1-Q3	2N4126	04713	TRANSISTOR
R1	RN60C1912F	81349	RES PREC 19.1K ±1%, 1/8W
R2	RN60C2002F	81349	RES PREC 20K ±1%, 1/8W
R3	RN60C4992F	81349	RES PREC 49.9K ±1%, 1/8W
R4,R5	103218-G6	23207	RES 10K ±1/2%, 1/8W
R6,R7	RCR07G153J	81349	RES CARB 15K ±5%, 1/4W
R8	RCR07G154J	81349	RES CARB 150K ±5%, 1/4W
R9	RCR07G393J	81349	RES CARB 39K ±5%, 1/4W
R10	103260-G1	23207	RES 124K ±1/2%, 1/2W
R11,R12,R14	RN60C3011F	81349	RES PREC 3.01K ±1%, 1/8W
R13	RN60C2001F	81349	RES PREC 2K ±1%, 1/8W
R15	103219-G4	23207	RES PREC 17.4K ±1%, 1/8W
R16,R18	RCR07G102J	81349	RES CARB 1K ±5%, 1/4W
R17	RCR07G563J	81349	RES CARB 56K ±5%, 1/4W
R19	RCR07G156J	81349	RES CARB 15M ±5%, 1/4W

REPLACEABLE PARTS LIST

A5 MAIN FRAME		DC AMPLIFIER CIRCUIT (ASSY NO. 102516)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R20	RN60C3013F	81349	RES PREC 301K ±1%, 1/8W
R21	RN60C4991F	81349	RES PREC 4.99 ±1%, 1/8W
R22	RN60C1101F	81349	RES PREC 1.10K ±1%, 1/8W
R23	RN60C8061F	81349	RES PREC 8.06K ±1%, 1/8W
R24	RN60C2741F	81349	RES PREC 2.74K ±1%, 1/8W
R25	RN60C3741F	81349	RES PREC 3.74K ±1%, 1/8W
R26	RN60C7501K	81349	RES PREC 7.5K ±1%, 1/8W
R27	RCR07G362J	81349	RES CARB 3.6K ±5%, 1/4W
R28	RN60C7151F	81349	RES PREC 7.15K ±1%, 1/8W
R29	RN60C1003F	81349	RES PREC 100K ±1%, 1/8W
R30	RN60C2003F	81349	RES PREC 200K ±1%, 1/8W
R31	RCR07G394J	81349	RES CARB 390K ±5%, 1/4W
R32,R33	RCR07G821J	81349	RES CARB 820 OHMS ±5%, 1/4W
R34	RN60C1212F	81349	RES PREC 12.1K ±1%, 1/8W
R35	RCR07G165J	81349	RES CARB 1.6M ±5%, 1/4W
R37	RN60C1871F	81349	RES PREC 1.87K ±1%, 1/8W
U1	SN72747N	01295	DUAL OP. AMP.
U2	102574	23207	SWITCH MODULE
U3-U5	103288	23207	OP. AMP.

REPLACEABLE PARTS LIST

A6 MAIN FRAME			DIFFERENTIATOR AND SWITCH CIRCUITS (ASSY NO. 101322)
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C1,C2	DM15-390J	81413	CAPACITOR, 39 pF
C3,C4	DM15-471J	81413	CAPACITOR, 470 pF
CR1	1N758A	81349	DIODE, ZENER
CR2,CR3	1N751A	81349	DIODE, ZENER
CR4-CR7	1N4009	81349	DIODE
Q1,Q4	2N3855A	03508	TRANSISTOR
Q2,Q3,Q6-Q11	103285	23207	TRANSISTOR
Q5	103286	23207	TRANSISTOR
R1,R2,R7,R8	RCR07G112J	81349	RESISTOR, 1.1K ±5%, 1/4W
R3	RCR07G182J	81349	RESISTOR, 1.8K ±5%, 1/4W
R4	RCR07G163J	81349	RESISTOR, 16K ±5%, 1/4W
R5,R10	RCR07G133J	81349	RESISTOR, 13K ±5%, 1/4W
R6	RCR07G272J	81349	RESISTOR, 2.7K ±5%, 1/4W
R9,R15	RN60C7501F	81349	RESISTOR, 7.5K ±1%, 1/8W
R11,R31,R32	RCR07G432J	81349	RESISTOR, 4.3K ±5%, 1/4W
R12	RN60C4020F	81349	RESISTOR, 402 OHMS ±1%, 1/8W
R13	RN60C5110F	81349	RESISTOR, 511 OHMS ±1%, 1/8W
R14	RCR07G153J	81349	RESISTOR, 15K ±5%, 1/4W
R16	RCR07G183J	81349	RESISTOR, 18K ±5%, 1/4W
R17	RCR07G562J	81349	RESISTOR, 5.6K ±5%, 1/4W
R18	RCR07G242J	81349	RESISTOR, 2.4K ±5%, 1/4W
R19	RCR07G223J	81349	RESISTOR, 22K ±5%, 1/4W
R20	RCR07G912J	81349	RESISTOR, 9.1K ±5%, 1/4W

REPLACEABLE PARTS LIST

A6 MAIN FRAME		DIFFERENTIATOR AND SWITCH CIRCUITS (ASSY NO. 101322)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R21	RCR07G113J	81349	RESISTOR, 11K ±5%, 1/4W
R22-R26,R29,R30, R33	RCR07G123J	81349	RESISTOR, 12K ±5%, 1/4W
R27,R28,R31,R32	RCR07G432J	81349	RESISTOR, 4.3K ±5%, 1/4W
R34,R35	RCR07G332J	81349	RESISTOR, 3.3K ±5%, 1/4W
R36	62PAR200	73138	RESISTOR, VAR, 200 OHMS

REPLACEABLE PARTS LIST

A7 MAIN FRAME		FLIP-FLOPS AND SWITCHES (ASSY NO. 102520)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C1	CS13F335K	81349	CAP 3.3 uF, 35V
CR1-CR4,CR15-CR18	1N4009	81349	DIODE
CR5,CR6	1N758A	81349	DIODE
CR13,CR14	1N757A	81349	DIODE
CR19,CR20	1N759A	81349	DIODE
Q1-Q4	2N3855A	03508	TRANSISTOR
Q5-Q8	2N4126	04713	TRANSISTOR
R1,R2,R5,R6, R9-R11,R14,R25, R26	RCR07G822J	81349	RES CARB 8.2K ±5%, 1/4W
R3,R4,R7,R8, R19,R20	RCR07G103J	81349	RES CARB 10K ±5%, 1/4W
R12,R13,R15-R18	RCR07G162J	81349	RES CARB 1.6K ±5%, 1/4W
R27-R29,R32	RCR07G112J	81349	RES CARB 1.1K ±5%, 1/4W
R30,R31	RCR07G242J	81349	RES CARB 2.4K ±5%, 1/4W
R33,R34	RCR07G392J	81349	RES CARB 3.9K ±5%, 1/4W
R35,R36	103260-G1	23207	RES 124K ±1/2%, 1/2W
U1	102574	23207	INTEGRATED CIRCUIT

REPLACEABLE PARTS LIST

A8 MAIN FRAME		DIFFERENTIATOR CIRCUITS (ASSY NO. 101324)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C1,C2	DM15-390J	81413	CAPACITOR, 39 pf
CR1	1N758A	81349	DIODE, ZENER
CR2,CR3	1N751A	81349	DIODE, ZENER
CR4,CR5	1N4009	81349	DIODE
Q1,Q4	2N3855A	03508	TRANSISTOR
Q2,Q3,Q6,Q7	103285	23207	TRANSISTOR
Q5	103286	23207	TRANSISTOR
			NOTE: UNLESS OTHERWISE NOTED, ALL RESISTORS ARE ±5%, 1/4W
R1,R2,R7,R8	RCR07G112J	81349	RESISTOR, 1.1K
R3	RCR07G182J	81349	RESISTOR, 1.8K
R4	RCR07G163J	81349	RESISTOR, 16K
R5,R10	RCR07G133J	81349	RESISTOR, 13K
R6	RCR07G272J	81349	RESISTOR, 2.7K
R9,R15	RN60C7501F	81349	RESISTOR, 7.5K ±1%, 1/8W
R11,R23,R24	RCR07G432J	81349	RESISTOR, 4.3K
R12	RN60C4020F	81349	RESISTOR, 402 OHMS ±1%, 1/8W
R13	RN60C5110F	81349	RESISTOR, 511 OHMS ±1%, 1/8W
R14	RCR07G153J	81349	RESISTOR, 15K
R16	RCR07G183J	81349	RESISTOR, 18K
R17	RCR07G562J	81349	RESISTOR, 5.6K
R18	RCR07G242J	81349	RESISTOR, 2.4K
R19	RCR07G223J	81349	RESISTOR, 22K

REPLACEABLE PARTS LIST

A8 MAIN FRAME	DIFFERENTIATOR CIRCUITS (ASSY NO. 101324)		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R20	RCR07G912J	81349	RESISTOR, 9.1K
R21	RCR07G113J	81349	RESISTOR, 11K
R22,R25	RCR07G123J	81349	RESISTOR, 12K
R26,R27	RCR07G332J	81349	RESISTOR, 3.3K
R28	62PAR200	73138	RESISTOR, VARIABLE 200 OHMS

REPLACEABLE PARTS LIST

A10 MAIN FRAME		OFFSET AND NULL CIRCUITS (MODEL 305D) (ASSY NO. 102222)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C1-C5	192P10492	80183	CAPACITOR, FILM, 0.1 uF, 200V
CR1-CR12	1N914	81349	DIODE
R1	RN60C6651F	81349	RESISTOR, PRECISION, 6650 OHMS ±1%
R2	RCR07G300J	81349	RESISTOR, 30 OHMS ±5%, 1/4W
R3	RN60C3321F	81349	RESISTOR, PRECISION, 3320 OHMS ±1%
R4	RN60C1002F	81349	RESISTOR, PRECISION, 10K ±1%, 1/8W
R5	RCR07G473J	81349	RESISTOR, 47K ±5%, 1/4W
R6,R7	RN60C1053F	81349	RESISTOR, PRECISION, 105K ±1%
R8	RCR07G123J	81349	RESISTOR, 12K ±5%, 1/4W
R9	RCR07G335J	81349	RESISTOR, 3.3 MEG ±5%, 1/4W
R10	RCR07G822J	81349	RESISTOR, 8.2K ±5%, 1/4W
R11,R12	RCR07G244J	81349	RESISTOR, 240K ±5%, 1/4W
R13,R14	RCR07G101J	81349	RESISTOR, 100 OHMS ±5%, 1/4W
R15,R24	RCR07G102J	81349	RESISTOR, 1K ±5%, 1/4W
R16	62PAR5K	73138	POTENTIOMETER, 5K
R17, R18	RCR07G621J	81349	RESISTOR, 620 OHMS ±5%, 1/4W
R19,R20,R21	RCR07G472J	81349	RESISTOR, 4.7K ±5%, 1/4W
R22	62PAR50K	73138	POTENTIOMETER, 50K
R23	RCR07G124J	81349	RESISTOR, 120K ±5%, 1/4W

REPLACEABLE PARTS LIST

A10 MAIN FRAME		OFFSET AND NULL CIRCUITS (MODEL 305D) (ASSY NO. 102222)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R25	62PAR10K	73138	POTENTIOMETER, 10K
U1,U2,U3	SN72741N	01295	INTEGRATED CKT: OP-AMP.
CR1	1N757A	81349	DIODE, ZENER
CR2,CR3	1N965B	81349	DIODE, ZENER
CR4	1N746A	81349	DIODE, ZENER
CR5	1N751A	81349	DIODE, ZENER

REPLACEABLE PARTS LIST

MAIN FRAME		DUAL POWER SUPPLY (ASSY NO. 101213)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
U1,U2	SN72741J	01295	INTEGRATED CKT
C1,C2	103203-G3	23207	CAPACITOR, 1300 uF, 50V
C3,C4	MTV100DE50	90201	CAPACITOR, 10 uF, 50V
CR1-CR4,CR7-CR9	1N4004	81349	DIODE
CR5,CR6	1N965B	81349	DIODE, ZENER
CR11	1N751A	81349	DIODE, ZENER
Q1	2N3740	04713	TRANSISTOR
Q2,Q6	2N5189	86694	TRANSISTOR
Q3	2N4037	86694	TRANSISTOR
Q4	2N3054	86694	TRANSISTOR
Q5	2N3638	07263	TRANSISTOR
R1,R2	RCR07G203J	81349	RESISTOR, 20K ±5%, 1/4W
R3	RCR20G182J	81349	RESISTOR, 1.8K ±5%, 1/2W
R4	RCR20G202J	81349	RESISTOR, 2K ±5%, 1/2W
R5,R7	4334	44655	RESISTOR, 1.5 OHM ±5%, 3W
R6,R8,R10,R12	RCR07G221J	81349	RESISTOR, 220 OHMS ±5%, 1/4W
R9,R13	RCR07G222J	81349	RESISTOR, 2.2K ±5%, 1/4W
R11	RCR07G912J	81349	RESISTOR, 9.1K ±5%, 1/4W
R14	RCR07G162J	81349	RESISTOR, 1.6K ±5%, 1/4W
R15	RN60C1002F	81349	RESISTOR, 10.0K, 1%, 1/8W
R16	62PR1K	73138	RESISTOR, VARIABLE: 1K
R17	RN60C2001F	81349	RESISTOR, 2K ±1%, 1/8W
R18	RCR07G623J	81349	RESISTOR, 62K ±5%, 1/4W

REPLACEABLE PARTS LIST

MAIN FRAME	DUAL POWER SUPPLY (ASSY NO. 101213)		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R19,R20	RN60C1212F	81349	RESISTOR, 12.1K ±1%, 1/8W
R21,R22	RCR20G272J	81349	RESISTOR, 2.7K ±5%, 1/2W
R23,R26	RCR07G471J	81349	RESISTOR, 470 OHMS ±5%, 1/4W
R24,R27	RCR07G331J	81349	RESISTOR, 330 OHMS ±5%, 1/4W
R25,R28	RCR07G103J	81349	RESISTOR, 10K ±5%, 1/4W
T1	100337	23207	TRANSFORMER

REPLACEABLE PARTS LIST

MAIN FRAME		REAR INPUTS (OPTION 101)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
J101	8BDJ6S	81312	PC CONNECTOR
J7,J8	31-102-1050	02660	BNC CONNECTOR

MAIN FRAME		REMOTE CONTROL (OPTION 102)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
S5	PA2041	71590	SWITCH, 18 POLE, 2 POS.
P9	8BDJ15S	81312	CONNECTOR, PC
	L28/40RLCW	32539	LAMP AND LENS ASSY
	70-4-2G	94145	KNOB

REPLACEABLE PARTS LIST

A9 MAIN FRAME		REMOTE CONTROL (OPTION 102) (ASSY NO. 101672)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
CR1 thru CR12	1N4009	03508	DIODE
CR13	1N759A	04713	DIODE
Q1,Q3,Q5,Q7,Q9, Q11,Q13,Q15,Q17, Q19,Q22	2N3855A	03508	TRANSISTOR
Q2,Q4,Q6,Q8,Q10, Q12,Q14,Q16,Q18	2N4126	04713	TRANSISTOR
Q20,Q21,Q23,Q24	2N4121	07263	TRANSISTOR
			NOTE: UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE ±5%, 1/4W
R1,R6,R11,R16, R20,R24,R29,R34, R39,R44,R50	RCR07G244J	81349	RESISTOR, 240K
R2,R7,R12,R17, R21,R25,R30,R35, R40,R45,R51,R56, R57	RCR07G362J	81349	RESISTOR, 3.6K
R3,R8,R13	RCR07G203J	81349	RESISTOR, 20K
R4,R9,R14,R18, R22,R46,R48,R52, R54	RCR07G913J	81349	RESISTOR, 91K
R5,R10,R15,R19, R23,R28,R33,R38, R43,R47,R49,R53, R55	RCR07G223J	81349	RESISTOR, 22K
R26	RCR07G133J	81349	RESISTOR, 13K
R27,R32,R37,R42	RCR07G473J	81349	RESISTOR, 47K
R31,R36,R41	RCR07G363J	81349	RESISTOR, 36K

REPLACEABLE PARTS LIST

A5 MAIN FRAME		DC AMPLIFIER CIRCUIT (OPTION 103) (ASSY NO. 102201-G1)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C1	CK06BX392K	81349	CAPACITOR, 0.0039 uF ±10%, 200V
C2	CK06BX332K	81349	CAPACITOR, 0.0033 uF ±10%, 200V
C3	CK06BX333K	81349	CAPACITOR, 0.033 uF ±10%, 100V
C4	CK06BX334K	81349	CAPACITOR, 0.33 uF ±10%, 50V
C5,C6	103204-G2	23207	CAPACITOR, 6.8 uF ±10%, 20V
C7,C19,C20	CK06BX473K	81349	CAPACITOR, 0.047 uF ±10%, 100V
C8	CK06BX474K	81349	CAPACITOR, 0.47 uF ±10%, 50V
C9	103204-G3	23207	CAPACITOR, 8.2 uF ±10%, 15V
C10	103204-G4	23207	CAPACITOR, 10 uF ±10%, 10V
C11	103204-G9	23207	CAPACITOR, 82 uF ±10%, 10V
C12	103204-G8	23207	CAPACITOR, 100 uF ±10%, 10V
C13	CK06BX223K	81349	CAPACITOR, 0.023 uF ±10%, 100V
C14	CK06BX224K	81349	CAPACITOR, 0.22 uF ±10%, 50V
C15	103204-G1	23207	CAPACITOR, 5.6 uF ±10%, 20V
C16	103204-G10	23207	CAPACITOR, 3.9 uF ±10%, 25V
C17	103204-G6	23207	CAPACITOR, 56 uF ±10%, 10V
C18	103204-G5	23207	CAPACITOR, 39 uF ±10%, 10V
CR1-CR3,CR5,CR8	1N4009	81349	DIODE
CR4,CR7	1N751A	81349	DIODE, ZENER
CR6	1N825A	81349	DIODE, ZENER

REPLACEABLE PARTS LIST

A5 MAIN FRAME		DC AMPLIFIER CIRCUIT (OPTION 103) (ASSY NO. 102201-G1)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
CR9,CR10	1N965B	81349	DIODE, ZENER
K1-K3	MRRN3A-24V	78290	RELAY
Q1-Q3,Q6,Q8	2N4126	04713	TRANSISTOR
Q4	2N3638	07263	TRANSISTOR
Q5	2N3404	03508	TRANSISTOR
Q7	2N3391A	03508	TRANSISTOR
			NOTE: UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE ±5%, 1/4W
R1	RCR07G153J	81349	RESISTOR 15K
R2,R17	RCR07G564J	81349	RESISTOR 560K
R3	103219-G5	23207	RESISTOR 49.9K ±1%, 1/8W
R4,R5	RN60C1211F	81349	RESISTOR 1.21K ±1%, 1/8W
R6	RCR07G243J	81349	RESISTOR 24K
R7,R13,R15	103219-G3	23207	RESISTOR 15.8K ±1%, 1/8W
R8	RCR07G513J	81349	RESISTOR 51K
R9	RCR07G433J	81349	RESISTOR 43K
R10	RCR07G123J	81349	RESISTOR 12K
R11	RCR07G333J	81349	RESISTOR 33K
R12	RN60C1001F	81349	RESISTOR 1K ±1%, 1/8W
R14	RN60C1691F	81349	RESISTOR 1.69K ±1%, 1/8W
R16,R26	RN60C8251F	81349	RESISTOR 8.25K ±1%, 1/8W
R18,R24	62PAR1K	73138	RESISTOR VARIABLE 1K
R19	RN60C7151F	81349	RESISTOR 7.15K ±1%, 1/8W

REPLACEABLE PARTS LIST

A5 MAIN FRAME			DC AMPLIFIER CIRCUIT (OPTION 103) (ASSY NO. 102201-G1)
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R20	103219-G1	23207	RESISTOR 2.49K ±1%, 1/8W
R21-R23	RCR07G122J	81349	RESISTOR 1.2K
R25	RN60C7681F	81349	RESISTOR 7.68K ±1%, 1/8W
U1	SN72747J	07263	DUAL OP. AMP.

DC AMPLIFIER, ASSY NO. 102201-G2
(USED FOR OPTION 103/105)

SAME AS ASSY NO. 102201-G1 EXCEPT R2 = 1.1K

REPLACEABLE PARTS LIST

A7 MAIN FRAME		FLIP-FLOP SWITCHES (OPTION 103) (ASSY NO. 101670)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
A1,A2	101664	23207	ANALOG GATE MODULE
C1	CS13F335K	81349	CAPACITOR, 3.3 uF, 35V
CR1-CR4,CR7-CR10, CR15-CR18	1N4009	81349	DIODE
CR5,CR6	1N758A	81349	DIODE, ZENER
CR11,CR12	1N750A	81349	DIODE, ZENER
CR13,CR14	1N755A	81349	DIODE, ZENER
CR19,CR20	1N965B	81349	DIODE, ZENER
Q1-Q4	2N3855A	03508	TRANSISTOR
Q5-Q8	103285	23207	TRANSISTOR
R1,R2,R5,R6, R9-R11,R14,R25, R26	RCR07G822J	81349	RESISTOR, 8.2K ±5%, 1/4W
R3,R4,R7,R8,R19, R20	RCR07G103J	81349	RESISTOR, 10K ±5%, 1/4W
R12,R13,R15-R18	RCR07G162J	81349	RESISTOR, 1.6K ±5%, 1/4W
R21,R22	RCR07G623J	81349	RESISTOR, 62K ±5%, 1/4W
R23,R24	RCR07G123J	81349	RESISTOR, 12K ±5%, 1/4W
R27,R28,R29,R32	RCR07G112J	81349	RESISTOR, 1.1K ±5%, 1/4W
R30,R31	RCR07G242J	81349	RESISTOR, 2.4K ±5%, 1/4W
R33,R34	RCR07G392J	81349	RESISTOR, 3.9K ±5%, 1/4W
R35,R36	103219-G5	23207	RESISTOR, 49.9K ±1%, 1/8W

REPLACEABLE PARTS LIST

MAIN FRAME		REMOTE ZERO (OPTION 105)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R10	RCR07G103J	81349	RESISTOR, 10K ±5%, 1/4W

MAIN FRAME		AUTOMATIC CALIBRATION CKTS. (OPTION 107)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
P11	ISM15DREH	54453	PC CONNECTOR
S2	7403	09353	TOGGLE SW, 4PDT, ON-OFF-ON
TB4	3008	83330	TERMINAL STRIP

REPLACEABLE PARTS LIST

A11 MAIN FRAME	AUTOMATIC CALIBRATION CIRCUITS (OPTION 107) (ASSY NO. 102524)		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C1,C9	103209-G2	23207	CAPACITOR, 0.22 uF, 50V
C2,C3	CS13D335K	81349	CAPACITOR, 3.3 uF, 15V
C4	CS13E106K	81349	CAPACITOR, 10 uF, 20V
C5,C8	DM15-102J	81413	CAPACITOR, 1000 PF ±5%
C6,C7	103209-G3	23207	CAPACITOR, 0.47 uF, 50V
CR1-CR10,CR12, CR14	1N4009	81349	DIODE
CR11,CR13	1N759A	81349	DIODE
Q1,Q2,Q7	2N3855A	03508	TRANSISTOR
Q3,Q4,Q5	2N5086	04713	TRANSISTOR
Q6	2N5550	04713	TRANSISTOR
R1,R3,R5,R7,R9, R11,R15-R17,R31, R54,R62,R63	RCR07G103J	81349	RESISTOR, CARBON, 10K ±5%, 1/4W
R2,R4,R6,R8,R10, R12,R19,R27	RCR07G134J	81349	RESISTOR, CARBON, 130K ±5%, 1/4W
R13	RCR07G101J	81349	RESISTOR, CARBON, 100 OHMS ±5%, 1/4W
R14	RCR07G303J	81349	RESISTOR, CARBON, 30K ±5%, 1/4W
R18,R25	RCR07G563J	81349	RESISTOR, CARBON, 56K ±5%, 1/4W
R20,R26,R36	RCR07G105J	81349	RESISTOR, CARBON, 1M ±5%, 1/4W
R21,R23,R71	RCR07G512J	81349	RESISTOR, CARBON, 5.1K ±5%, 1/4W
R22,R24	RCR07G203J	81349	RESISTOR, CARBON, 20K ±5%, 1/4W

REPLACEABLE PARTS LIST

A11 MAIN FRAME		AUTOMATIC CALIBRATION CIRCUITS (OPTION 107) (ASSY NO. 102524)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R28	RCR07G202J	81349	RESISTOR, CARBON, 2K ±5%, 1/4W
R30	RCR07G752J	81349	RESISTOR, CARBON, 7.5K ±5%, 1/4W
R32,R73	RCR07G243J	81349	RESISTOR, CARBON, 24K ±5%, 1/4W
R33	RCR07G183J	81349	RESISTOR, CARBON, 18K ±5%, 1/4W
R34	RCR07G333J	81349	RESISTOR, CARBON, 33K ±5%, 1/4W
R35	RCR07G273J	81349	RESISTOR, CARBON, 27K ±5%, 1/4W
R37	RCR07G514J	81349	RESISTOR, CARBON, 510K ±5%, 1/4W
R38	RCR07G244J	81349	RESISTOR, CARBON, 240K ±5%, 1/4W
R39	RN60C1243F	81349	RESISTOR PREC., 124K ±1%, 1/8W
R40	RN60C1003F	81349	RESISTOR PREC., 100K ±1%, 1/8W
R41,R42	RN60C4992F	81349	RESISTOR PREC., 49.9K ±1%, 1/8W
R43,R44	RCR07G223J	81349	RESISTOR, CARBON, 22K ±5%, 1/4W
R45	RCR07G153J	81349	RESISTOR, CARBON, 15K ±5%, 1/4W
R46	RN60C6651F	81349	RESISTOR, PREC., 6.65K ±1%, 1/8W
R47	3386P-1-201	80294	RESISTOR VARIABLE 200 OHMS
R48	RN60C6651F	81349	RESISTOR, 6.65K ±1%, 1/8W

REPLACEABLE PARTS LIST

A11 MAIN FRAME			AUTOMATIC CALIBRATION CIRCUITS (OPTION 107) (ASSY NO. 102524)
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R49	3386P-1-104	80294	RESISTOR VARIABLE 100K
R50	RCR07G335J	81349	RESISTOR CARBON, 3.3M ±5%, 1/4W
R51	RCR07G332J	81349	RESISTOR CARBON, 3.3K ±5%, 1/4W
R52	RN60C6650F	81349	RESISTOR PREC. 665 OHMS ±1%, 1/8W
R53	RN60C1333F	81349	RESISTOR PREC. 133K ±1%, 1/8W
R55	RN60C2001F	81349	RESISTOR PREC. 2K ±1%, 1/8W
R56	3386P-1-503	80294	RESISTOR VARIABLE 50K
R57	RN60C2000F	81349	RESISTOR PREC., 200 OHMS ±1%, 1/8W
R58	RN60C1821F	81349	RESISTOR PREC., 1.82K ±1%, 1/8W
R59	RCR07G102J	81349	RESISTOR CARBON, 1K ±5%, 1/4W
R60,R61	RCR07G565J	81349	RESISTOR CARBON, 5.6M ±5%, 1/4W
R64	RCR07G681J	81349	RESISTOR CARBON, 680 OHMS ±5%, 1/4W
R65	RCR07G754J	81349	RESISTOR CARBON, 750K ±5%, 1/4W
R66	RCR07G364J	81349	RESISTOR CARBON, 360K ±5%, 1/4W
R67	RCR07G184J	81349	RESISTOR CARBON, 180K ±5%, 1/4W
R68	RN60C9092F	81349	RESISTOR, PREC., 90.9K ±1%, 1/8W
R69	RN60C7152F	81349	RESISTOR, PREC., 71.5K ±1%, 1/8W

REPLACEABLE PARTS LIST

A11 MAIN FRAME		AUTOMATIC CALIBRATION CIRCUITS (OPTION 107) (ASSY NO. 102524)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R70	RN60C3572F	81349	RESISTOR PREC., 35.7K ±1%, 1/8W
R72	RCR07G221J	81349	RESISTOR CARBON, 220 OHMS ±5%, 1/4W
R74	RCR07G274J	81349	RESISTOR CARBON, 270K ±5%, 1/4W
U1,U2	LM3900CN	12040	INTEGRATED CKT: QUAD AMPL.
U3	MM74C174P	12040	INTEGRATED CKT: HEX D FLIP-FLOP
U4-U6,U8	CD4001AE	86694	INTEGRATED CKT: QUAD 2-INPUT NOR GATES
U7,U9	CD4047AE	86694	INTEGRATED CKT: MULTIVIBRATOR
U10	SN72747N	01295	INTEGRATED CKT: DUAL OP-AMP
U11	MM74C174P	12040	HEX D FLIP-FLOP
U12,U13	CD4016AF	86694	INTEGRATED CKT: QUAD BILATERAL SWITCH

REPLACEABLE PARTS LIST

MAIN ASSY	PLUG-IN MODEL 305-PA-3001		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
I1-I4	L-28/40RLCW	32539	LAMP AND LENS ASSY
J1,J2	31-102-1050	02660	CONNECTOR, BNC
J3	SM2SN-T34	81312	CONNECTOR
P6	5720360	02660	CONNECTOR

REPLACEABLE PARTS LIST

A1 AND A2 PLUG-IN MODEL 305-PA-3001		INPUT AMPLIFIER (ASSY NO. 102616)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C1,C5	103213-G2	23207	CAPACITOR, VARIABLE: 2.5 TO 11 PF
C2,C19	CY06C200J	16299	CAPACITOR, 20 PF ±5%
C7	103213-G4	23207	CAPACITOR, VARIABLE: 7 TO 25 PF
C9	CY06C241J	81349	CAPACITOR, 240 PF ±5%
C11	CY08C242J	81349	CAPACITOR, 2400 PF ±5%
C12	192P10392	80183	CAPACITOR, 0.01 uF ±10%
C13,C14,C16	CS13F476K	81349	CAPACITOR, 47 uF, 35V
C15	CS13D226K	81349	CAPACITOR, 22 uF, 15V
C17,C18	AF10	18736	CAPACITOR, VARIABLE: 1-10 PF
CR1,CR2	101345	23207	DIODE
CR3	1N758A	81349	DIODE, ZENER
CR4	1N759A	81349	DIODE, ZENER
CR5,CR6	1N4009	81349	DIODE
K1 thru K6	MRRNIA-24V	78290	RELAY, SPST, 24V
Q1	101396	23207	TRANSISTOR
Q2	101397	23207	TRANSISTOR
Q3	101398	23207	TRANSISTOR
R1	RN65C1004F	81349	RESISTOR, PRECISION: 1 MEG, ±1%, 1/4W
R2	103221-G7	23207	RESISTOR, PRECISION, 909K, 1%
R3	RCR07G566J	81349	RESISTOR CARBON, 56 MEG, 1/4W, 5%

REPLACEABLE PARTS LIST

A1 AND A2
PLUG-IN MODEL 305-PA-3001

INPUT AMPLIFIER
(ASSY NO. 102616)

REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R4	RN60C1003F	81349	RESISTOR PRECISION 100K, 1/8W, 1%
R5	103221-G8	23207	RESISTOR PRECISION 1 MEG, 1%
R7	RN60C1002F	81349	RESISTOR PRECISION 10K, 1/8W, 1%
R8	RCR07G471J	81349	RESISTOR CARBON, 470 OHMS, 1/4W, 5%
R9,R10	RCR07G562J	81349	RESISTOR CARBON, 5.6K, 1/4W, 5%
R11,R12,R19	RCR07G221J	81349	RESISTOR CARBON, 220 OHMS, 1/4W, 5%
R13	RCR07G103J	81349	RESISTOR CARBON, 10K, 1/4W, 5%
R14	RCR07G133J	81349	RESISTOR CARBON, 13K, 1/4W, 5%
R15	RCR07G107J	81349	RESISTOR CARBON, 100 MEG, 1/4W, 5%
R16	RCR07G511J	81349	RESISTOR CARBON, 510 OHMS, 1/4W, 5%
R17	3386P-502	80294	RESISTOR VARIABLE 5K
R18	RCR07G753J	81349	RESISTOR CARBON, 75K, 1/4W, 5%
R20	RCR07G302J	81349	RESISTOR CARBON, 3K, 1/4W, 5%
R21	RCR07G222J	81349	RESISTOR CARBON, 2.2K, 1/4W, 5%
R22	RCR07G201J	81349	RESISTOR CARBON, 200 OHMS, 1/4W, 5%
R23	RCR07G113J	81349	RESISTOR CARBON, 11K, 1/4W, 5%

REPLACEABLE PARTS LIST

A1 AND A2 PLUG-IN MODEL 305-PA-3001		INPUT AMPLIFIER (ASSY NO. 102616)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R24	RCR07G512J	81349	RESISTOR CARBON, 5.1K, 1/4W, 5%
R25	RCR07G826J	81349	RESISTOR CARBON, 82 MEG, 1/4W, 5%

REPLACEABLE PARTS LIST

A3 AND A4 PLUG-IN MODEL 305-PA-3001 — AUTO LEVEL BOARD (ASSY NO. 101359)

REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C1,C2	TE1209	09023	CAPACITOR, 50 uF, 25V
C3,C5,C10	TE-1155	80183	CAPACITOR, 10 uF, 15V
C4	DM10-330J	81413	CAPACITOR, 33 PF, 500V
C6	TE-1160	80183	CAPACITOR, 50 uF, 15V
C7,C9	TGS-50	80183	CAPACITOR, 0.05 uF, 100V
C8	TE-1162	80183	CAPACITOR, 100 uF, 15V
CR1-CR8,CR10, CR12-CR15	1N4009	81349	DIODE
CR9	1N967B	81349	DIODE, ZENER
CR11	1N965B	81349	DIODE, ZENER
			NOTE: UNLESS OTHERWISE SPECIFIED, ALL RESISTORS ARE ±5%, 1/4W
R1,R2,R4	RCR07G181J	81349	RESISTOR, 180 OHMS
R3,R5,R14,R55, R56	RCR07G393J	81349	RESISTOR, 39K
R6,R13	RCR07G243J	81349	RESISTOR, 24K
R7	RCR07G392J	81349	RESISTOR, 3.9K
R8,R10,R11, R31-R34	RCR07G512J	81349	RESISTOR, 5.1K
R9,R37	RCR07G133J	81349	RESISTOR, 13K
R12,R54	RCR07G333J	81349	RESISTOR, 33K
R15-R18,R36,R38, R58,R59	RCR07G912J	81349	RESISTOR, 9.1K
R19-R22	RCR07G123J	81349	RESISTOR, 12K
R23-R26,R47	RCR07G303J	81349	RESISTOR, 30K

REPLACEABLE PARTS LIST

A3 AND A4 PLUG-IN MODEL 305-PA-3001		AUTO LEVEL BOARD (ASSY NO. 101359)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R28,R29	RCR07G432J	81349	RESISTOR, 4.3K
R35	RCR07G433J	81349	RESISTOR, 43K
R39,R53	RCR07G223J	81349	RESISTOR, 22K
R40	RCR07G151J	81349	RESISTOR, 150 OHMS
R41,R49	RCR07G513J	81349	RESISTOR, 51K
R42	RCR07G104J	81349	RESISTOR, 100K
R43,R44	RCR07G102J	81349	RESISTOR, 1K
R45,R48	RCR07G621J	81349	RESISTOR, 620 OHMS
R46	RCR07G302J	81349	RESISTOR, 3K
R51	RCR07G103J	81349	RESISTOR, 10K
R52	RCR07G911J	81349	RESISTOR, 910 OHMS
R57	RCR07G475J	81349	RESISTOR, 4.7 MEG
R60	RCR07G106J	81349	RESISTOR, 10 MEG
R61,R62	RCR07G470J	81349	RESISTOR, 47 OHMS
R63,R64	RCR07G113J	81349	RESISTOR, 11K
R65,R66	RCR07G272J	01121	RESISTOR, 2.7K
R67	3386W-1-104	80294	RESISTOR, VARIABLE, 100K
Q1,Q2,Q3	2N4126	04713	TRANSISTOR
Q4-Q9	2N3855A	03508	TRANSISTOR
Q10	2N4126	04713	TRANSISTOR
Q11,Q12	2N3638	07263	TRANSISTOR
U1,U2	SN72741J	01295	INTEGRATED CKT. OP. AMP.

REPLACEABLE PARTS LIST

A5 COMPARATOR (ASSY NO. 102620)
PLUG-IN MODELS 305-PA-3001 AND 305 PA-3002

REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C1,C2,C17,C18	CS13B277K	81349	CAPACITOR, 270 uF, 6V
C3,C4,C5,C19-C21	103209-G2	23207	CAPACITOR, 0.22 uF
C6,C7	DM15----J	81413	SELECT AT TEST
C8	DM15-331F	81413	CAPACITOR, 330 PF, 1%
C9,C25	192P5629R8	80183	CAPACITOR, 0.0056 uF
C11,C12,C27,C28	DM15-010D	81413	CAPACITOR, 1 PF
C13	DM15----J	81413	SELECT AT TEST
C14,C30	DM15-360J	81413	CAPACITOR, 36 PF
C15,C31	DM15-470J	81413	CAPACITOR, 47 PF
C22,C23			SELECT AT TEST
C24	DM15-301J	81413	CAPACITOR, 300PF
C29	DM15----J	81413	SELECT AT TEST
C32	DM15----J	81413	SELECT AT TEST
CR1,CR4	1N751A	81349	DIODE, ZENER
CR2,CR3,CR5,CR6	1N759A	81349	DIODE, ZENER
R1	3386W-1-101	80924	RESISTOR, VARIABLE, 100 OHMS
R2,R3,R6,R21, R22,R25	RCR07G821J	81349	RESISTOR, CARBON, 820 OHMS ±5%, 1/4W
R4,R5	RCR07G----J	81349	SELECT AT TEST
R8,R27	3386W-1-504	80924	RESISTOR, VARIABLE, 500K
R9	RCR07G---J		SELECT AT TEST
R10,R29	RCR07G274J	81349	RESISTOR, 270K ±5%, 1/4W
R11,R30	RCR07G514J	81349	RESISTOR, 510K ±5%, 1/4W
R12,R31	RCR07G274J	81349	RESISTOR, 270K ±5%, 1/4W

REPLACEABLE PARTS LIST

A5 COMPARATOR (ASSY NO. 102620)
PLUG-IN MODELS 305-PA-3001 AND 305-PA-3002

REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R13			SELECT AT TEST
R14,R33	RCR07G204J	81349	RESISTOR, CARBON, 200K ±5%, 1/4W
R15,R16,R34,R35	RCR07G104J	81349	RESISTOR, CARBON, 100K, 1/4W, 5%
R17,R18	RCR07G---J	81349	SELECT AT TEST
R19,R38	3386W-1-204	80924	RESISTOR, VARIABLE, 200K
R20	3386W-1-101	80924	RESISTOR, VARIABLE, 100 OHMS
R23,R24,R28 R32,R36,R37	RCR07G---J	81349	SELECT AT TEST
R26	RCR07G---J	81349	SELECT AT TEST
R39,R40	RCR07G205J	81349	RESISTOR, 2 MEG, 1/4W, 5%
R41	RCR07G824J	81349	RESISTOR, 820K, 1/4W, 5%
R42	RCR07G155J	81349	RESISTOR, 1.5 MEG, 1/4W, 5%
U1,U3	102624	23207	INTEGRATED CKT.
U2,U4	102625	23207	INTEGRATED CKT.

REPLACEABLE PARTS LIST

MAIN ASSY	PLUG-IN MODEL 305-PA-3002		
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
J1,J2	31-102-1050	02660	CONNECTOR, BNC
J3	SM2SN-734	81312	CONNECTOR
P6	57-20360	02660	CONNECTOR

REPLACEABLE PARTS LIST

A1 & A2 PLUG-IN MODEL 305-PA-3002		INPUT AMPLIFIER (ASSY NO. 102841)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
C7	103213-G4	23207	CAPACITOR, VARIABLE, 7-25PF
C12	192P10392	80183	CAPACITOR, 0.01 uF
C14,C16	CS13F476K	81349	CAPACITOR, 47 uF, 35V
C15	CS13D226K	81349	CAPACITOR, 22 uF, 15V
CR1,CR2	101345	23207	DIODE
CR3	1N758A	81349	DIODE, ZENER
CR4	1N759A	81349	DIODE, ZENER
CR5,CR6	1N4009	81349	DIODE
Q1	101396	23207	TRANSISTOR
Q2	101397	23207	TRANSISTOR
Q3	101398	23207	TRANSISTOR
R1	RN65C1004F	81349	RESISTOR PRECISION, 1 MEG, 1/4W, 1%
R8	RCR07G471J	81349	RESISTOR, CARBON, 470 OHMS, 1/4W, 5%
R9,R10	RCR07G562J	81349	RESISTOR, CARBON, 5.6K, 1/4W, 5%
R12,R19	RCR07G221J	81349	RESISTOR, CARBON, 220 OHMS, 1/4W, 5%
R13	RCR07G103J	81349	RESISTOR, CARBON, 10K, 1/4W, 5%
R14	RCR07G133J	81349	RESISTOR, CARBON, 13K, 1/4W, 5%
R15	RCR07G107J	81349	RESISTOR, CARBON, 100 MEG, 1/4W, 5%
R16	RCR07G511J	81349	RESISTOR, CARBON, 510 OHMS, 1/4W, 5%

REPLACEABLE PARTS LIST

A1 & A2 PLUG-IN MODEL 305-PA-3002		INPUT AMPLIFIER (ASSY NO. 102841)	
REFERENCE NUMBER	PART NUMBER	MFG. CODE IDENT	DESCRIPTION
R17	3386P-1-502	80924	RESISTOR, VARIABLE, 5K
R18	RCR07G753J	81349	RESISTOR, CARBON, 75K, 1/4W, 5%
R20	RCR07G302J	81349	RESISTOR, CARBON, 3K, 1/4W, 5%
R21	RCR07G222J	81349	RESISTOR, CARBON, 2.2K, 1/4W, 5%
R22	RCR07G201J	81349	RESISTOR, CARBON, 200 OHMS, 1/4W, 5%
R23	RCR07G113J	81349	RESISTOR, CARBON, 11K, 1/4W, 5%
R24	RCR07G512J	81349	RESISTOR, CARBON, 5.1K, 1/4W, 5%

SECTION VIII

AVAILABLE OPTIONS

8-1. GENERAL

8-2. This section covers the various optional configurations available with the Phasemeter Series 305. The following information defines each option and, together with the information in the preceeding sections, explains their operation.

8-3. OPTION 101

8-4. Option 101 provides rear BNC connectors for both SIGNAL and REFERENCE inputs. These rear inputs are wired in parallel with existing front panel inputs. This option may only be used with plug-in units which also contain Option 101. It cannot be used with Plug-in Models 305-PA-3005 or 305-PA-3008.

8-5. The installation of Option 101 adds approximately 100 pf to the 40 pf input capacity typical of unmodified units. Note that this may cause difficulty if standard oscilloscope probes are used with a phasemeter/plug-in combination having Option 101.

8-6. OPTION 102

8-7. The following paragraphs describe the differences between the Series 305 units with Option 102 and the standard Series 305 units. Information in these paragraphs supersedes that contained in the previous sections of this manual.

8-8. Option 102 units have provision for full remote control of all main frame operating controls. This control includes all front panel switches except the power switch. Control is also provided over the following functions which the Series 305 units normally perform automatically: frequency range selection and output time constant selection. Control over the normally automated functions is provided to allow a reduction in the time required to perform a measurement.

8-9. A switch is provided on the unit rear panel for selection of either REMOTE or LOCAL operation. When the switch is in the LOCAL position, the unit functions as an unmodified Series 305. Front panel controls are operative and other required functions are automated. When the switch is in the REMOTE position, front panel controls and internal automation are disabled, while the control inputs on connector J3 are enabled. The unit will not function in REMOTE unless control signals are provided for all necessary functions, as detailed in table 8-2. When the unit is switched to REMOTE operation, an indicator lamp labeled R is illuminated on the front panel.

8-10. REMOTE Operation.

8-11. Connect control leads to pins 12 through 22 on connector J3. Pin J3-10 provides ground return for the control inputs. Details of connector J3 pin functions are provided in table 8-1.

8-12. Control input information may take either of two forms: switch closures to ground or TTL/DTL logic outputs. The currents drawn are in the order of 1 milliampere for either condition. When switch closures to ground are to be used, a closed switch represents a logical-0 while an open switch represents a logical-1. For drive from TTL or DTL logic circuits, the following input levels are required:

a. Logical-0: 0 to +0.8 volts dc.

b. Logical-1: +2.5 to +5 volts dc.

8-13. Table 8-2 provides the logic inputs required to control all aspects of the phasemeter operation.

Table 8-1. CONNECTOR J3 PIN FUNCTIONS FOR UNITS WITH OPTION 102

Pin Designation	Function	
J3-1	N.C.	
J3-2	N.C.	
J3-3	N.C.	
J3-4	Null Output (305D only)	
J3-5	Analog Ckt. Gnd	
J3-6	Panel Readout Input	Internal Jumper
J3-7	Analog Output, -1.80 to +3.60 VDC	Internal Jumper
J3-8	Corrected Analog Output (Option 107 only)	
J3-9	Gnd (Zero) for Meas (Option 107 only)	
J3-10	Digital Ckt. Gnd.	
J3-11	N.C.	
J3-12	Cal. High	Calibration
J3-13	Cal. Low	Calibration
J3-14	0 ±180°	Ø Range Selection
J3-15	0 +360°	Ø Range Selection
J3-16	Inhibit Time Selection	Frequency Range Selection
J3-17	Inhibit Time Selection	Frequency Range Selection
J3-18	Inhibit Time Selection	Frequency Range Selection
J3-19	Inhibit Time Selection	Frequency Range Selection
J3-20	Output Time Constant Selection	Frequency Range Selection
J3-21	Output Time Constant Selection	Frequency Range Selection
J3-22	Output Time Constant Selection	Frequency Range Selection
J3-23	Gnd (Zero) for F.S. (Option 107 only)	
J3-24	Remote Zero (Option 105 only)	
J3-25	N.C.	

Table 8-2. OPERATION OF CONTROL CIRCUITS (CONNECTOR J3, PINS 12 TO 22)

1. CALIBRATION CHECK

Connector J3	Measure	Cal High	Cal Low
Pin 12	0	1	0
Pin 13	0	0	1

2. PHASE RANGE SELECTION

Connector J3	0 ±180° Range	0 +360° Range	Automatic
Pin 14	1	0	1
Pin 15	0	1	1

3. FREQUENCY RANGE SELECTION

Connector J3	5 to 50 Hz	50 to 500 Hz	0.5 to 5 kHz	5 to 50 kHz	50 to 500 kHz
Pins 16 and 20	0	1	1	1	1
Pins 17 and 21	0	0	1	1	1
Pins 18 and 22	0	0	0	1	1
Pin 19	0	0	0	0	1

4. TIME CONSTANT CONTROL

NOTE

If output time constant selection is desired independent of inhibit time setting requirements, drive pins 16,17, 18 and 19 as in Step 3 above and set time constant using pins 20, 21, and 22 as follows:

Connector J3	700 ms	350 ms	50 ms	10 ms
Pin 20	0	1	1	1
Pin 21	0	0	1	1
Pin 22	0	0	0	1

8-14. Calibration Check. A calibration check is obtained by using pins 12 and 13 on connector J3. When pin 12 is "1" and pin 13 is "0", the phasemeter will indicate the highest point on the phase range in use (+180° or +360°). For pin 12 "0" and pin 13 "1", the phasemeter will indicate the lowest point on the phase range in use (-180° or 0°). When pins 12 and 13 are both returned to the "0" state, normal measurement resumes.

8-15. Phase Range Selection. The desired phase range is selected by using pins 14 and 15 on connector J3. A logical "1" at pin 14 with a "0" at 15 will select the 0 ±180° range while a logical "0" at pin 14 with a "1" at pin 15 will select the 0/+360° range. Note that erroneous results will be obtained if the angle to be measured is near either end of the phase range selected for the measurement. If sufficient information is not available to select the correct range, logical "1" may be applied to both pins 14 and 15. This will allow the Series 305 Phasemeter to automatically select an appropriate range.

8-16. Frequency Range Selection. The Series 305 Phasemeters require frequency range switching in decade ranges. When operated in the REMOTE mode, internal frequency sensors are disabled, and this information must be provided in accordance with the code given by step 3 in table 8-2. This frequency range information controls inhibit times required for operation and adjusts the time constant of the analog output for a speed commensurate with low ripple.

8-17. Time Constant Control. If time constant control is desired independent of the frequency range setting required, selection is accomplished according to the code given by step 4 of table 8-2. Note that use of a time constant shorter than normal for any frequency will cause an increase in the ripple on the analog output. This ripple is a function of phase angle with maximums at ±90° and minimums at 0° and 180°. When using a shortened time constant, it is advisable to apply a 90° angle to the Series 305 Phasemeter at the lowest intended frequency of use. The ripple on the analog output may then be measured at its maximum value, and a determination of its effects on the readout device may be made.

8-18. ADDITIONAL OPERATING CONTROL INFORMATION FOR REMOTE OPERATION OF AUTOMATIC CALIBRATOR WHEN OPTION 107 IS USED.

8-19. Table 8-3 provides the programming information necessary to remotely initiate automatic zero and full scale calibration sequences.

Table 8-3. AUTOMATIC CALIBRATION

Connector J3	Measure	AUTO CAL 0	AUTO CAL F.S.
Pin 9	0	1	1
Pin 23	1	1	0

For all normal measurements, the "Measure" setting should be maintained. When it is desired to perform an automatic calibration (not simply a calibration check which is described in Section 1 of Table 8-2, the following sequence of commands must be given:

a. Command "0/360^{o} Range"

b. Command "Cal Low"

c. Command "10 ms time constant"

d. Command "Auto CAL 0"

e. Wait 10 or more seconds

f. Command "Cal High"

g. Command "Auto CAL F.S."

h. Wait 10 or more seconds

i. Return to normal use

Refer to paragraph 8-31 for additional information on the use of Option 107.

8-20. Diagrams. Figures 8-2 and 8-3 are schematic and assembly drawings showing the remote control circuits used in Option 102. They are included in this manual to assist in maintenance of the remote control circuits if required. Note that maintenance of these circuits is normally not required.

Note

Figure 8-1 shows the interconnections of Option 102.

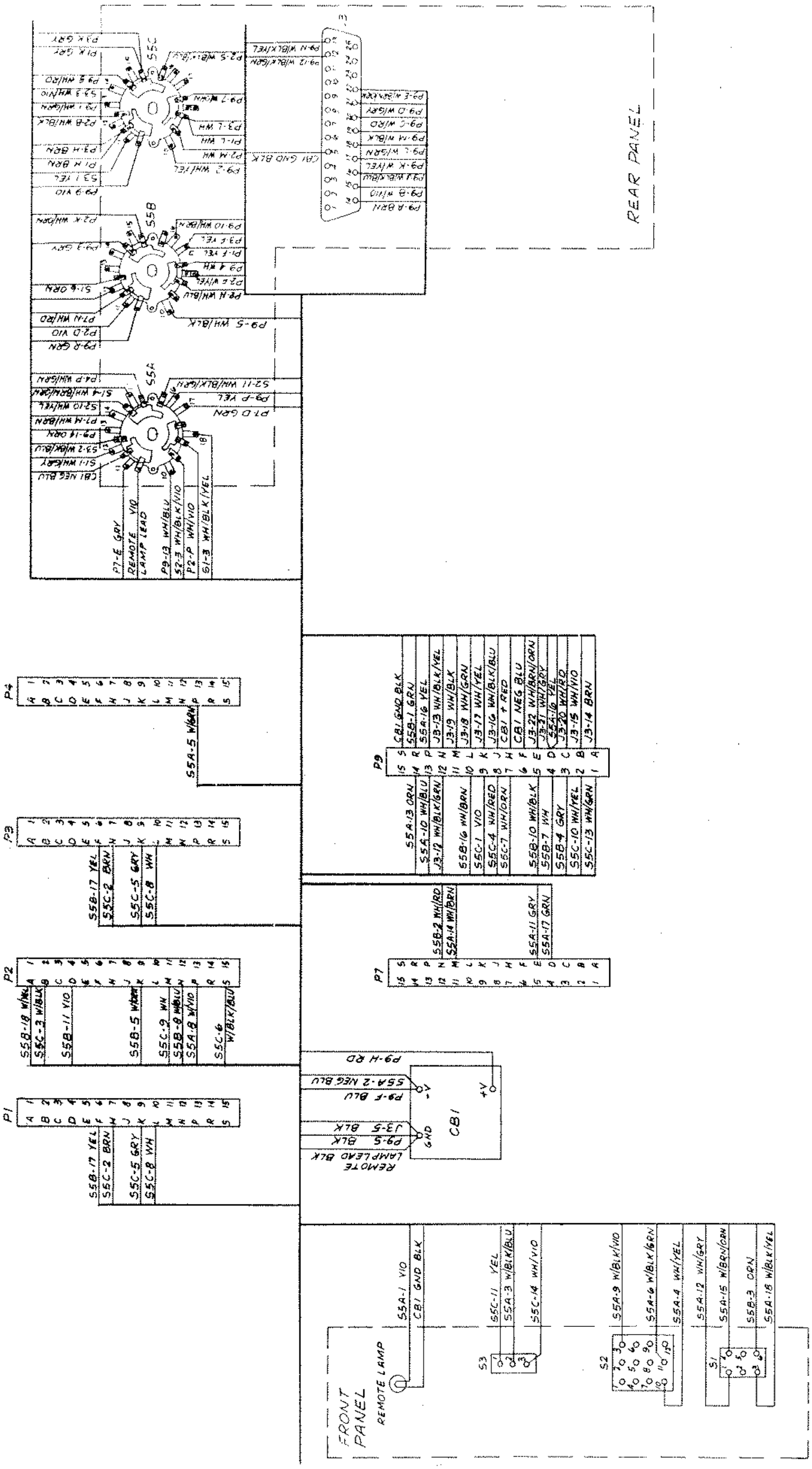


Figure 8-1. Option 102 Interconnecting Diagram (Drawing No. 102567D)

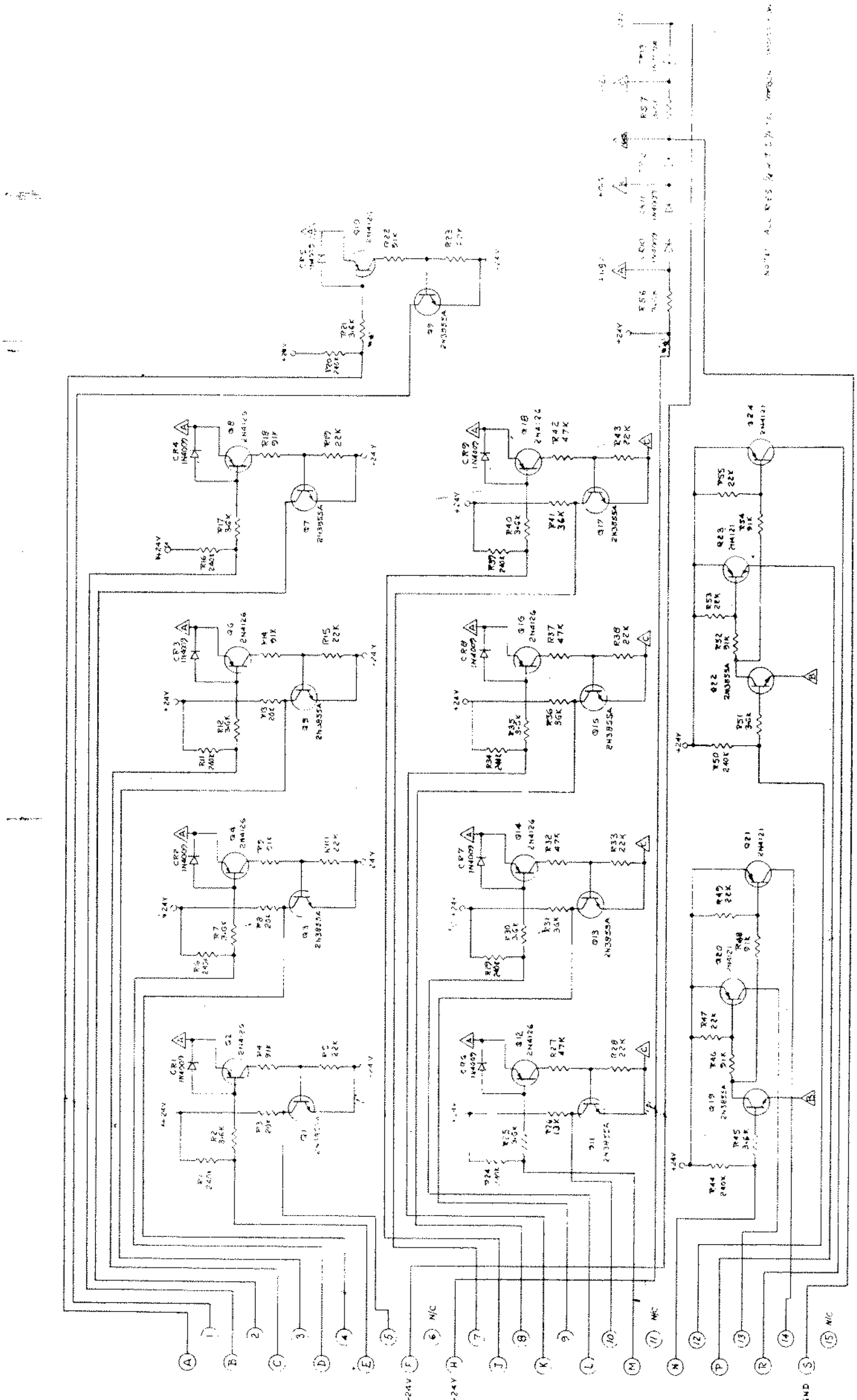


Figure 8-2. Option 102 Main Frame Card A9 - Remote Control Circuits, Schematic Diagram (Drawing No. 101673B)

101672A

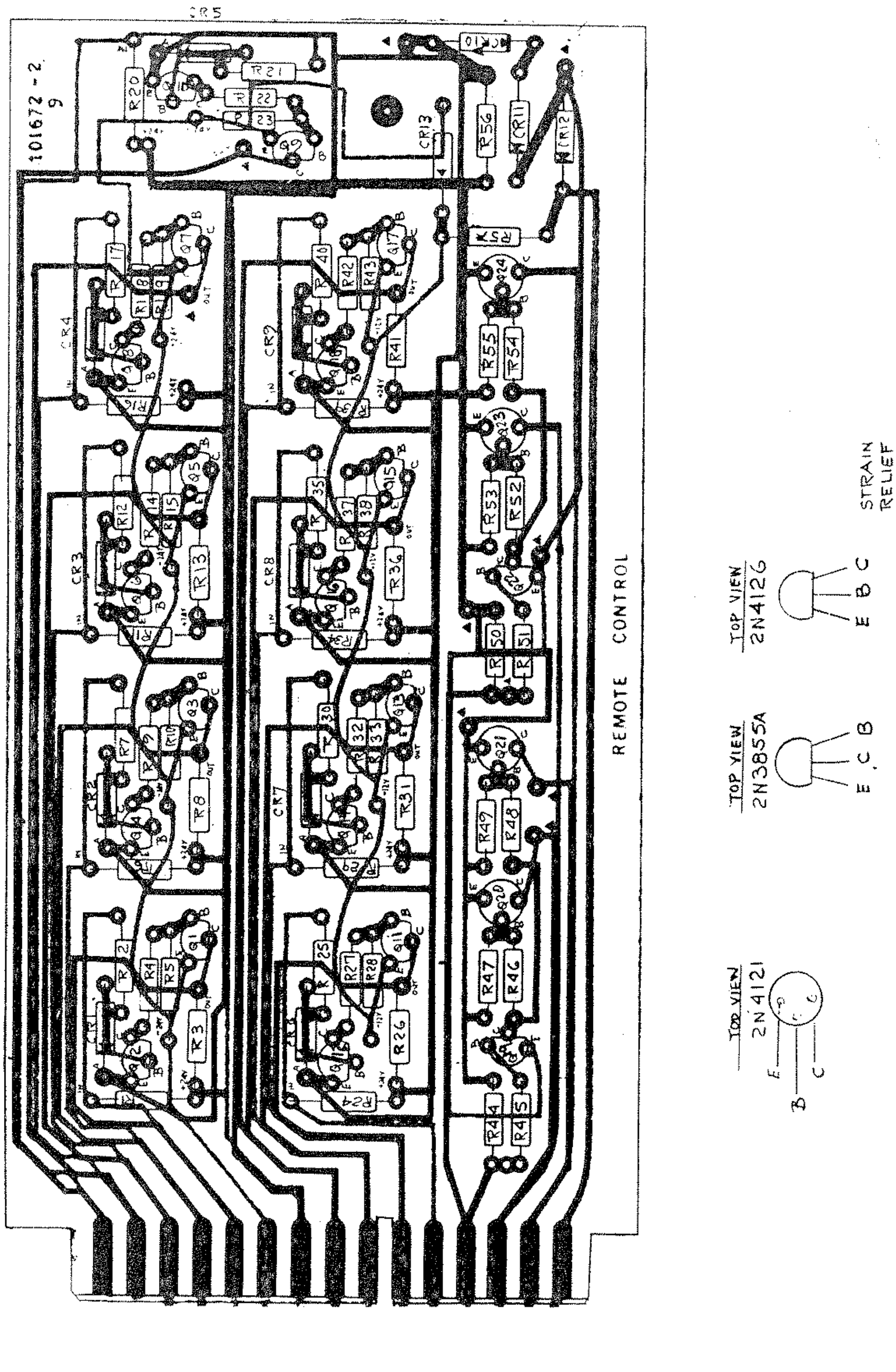


Figure 8-3. Option 102 Main Frame Card A9 - Remote Control Circuits, Parts Location (Drawing No. 101672A)

8-21. OPTION 103

8-22. Option 103 added to any of the Dranetz Series 305 Phasemeter main frames provides for a faster output response. This feature allows faster tracking of phase angle changes.

8-23. Characteristics

8-24. The following is a comparison of typical output response times between a standard Series 305 Phasemeter and a Series 305 with Option 103:

RESPONSE TIME FOR 99% OF STEP CHANGE OF INPUT ANGLE		
Frequency Range	Standard Series 305	Series 305 with Option 103
5 to 50 Hz	3.2 seconds	1 second
50 to 500 Hz	1.6 seconds	100 ms
0.5 to 5.0 kHz	230 ms	10 ms
5 to 500 kHz	46 ms	1 ms

8-25. Output ripple is not increased by this modification. The increased speed is achieved by using a 3-pole underdamped output filter rather than the standard single pole type. The addition of two extra poles to the filter design may slightly decrease time and temperature stability. Typical values for these characteristics are, $\pm 0.1^{\circ}$ per month and $\pm .01^{\circ}$ per $^{\circ}$C, for units having Option 103.

8-26. Circuit Differences - Option 103 is added to a standard Series 305 Phasemeter by removal of Card 5, Assembly No. 102,516 and installation in its place Card 5 Assembly No. 102,201, and removal of Card 7, Assembly No. 102520 and installation in its place Card 7, Assembly No. 101670. (See figures 8-4 through 8-7 for schematics and assembly drawings, respectively.)

8-27. Maintenance - Paragraph 3-5 of this instruction manual refers to coarse zero and coarse gain adjustments on card 5 (paragraph 5-31). Potentiometer R18 is the coarse zero adjustment and R24 is the coarse gain adjustment. These potentiometers may be located by reference to figure 8-5. A schematic diagram (figure 8-4) is also supplied for repair purposes.

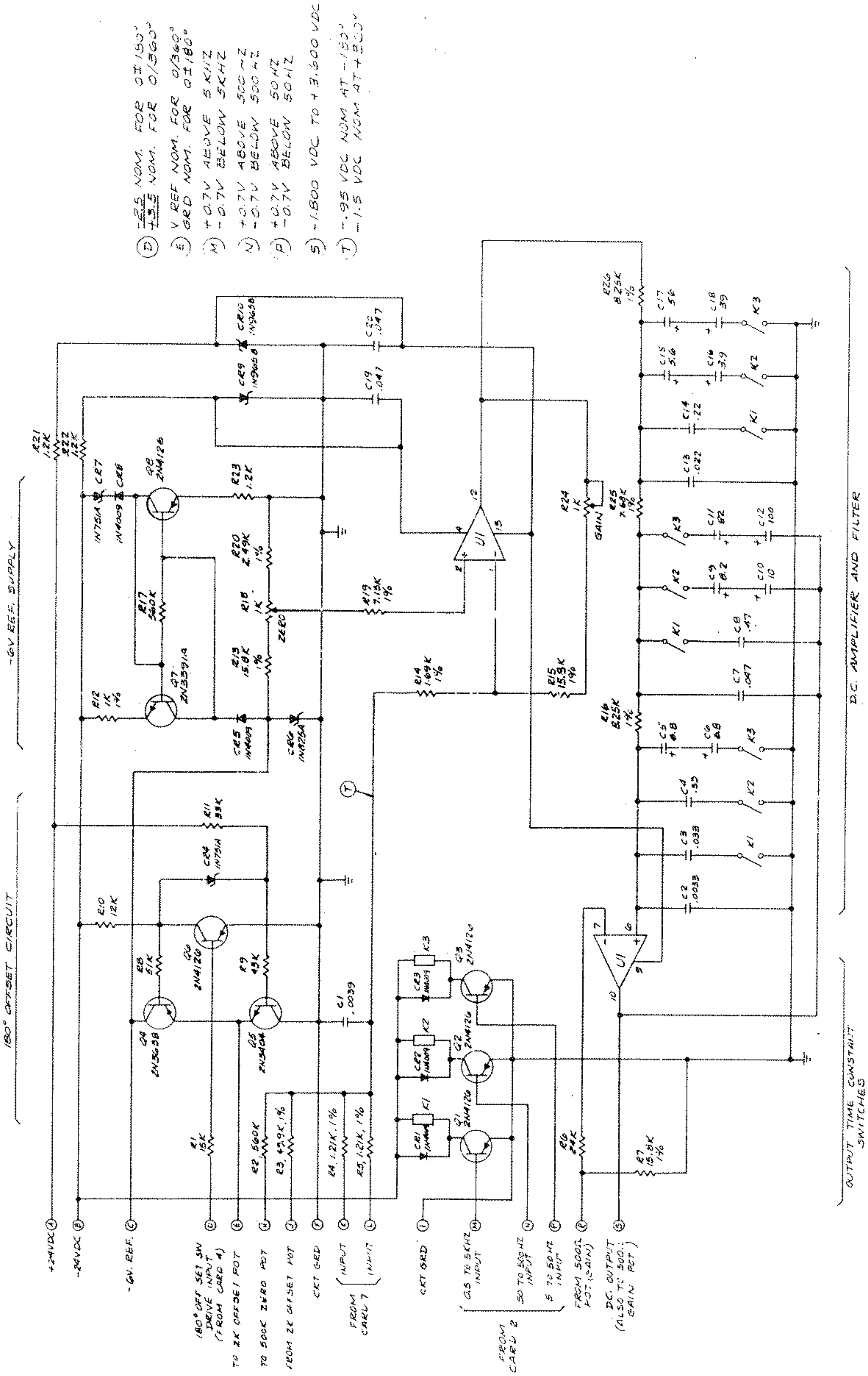


Figure 8-4. Option 103 Main Frame Card A5 DC Amplifier Circuits, Schematic Diagram (Drawing No. 102203B)

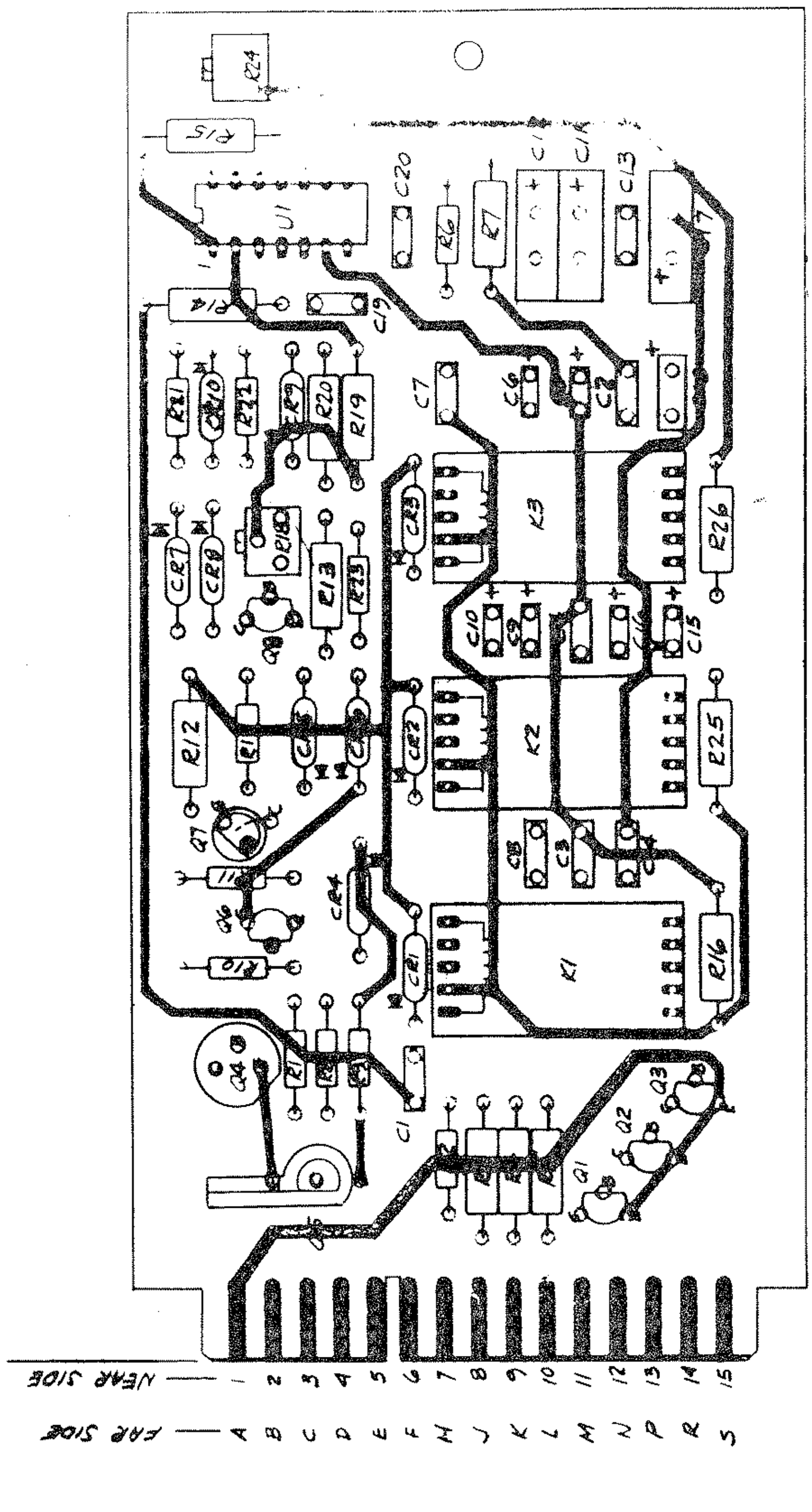


Figure 8-5. Option 103 Main Frame Card A5 DC Amplifier Circuits, Parts Location (Drawing No. 102201B)

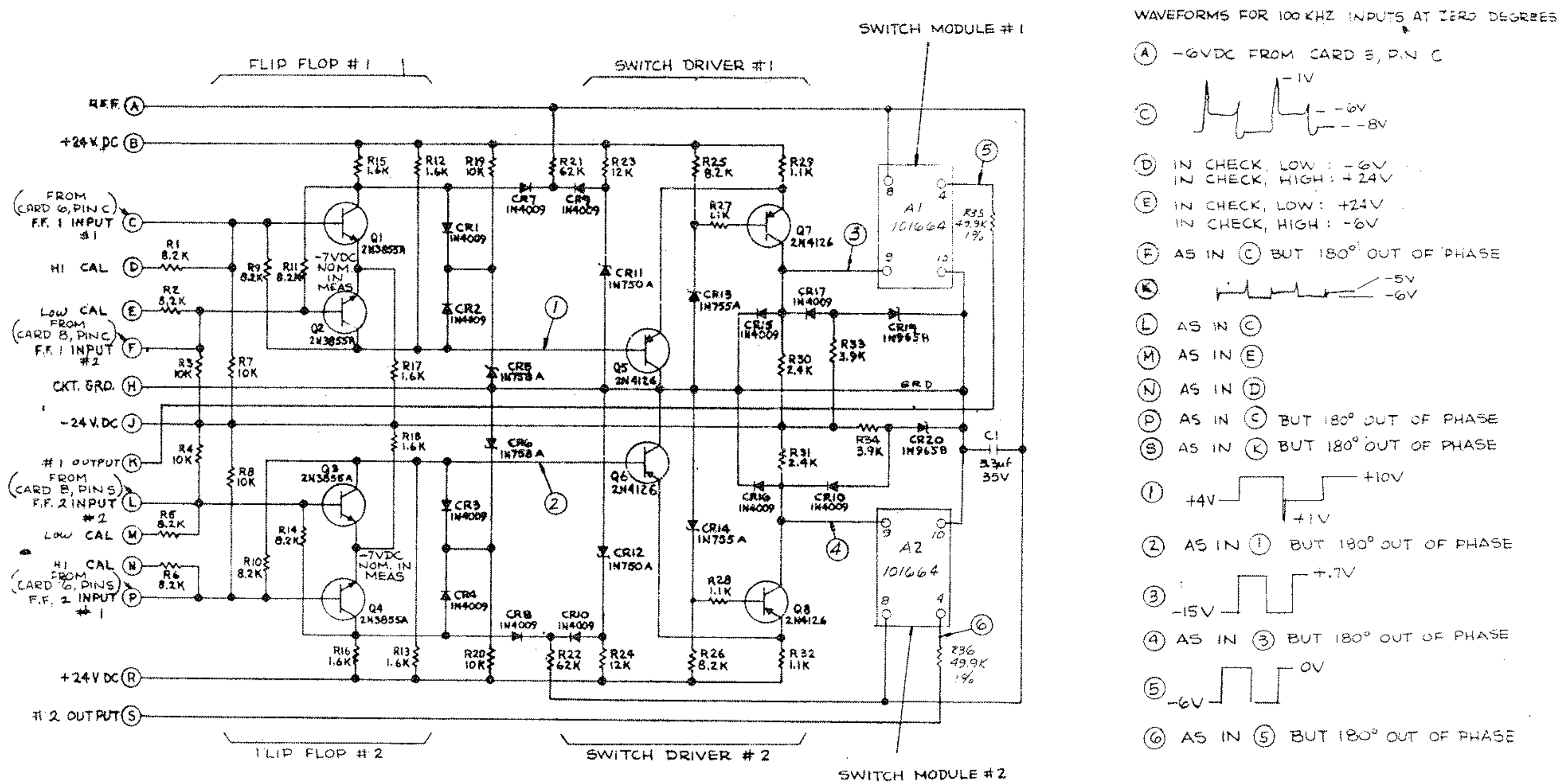


Figure 8-6. Option 103 Main Frame Card A7, Flip-Flop and Switches, Schematic Diagram (Drawing No. 101671C)

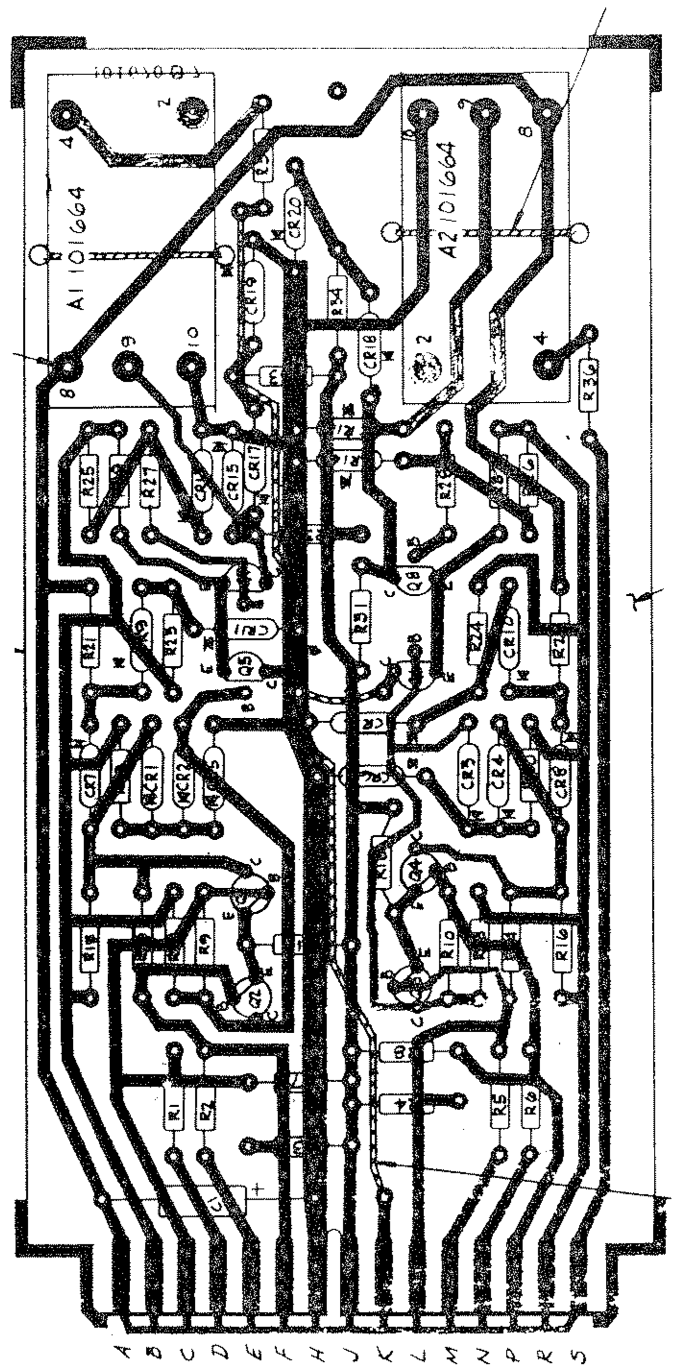


Figure 8-7. Option 103 Main Frame Card A7 Flip-Flop and Switches, Parts Location (Drawing No. 101670C)

8-28. OPTION 105

8-29. Option 105 provides for remote zero adjustment by application of a voltage input to pin 24 of the MAIN FRAME connector J3. This feature may be used to remotely correct a ZERO CAL reading; or, preferably to make a zero correction with in-phase inputs applied as nearly as possible simulating conditions of use.

8-30. Application of +1 volt dc will provide an offset of -1 ±0.2 degrees while application of -1 volt dc will provide an offset of +1 ±0.2 degrees. Note that the phase offset polarity is opposite to that of the applied voltage.

8-31. OPTION 107

8-32. Option 107 provides automatic calibration of the digital readout and outputs of 305 Series phasemeters using 5 digit displays (0.01° resolution). When measuring phase to accuracies greater than ±0.1°, small time and temperature drifts in a digital panel meter become very significant. Option 107, by going through a calibration sequence, removes the errors due to various drifts as often as desired. The complete Zero and Full Scale calibration sequence requires approximately 16 seconds.

8-33. Characteristics - Through the use of a 3-position front panel toggle switch, Option 107 calibrates Zero and Full Scale points with a worst case accuracy of ±0.02 degrees.

8-34. Operation - Except for simplified calibration, Option 107 does not change the operating characteristics of the 305 series phasemeters. The user, however, must perform the automatic calibration sequence detailed in paragraph 2-12 at least once after turning on the instrument. To obtain maximum benefit from this feature, the automatic calibration should be performed immediately prior to each set of measurements taken.

8-35. Circuit Differences - Option 107 consists of circuitry (Card 11) added between the phasemeter"s analog output and the input to the digital panel meter (DPM). The two calibration switches formerly used on the front panel are replaced by a single Automatic Calibrator switch. Since this circuit introduces corrections into the DPM input by reading the BCD outputs, calibration is performed only on the front panel meter readout and on the BCD outputs. The analog output is not affected by this calibration.

8-36. Maintenance - No routine maintenance on Option 107 (Card 11) is required. If the unit does not function to specified ($\pm 0.02^{\circ}$) accuracy, it should be adjusted in accordance with the procedure on paragraph 6-9. If it remains out of spec. after adjustment, repair is required. A schematic diagram (figure 8-9) and an assembly drawing (figure 8-10) are included to aid in repair. Figure 8-8 shows the interconnection diagram for Option 107.

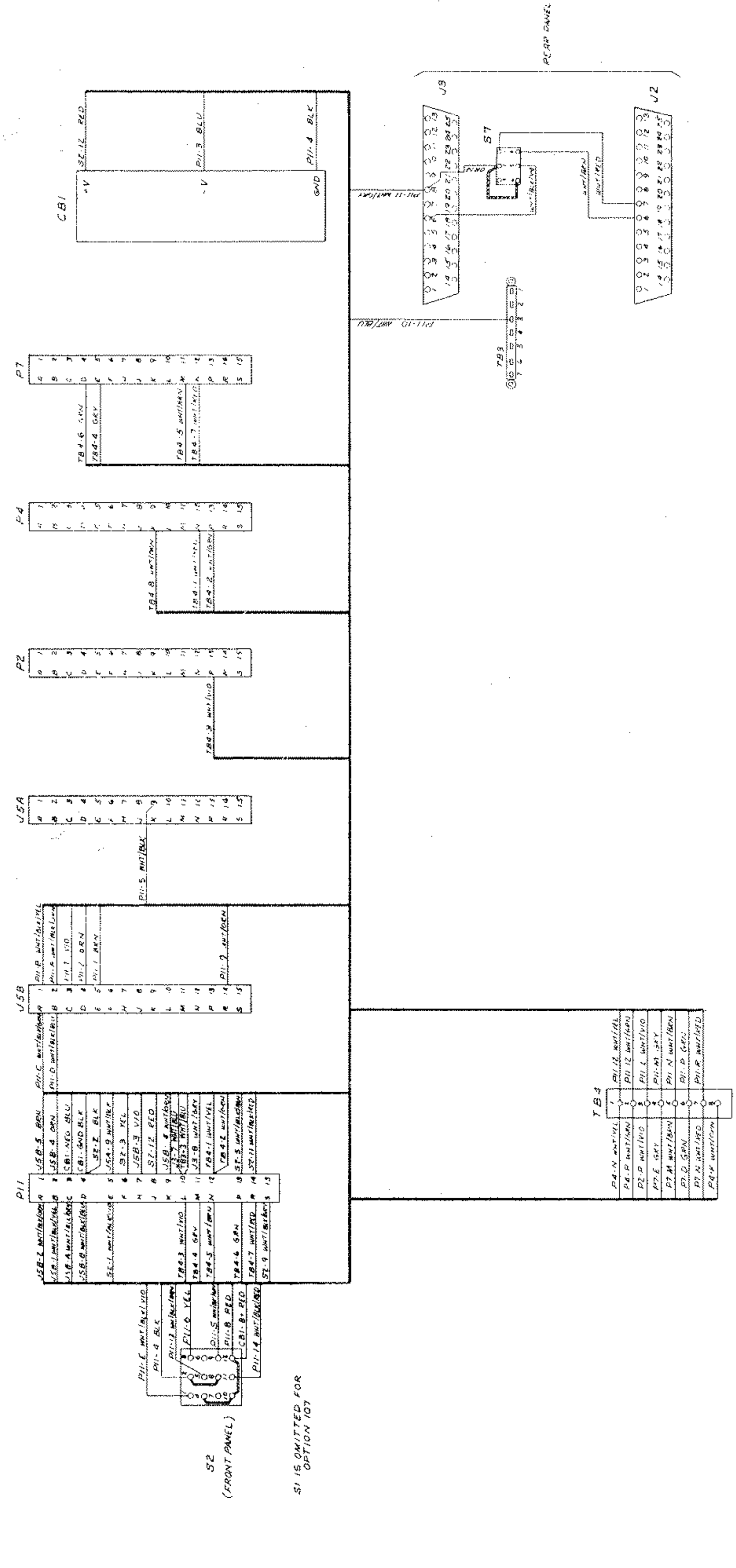


Figure 8-8. Option 107 Interconnecting Diagram
(Drawing No. 102569D)

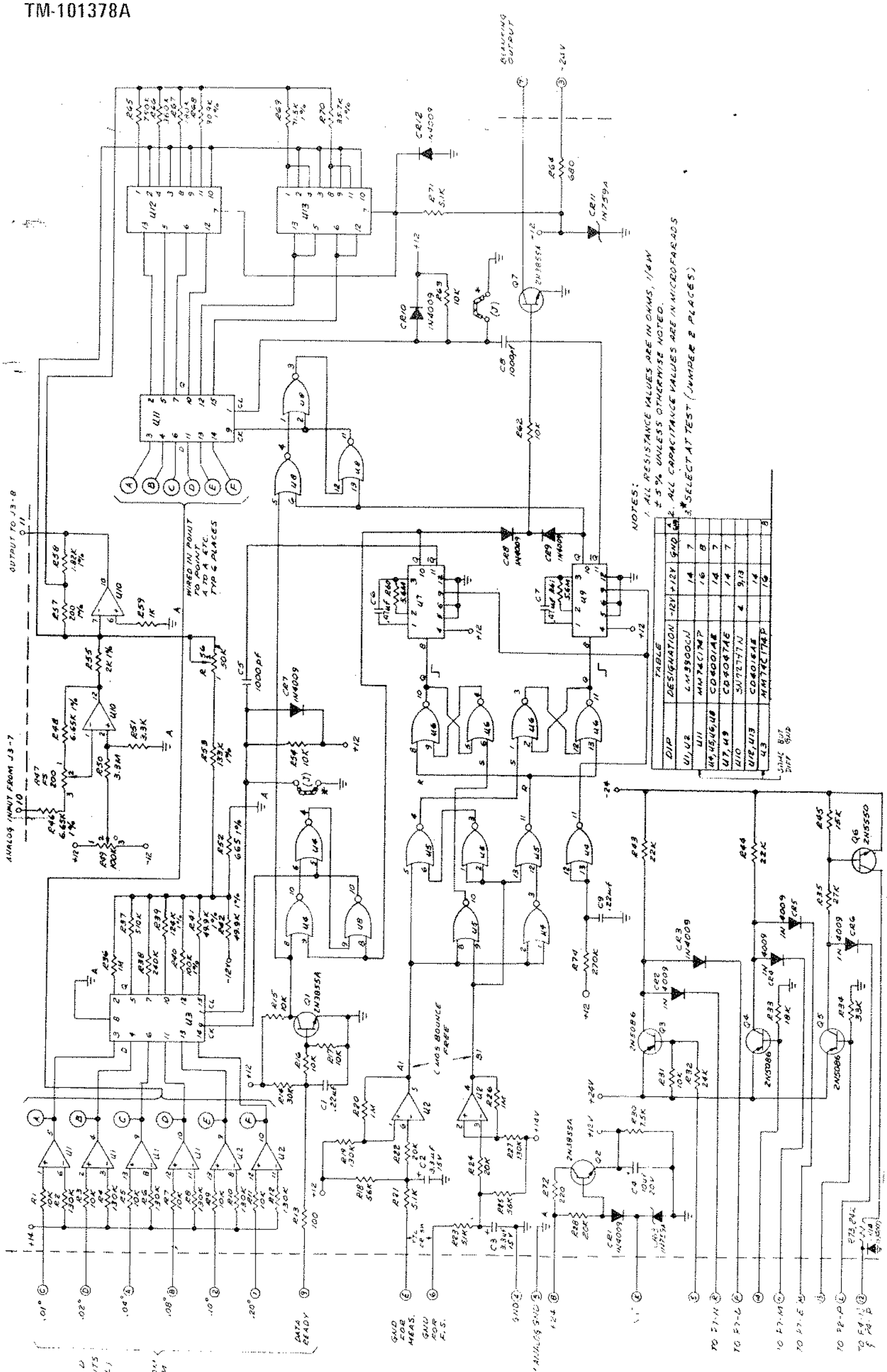


Figure 8-9. Option 107 Main Frame Card All, Automatic Calibration Circuits, Schematic Diagram (Drawing No. 102526E)

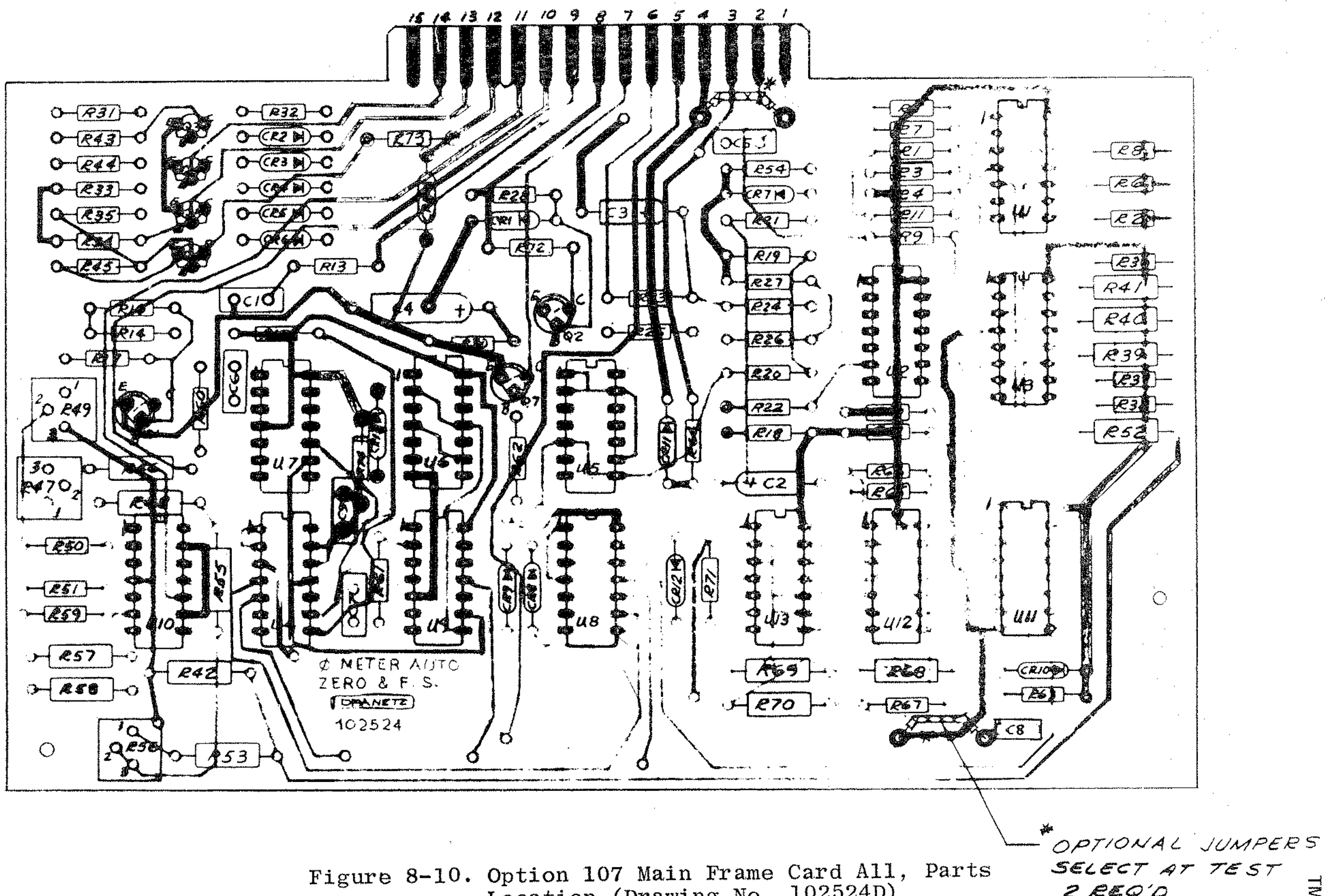


Figure 8-10. Option 107 Main Frame Card A11, Parts Location (Drawing No. 102524D)

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AVAILABLE 305-PA-(   ) PLUG-INS

–3001 -- LEVEL AUTORANGING
–3002 -- SINGLE RANGE
–3005 -- HIGH FREQUENCY (to 11 MHz)
–3007 -- PROGRAMMABLE & AUTORANGING
–3008 -- SINGLE FREQUENCY (50, 60, 400 Hz)
–3009 -- GAIN/PHASE/AMPLITUDE
–3010 -- SPECIAL PURPOSE
–3015 -- PROGRAMMABLE FILTERS

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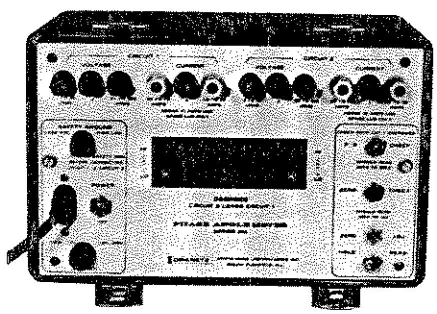

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APPLICATIONS

- Testing and Adjustment of Protective Relays
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- Testing Polyphase Balance
- Determining Power Flow in Interconnected Systems
- Minimizing Circulating Reactive Currents
- Synchronizing Multiple Sources

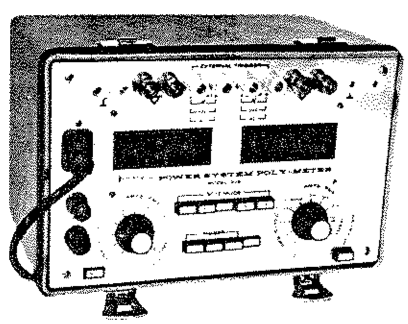
Accurate, precise, and rapid phase measurement is an essential technique in the setup, operation, and maintenance of modern power systems. With the Model 314, virtually all of the limitations and error sources of electromechanical phase meters have been removed, and the overall accuracy of this class of phase measurements has been increased by more than a full order of magnitude. The direct-reading digital presentation of phase, to 0.1° resolution, requires no interpretation or interpolation, and is not subject to reading errors or parallax.

FOR FULL INFORMATION AND DETAILED SPECIFICATIONS WRITE FOR BULLETIN 314.

SERIES 325 POWER SYSTEM POLYMETER

FEATURES

- Field Portable
- Laboratory Accuracy
- Large Digital Display
- Simultaneous measurement and display of two selectable parameters
- Displays continuous, triggered, or maximum readings



The Series 325 is specifically designed for measuring key parameters in electric power systems. Simultaneous measurement combinations of voltage, current, time, and frequency are easily made. Readings may be taken on a continuous basis, or the meter may be triggered to "freeze" readings at a specific time. Time may be measured either in seconds or cycles of the power line frequency. Timing and trigger imputs may be actuated from type A or B dry contacts, or by AC or DC voltages. Special circuits assure positive triggering on first contact (thereby eliminating problem of contact "bounce") and prevent simultaneous start/stop conditions. Options and adapters are available for DC current, DC voltage, fast frequency measurement, low pass filters, and BCD outputs.

FOR FULL INFORMATION AND DETAILED SPECIFICATIONS WRITE FOR BULLETIN 325.

DRANETZ ENGINEERING LABORATORIES INCORPORATED
2385 S. CLINTON AVENUE, SOUTH PLAINFIELD, NEW JERSEY 07080
TEL: (201) 755-7080
TWX: 710-997-9553

DRANETZ Worldwide Leadership in High Speed Precision AC Instrumentation

SERIES 606 POWER LINE DISTURBANCE ANALYZER

DISTURBANCES MEASURED

- Transient Impulse (0.5 - 800μsec.)
- Sag/Surge (instantaneous cycle-to-cycle RMS variations)
- Slow-Averaged Steady-State RMS Variations
- Under/Over Frequency (optional)
- Power interruptions

FEATURES

- Precise Time Correlation
- Audible Alarm
- Battery Carry-over
- Prints only upon disturbance
- Automatic Daily Summary
- Alphanumeric Printout
- No interpretation required
- Portable (16 lbs.)

The 606 is designed specifically for monitoring power lines (single or three phase) connected to line-sensitive electronic equipment. Using a microprocessor and an alphanumeric printer, the 606 classifies each disturbance into IMPULSE, SAG/SURGE, or SLOW AVG change. When preset thresholds are exceeded, the instrument prints out time, classification, channel, magnitude, and duration. Data is also accumulated for end-of-day printout. Since the instrument prints only when a threshold is exceeded, no paper is wasted. The printed record is an easy-to-read list of disturbance events that can total more than 36,000 within each 24 hour time period.

FOR FULL INFORMATION AND DETAILED SPECIFICATIONS WRITE FOR BULLETIN 606.

SERIES 616 DC-AC VOLTAGE DISTURBANCE ANALYZER

- Isolated inputs for simultaneously monitoring AC and DC voltages
- Ultra-high sensitivity for detecting disturbances in DC voltage
- Perfect for pinpointing the effects of AC input line disturbances on the DC outputs of power supplies in computers, digital communications equipment, and medical instrumentation.

The Series 616 is a highly portable easy-to-connect analyzer for recording voltage disturbances on three channels: one AC channel (40-350 VRMS, 45-65 Hz) and two DC channels (4-50 VDC, independent of polarity). As in the Series 606 (described above), IMPULSES, SAGS and SURGES, and SLOW AVERAGE variations are conveniently recorded, when they occur, in an easy-to-interpret alphanumeric printout. The Series 616, with considerably higher disturbance sensitivity on the DC channels than the 606, is specially adapted for a wide range of DC monitoring applications. Two models, the Model 616A and the Model 616B, are available for voltage ranges of 4 to 25 VDC or 8 to 50 VDC.

FOR FULL INFORMATION AND DETAILED SPECIFICATIONS WRITE FOR BULLETIN 616

FREE TECHNICAL ARTICLES

Prepared by the Engineering Department of Dranetz Engineering Laboratories

TM-102,081 Measurement of Power Factor in Single-Phase and Three-Phase Systems Using Phasemeter Techniques (17 page technical paper).
TP-102,980 Phasemeter Specs Can Fool You (6 page reprint from **Electronic Design,** November 22, 1976).
TP-102,981 Application Notes for Sampling Log Voltmeter (10 page technical paper).
TP-102,982 Analysis of Electroacoustic Transducers by Differential Admittance Techniques (5 page reprint from *Journal of Acoustical Society of America,* August, 1966).
TP-102,983 Recording Impedance & Admittance of Transducers under High Power (6 page reprint from **Electronic Products,** May, 1965).
TP-102,984 Application Handbook of Precision Phase Measurement (28 page publication).
TP-102,985 Advantages of Phase-Angle Measurement by Digital Techniques (7 page technical paper).
TP-102,986 Power Line Monitoring & Transient Analysis (19 page technical paper).
TP-102,987 Power Monitoring - It Can Help Cure Your Repair/Replacement Problems (2 page reprint from **Maintenance Engineering,** January, 1976).
TP-102,988 Tracking Down and Identifying Power Line Aberrations (4 page reprint from **Mini-Micro Systems,** July, 1976).
TP-102,989 Incoming Inspection for AC Power (6 page reprint from **Design News,** December 20, 1976).
TP-102,991 When & How to Automate Phase Instrumentation (13 page technical paper).
TP-102,992 Trip-point Testing of Overcurrent, Overvoltage and Impedance Relays (4 page technical paper).

FOR INFORMATION AND A DEMONSTRATION CONTACT THE MAIN OFFICE

OR YOUR LOCAL DRANETZ REPRESENTATIVE

DRANETZ ENGINEERING LABORATORIES INCORPORATED
2385 S. CLINTON AVENUE, SOUTH PLAINFIELD, NEW JERSEY 07080
TEL: (201) 755-7080
TWX: 710-997-9553

CUSTOMER SERVICE DEPT.
DRANETZ ENG. LABS., INC.
2385 So. Clinton Ave.
So. Plainfield, N.J. 07080

REPAIR/SERVICE ORDER

TEL. (201) 755-7080
TWX: (710) 997-9553
CABLE: DRANETZ

IMPORTANT (SEE OTHER SIDE FOR INSTRUCTIONS)

IMPORTANT (ENCLOSE THIS ENTIRE FORM WITH EQUIPMENT)

NOTE: THIS COMPLETED FORM MUST ACCOMPANY RETURNED EQUIPMENT

CUSTOMER SHIPPING & BILLING INFORMATION

CUSTOMER P. O. # ______________ P. O. DATE ______________

SHIP TO: ______________ INVOICE TO: ______________

In Continental U. S., material will be returned by Dranetz to you by UPS, UPS Blue or other carrier chosen by Dranetz unless otherwise designated.

EQUIPMENT BEING RETURNED

Date of Original Purchase: ______________ Original P. O. # ______________

Model No. ______________ S/N ______________

Model No. ______________ S/N ______________

Ancillary equipment also being returned (If you neglect this, these items may not be returned to you).

- ☐ Power & Other Cables ______________
- ☐ Instr. Book ______________
- ☐ Plug-ins (incl. S/N) ______________
- ☐ Connectors ______________
- ☐ Other ______________

RETURN AUTHORIZATION

Have you discussed the problem with Dranetz Sales or Service personnel?

Dranetz Return Authorization # ______________

By: ______________

If so, with whom ______________ Date: ______________

Whom should the Dranetz Customer Service Dept. contact for technical questions?

______________ ______________ ( )______________

NAME (Print) DEPARTMENT TELEPHONE

DESCRIPTION OF PROBLEM

Please be detailed, explicit and complete. Include test data, if this helps to describe the problem.
IMPORTANT: Repairs cannot be made unless this section is completely filled out.
(Attach added sheets if necessary)

____

CHECK WHERE APPLICABLE: IS MALFUNCTION RELATED TO: Warmup ☐ Temperature ☐
Intermittency ☐ Mechanical Handling ☐ Visual Defects ☐ Grounding ☐ Test Data Attached ☐

INITIATOR OF THIS ORDER

____

NAME/TITLE SIGNATURE TELEPHONE

(SEE OTHER SIDE FOR INSTRUCTIONS)

IMPORTANT: FOLLOW INSTRUCTIONS & USE THIS FORM. IT IS DESIGNED TO HELP US HELP YOU.

1. Before returning equipment to our factory, call our Customer Service Department, Tel: (201) 755-7080. Give the model No., serial number, and information on the problem.

   A. Our specialists may be able to solve your problem rapidly without equipment return.

   B. If equipment return is needed, you will be supplied with appropriate instructions and authorization information to expidite the service.

2. If return is to be made,

   A. Fill out the other side of this form COMPLETELY.

   B. Enclose original of form INSIDE the shipping carton, preferably attached by masking tape to the equipment.

   C. Ship prepaid (including insurance); we will return prepaid unless otherwise advised by you.

   D. IMPORTANT - PACK PROPERLY! SHIPPING DAMAGE WILL BE CHARGED TO YOU!

NOTE:

Statement of Warranty - All products of Dranetz Eng. Labs., Inc. are warranted to the original purchaser against defective material and workmanship for a period of one year from the date of delivery. Dranetz will repair or replace, at its option, all defective equipment returned to it, freight prepaid, during the warrantee period, without charge, provided there is no evidence that the equipment has been mishandled or abused.

FILL OUT OPPOSITE SIDE OF THIS FORM AND RETURN WITH EQUIPMENT.

INSTRUCTIONS FOR REPAIR ORDER – DRANETZ ENGINEERING LABS.