OPERATING AND SERVICE MANUAL

MODEL 4270A
AUTOMATIC CAPACITANCE BRIDGE

SERIAL PREFIXED : 1127J-

See Section VII for Other Serial Prefixes.

Part No. 04270-99003

Printed : JUNE 1972

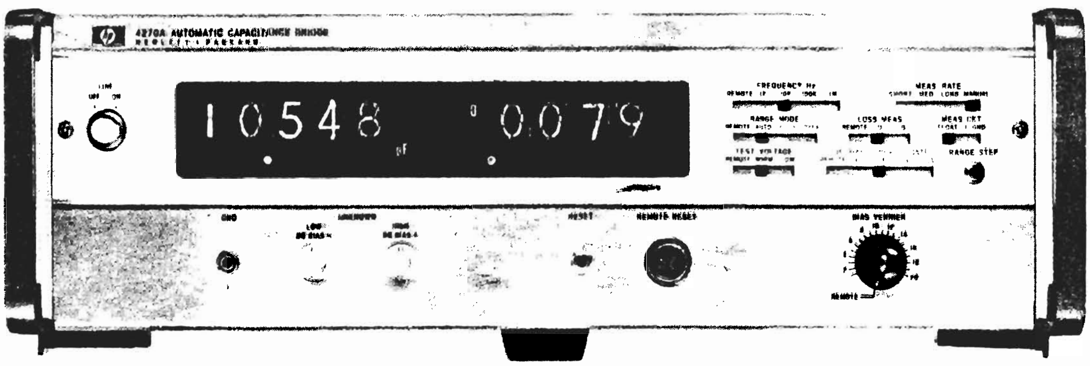
HEWLETT PACKARD

HP 4270A

OPERATING AND SERVICE MANUAL

AUTOMATIC CAPACITANCE BRIDGE

4270A



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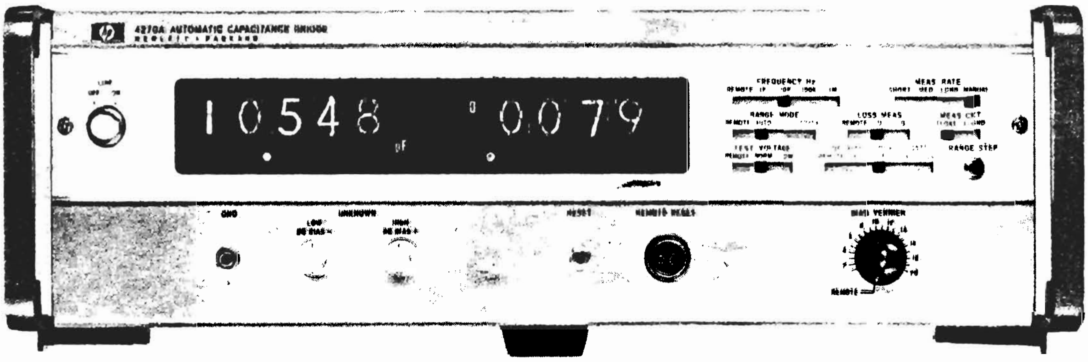
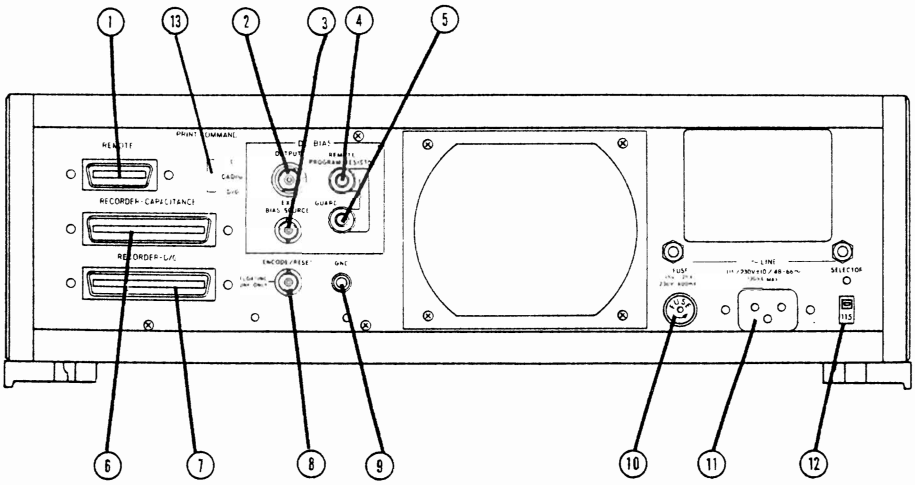


HEWLETT hp PACKARD

HP 4270A



1. REMOTE connector contains remote programming connections to internal switching circuits. See Table 3-7 for actual pin designations. Programming control inputs are applied at these pins as external contact closure to control front panel functions.

2. OUTPUT: DC bias applied to capacitor under test may be monitored. Output impedance is 100kΩ. When measuring unknown with internal dc bias supply at L-GND, this connector supplies dc bias to unknown. See Figure 3-5.

3. EXT BIAS SOURCE: Input connector accepts dc voltage to be applied to unknown capacitor when DC BIAS RANGE control is set to EXT. Input impedance is 100kΩ in series with unknown.

4. REMOTE PROGRAM RESISTOR terminal to be used with GUARD terminal ⑤ when using external control of dc bias.

5. GUARD to be connected to the outer conductor of UNKNOWN connectors. The short strap should be tied to REMOTE PROGRAM RESISTOR terminal ④ except when using remote controller for dc bias.

6. RECORDER-CAPACITANCE connector provides the displayed capacitance data in binary coded decimal form to recorder, analog converter, or data processing equipment. See Paragraph 3-46.

7. RECORDER - D/G connector provides the displayed loss component data.

8. ENCODE/RESET provides connection for remote reset. This is valid only when unknown is floating.

9. GND connector to be used in the absence of suitable power-line grounding.

10. FUSE provides overload protection. Use 1.25 amp slow-blow fuse for 115 V ac operation, 1 amp normal-blow fuse for 230V ac operation.

11. LINE receptacle accepts female connector.

12. Line voltage slide-switch permits selection of either 115 V ac or 230 V ac line voltage.

13. Print Command Selector switch connects Print Command signal to pin 23 of J9 (Recorder Output connector for capacitance) in C-position, or to pin 23 of J10 (Recorder Output Connector for D/G) in D/G or to both of these in parallel in C & D/G-position.

Figure 3-2. Rear Panel Controls and Connectors

OPERATING AND SERVICE MANUAL

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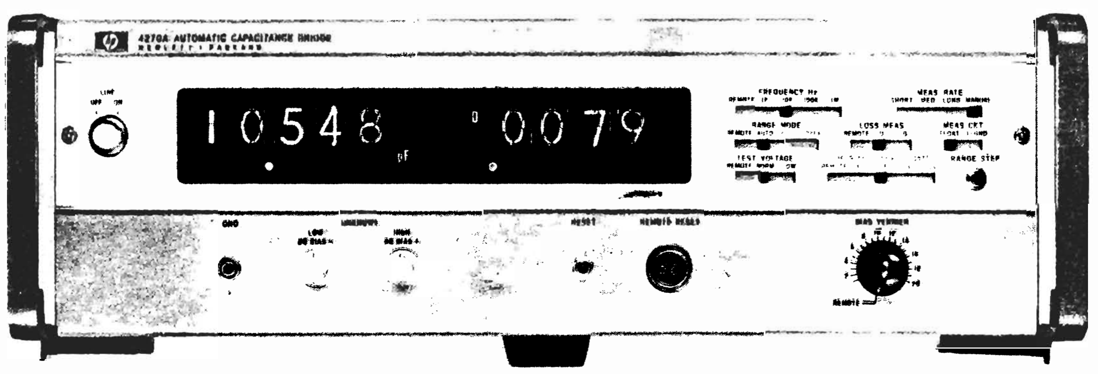
4270A



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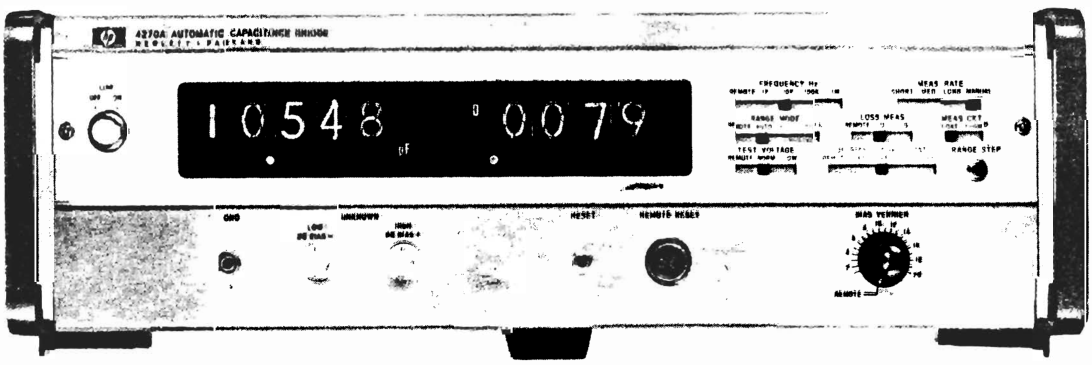
OPERATING AND SERVICE MANUAL

AUTOMATIC CAPACITANCE BRIDGE

4270A



HEWLETT hp PACKARD

CERTIFICATION

The Hewlett-Packard Company certifies that this instrument was thoroughly tested and inspected and found to meet its published specifications when it was shipped from the factory. The Hewlett-Packard Company further certifies that its calibration measurements are traceable to the U.S. National Bureau of Standards to the extent allowed by the Bureau's calibration facility.

WARRANTY AND ASSISTANCE

All Hewlett-Packard products are warranted against defects in materials and workmanship. This warranty applies for one year from the date of delivery, or, in the case of certain major components listed in the operating manual, for the specified period. We will repair or replace products which prove to be defective during the warranty period provided they are returned to Hewlett-Packard. No other warranty is expressed or implied. We are not liable for consequential damages.

Service contracts or customer assistance agreements are available for Hewlett-Packard products that require maintenance and repair on-site.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

OPERATING AND SERVICE MANUAL

MODEL 4270A

AUTOMATIC CAPACITANCE BRIDGE

SERIAL PREFIXED : 1127J-

See Section VII for Other Serial Prefixes.

9-1, TAKAKURA-CHO, HACHIOJI-SHI, TOKYO, JAPAN

Part No. 04270-99003

Printed : JUNE 1972

HEWLETT PACKARD

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SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION

1-2. The Hewlett-Packard Model 4270A Automatic Capacitance Bridge, Figure 1-1, is designed to meet the requirements of the laboratory, manufacturing and incoming inspection where accuracy and speed are essential. The HP 4270A performs capacitance and loss measurement in direct digital readout with completely automatic operation at 4 frequencies from 1kHz to 1MHz. Capacitance measurement capability from 0.001pF to 1.2μF is provided in six automatically selectable ranges. The loss component is measured as either parallel conductance or dissipation factor; loss (G) is measurable down to 0.1 nano-mhos (n ℧). Three-terminal measurement guards the unknown, eliminating the error effects of unwanted stray capacities at the measuring terminals. The instrument is provided with a continuously variable internal dc bias supply up to 200V.

1-3. All major instrument functions are remotely programmable at rear panel connectors, eliminating manipulation of front panel controls in high volume, multi-variable applications. Digitally coded (BCD) output information is available on the rear panel for use with printers, recorders, sorters, controllers or computers. Complete specifications for the Model 4270A are listed in Table 1-1.

1-4. INSTRUMENT IDENTIFICATION

1-5. Hewlett-Packard uses a two-section nine-character (0000A00000) or eight-character (000-00000 or 000A00000) serial number. The first three or four digits (serial prefix) identify a series of instrument; the last five digits identify a particular instrument in that series. A letter placed between the two sections identifies the country where the instrument was manufactured. The serial number appears on a plate located on the rear panel. All correspondence with Hewlett-Packard Sales/Service Offices with regard to an instrument should refer to the complete serial number.

1-6. MANUAL CHANGES

1-7. This manual provides operating and service information for the HP Model 4270A Automatic Capacitance Bridge. The information in this manual applies directly to an instrument with the serial prefix or number indicated on the title page of this manual.

1-8. If the serial prefix of an instrument is higher than that on the title page, a "Manual Changes" sheet supplied will describe changes which will adapt this manual to provide correct coverage. Technical corrections (if any) to this manual, due to known error in print, are called Errata and are shown on the change sheet.

1-9. If the serial prefix or number of an instrument is lower than that on the title page, see Section VII Manual Changes and Options. For information on Manual coverage of any HP instrument, contact the nearest Hewlett-Packard Sales/Service Office (addresses are listed at the rear of this manual).

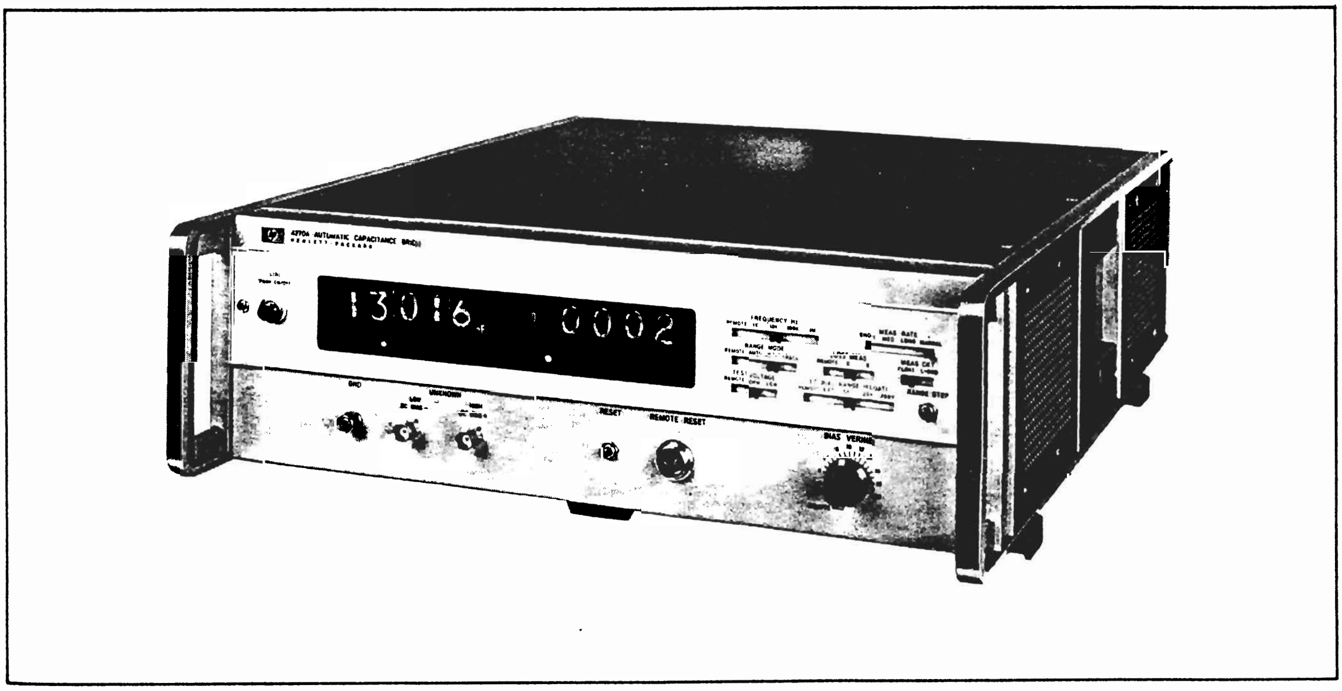


Figure 1-1. Model 4270A Automatic Capacitance Bridge

1-10. OPTIONS

1-11. The five options offered for the Model 4270A are described in Section VII.

1-12. SERVICE KIT AVAILABLE

1-13. A SERVICE KIT for 4270A Automatic Capacitance Bridge is available. It consists of four special extenders, RF connectors, and a cable, all listed in Table 1-2.

Table 1-2. Contents of 4270A Service Kit

Q'ty	Description	HP Part No.
1	Extender for A14 and A15	04270 - 7760
1	Special Extender I	04270 - 7762
1	Special Extender II	04270 - 7764
1	Extender	04270 - 7765
1	RF Connector	1250 - 0813
1	BNC to RF Cable	04342 - 7601

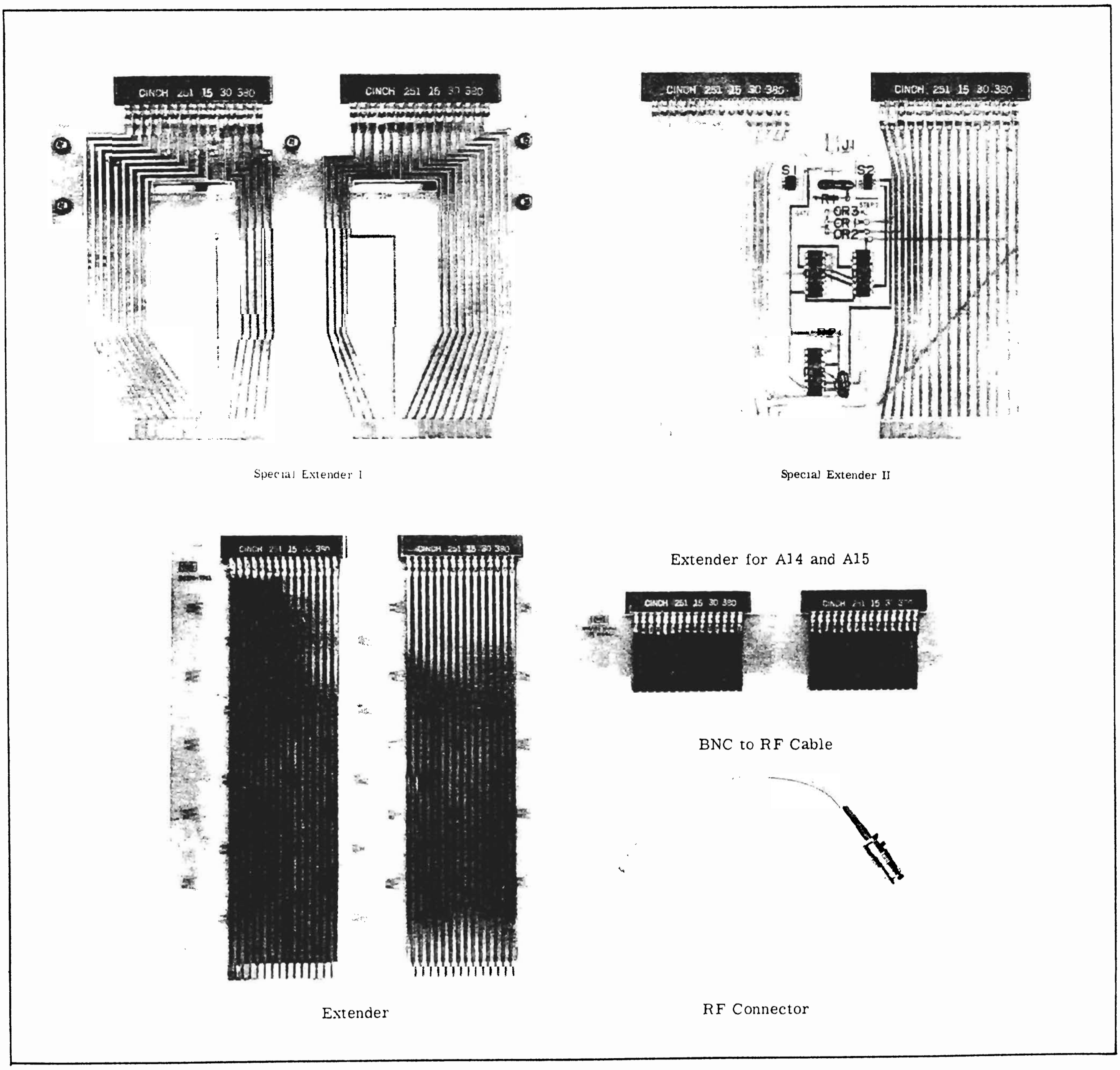


Figure 1-2. Service Kit.

Table 1-1. Specifications.

MEASURING CIRCUIT:

FLOAT: guarded terminals of unknown are floated from ground.

L-GROUND: one side of unknown terminals is grounded, guard is retained.

PARAMETERS MEASURED:

Capacitance, equivalent parallel conductance and dissipation factor.

MEASURING FREQUENCY:

1 kHz, 10 kHz, 100 kHz and 1 MHz. ±1%

AVAILABLE FULL SCALE RANGES:

CAPACITANCE 1 kHz	CAPACITANCE 10 kHz	CAPACITANCE 100 kHz	CAPACITANCE 1MHz	CONDUCTANCE	DISSIPATION FACTOR
180.00pF	18.000pF			999.9n ℧	.9999
1800.0pF *	180.00pF	18.000pF		9.999µ ℧	
18.000nF	1800.0pF	180.00pF	18.000pF	99.99µ ℧	
180.00nF	18.000nF	1800.0pF	180.00pF	999.9µ ℧	
1.2000µF	180.00nF	18.000nF	1200.0pF	9.999m ℧	

NOTE: heavy line encloses available full-scale ranges in L-GROUND
full display of D/G is obtained at TRACK MODE, and is limited by AUTO RESET of 1.5 sec at AUTO/HOLD MODE
* Accuracy at L-GROUND is not specified on this range

REPEATBILITY:

TEST VOLTAGE		C G	D
NORMAL		± 2 counts	± 2 Cs/Cx counts
LOW		± 8 counts	± 8 Cs/Cx counts
DC BIAS ON 1 kHz 100 pf 10 kHz 10 pf RANGE	NORMAL	± 4 counts	± 4 Cs/Cx counts
	LOW	± 16 counts	± 16 Cs/Cx counts

RANGE MODE:

AUTO: range selection and balance performed automatically.

HOLD: range is held on fixed position determined by previous AUTO, and can be selected manually by depressing RANGE STEP. Balance begins with fourth digit from right.

TRACK: range held on fixed position, balance begins with last digit.

BALANCING TIME:

typically 0.5s.

MEASURING RATE:

Time interval between balancing operations, selected by MEAS RATE, are 70 ms, 2 secs and 5 secs. Repetition period equals balance time plus time interval between balancing. Display is stored until completion of succeeding balancing operation.

RESET:

Bridge is reset and new balance operation started automatically (at MEASURING RATE), or manually by RESET push button, or remotely by contact closure. If the unknown changes value during the balance operation, or other changes shift the unknown outside of the balance range, the bridge resets to rebalance after 1.5 seconds.

TEST VOLTAGE ACROSS UNKNOWN:

NORMAL: 1V rms constant, in pF or nF at 1 kHz, 0.1V rms constant, in µF at 1 kHz. 0.5V rms constant, at 10 kHz, 100 kHz, and 1 MHz.

LOW: One-fifth of Normal

TEST VOLTAGE ACCURACY: ±10%

RESIDUAL DC VOLTAGE: at HIGH terminal: less than ±200mV
at LOW terminal: less than ±200mV

ACCURACY:

Accuracy listed in Table applies over a temperature range of 25°C ± 5°C.

			1 kHz 1µF RANGE	1 kHz except 1µF RANGE	10 kHz	100 kHz	1 MHz
CAPACITANCE	TEST VTG NORMAL	D<0.1	±(0.1% + 1 count + 0.01pF)			±(0.3% + 1 count + 0.01pF)	±(1% + 1 count + 0.01pF)
		0.1≤D<1	±(0.2% + 1 count + 0.01pF)			±(0.5% + 1 count + 0.01pF)	±(2% + 1 count + 0.02pF)
	TEST VTG LOW	D<0.1	±(0.3% + 6 counts)	±(0.2% + 6 counts + 0.01pF)		±(0.4% + 6 counts + 0.01pF)	±(1.1% + 6 counts + 0.01pF)
		0.1≤D<1	±(0.6% + 6 counts)	±(0.4% + 6 counts + 0.01pF)		±(0.8% + 6 counts + 0.01pF)	±(2.2% + 6 counts + 0.01pF)
	if DC BIAS used add.	FLOAT	−3.2 Dx·Cs (µF) x (100 ± 10)%				
		L-GND	unspecified. (depends on C & D of blocking capacitor used.)				
CONDUCTANCE	TEST VTG:	NORMAL	±(1% + 10 counts)				±(3% + 10 counts)
	TEST VTG.	LOW	±(1.2% + 15 counts)	±(1 1% + 15 counts)			±(3.1% + 15 counts)
	if DC BIAS used add.	FLOAT	+{3.2 Cs (µF)}^{2} x (100 ± 20)%				
		L-GND	unspecified,				
DISSIPATION FACTOR	TEST VTG.	NORMAL	±{1% + (10 + Cs/Cx) counts}				±{3% + (10 + Cs/Cx) counts}
	TEST VTG.	LOW	★	±{(1.2 + 0.06 Cs/C'x)% + (10 + 5Cs/Cx) counts}			±{(3.2 + 0.06 Cs/Cx)% + (10 + 5 Cs/Cx) counts}
	if DC BIAS used Add:	FLOAT	+{(3.2 Cs (µF)^2 + 3.2 Dx·Cs(µF)} x (100 ± 20)%				
		L-GND	unspecified,				

NOTE: Cs = internal standard capacitor
Cx = capacitance measured
Dx = dissipation factor measured

★ ±{(1.4 + 0.06 Cs/Cx)% + (10 + 5 Cs/Cx) counts}

ACCURACY: 0°C ~ 20°C and 30°C ~ 50°C

CAPACITANCE; Accuracy reduced by factor of 2.

CONDUCTANCE; Accuracy reduced by additional error of 0.5% at 1 kHz, 10 kHz and 100 kHz, 1% at 1 MHz.

DISSIP. FACTOR; Accuracy reduced by factor of 2.

Table 1-1. Specifications. (Cont'd)

STANDARD CAPACITANCE;

STANDARD CAPACITANCE:

STANDARD CAPACITANCE:

FULL SCALE RANGE	STANDARD CAPACITANCE
18.000pF	10pF
180.00pF	100pF
1800.0pF and 1200.0pF	1nF
18.000nF	10nF
180.00nF	100nF
1.2000μF	100nF

DC BIAS: INTERNAL OR EXTERNAL to ±200V, in HOLD and TRACK mode.

INTERNAL BIAS at FLOAT measurement:

VOLTAGE: 0 to 20V dc; 0 to 200V dc; continuously variable on front panel

DIAL ACCURACY: ±5% of full scale

SOURCE RESISTANCE: 100kΩ

POLARITY: LOW unknown terminal (−), HIGH unknown terminal (+) in FLOAT position of MEAS CKT control.

REMOTE: programmable by resistor with 250Ω/V rate at 20V range, 25Ω/V rate at 200V range.

REMOTE ACCURACY: ±2% of full scale.

INTERNAL BIAS at L-GROUND: an additional connection using a blocking capacitor and a coaxial cable is necessary for INTERNAL source.

BLOCKING CAPACITOR: HP MODEL 16018A (1 μF ±200V DC max.) is recommended for this purpose.

DATA OUTPUTS: (If unknown in FLOAT)

CODE: positive 4 line BCD (1-2-4-8), 13 columns consisting of decimal location, over-range, units, 5 digits of capacitance and 4 digits of conductance or dissipation factor.

"1" LEVEL: +5V, open circuit, source impedance 2.5K at all data except at 10^4 digit of C data and OUT OF RANGE
+4V, open circuit, source impedance 2.5K at 10^4 digit of C data and OUT OF RANGE

"0" LEVEL: ground

PRINT COMMAND: DC coupled, print level +5V, print hold-off level OV.

CONTROL INPUTS

TRIGGER HOLD OFF LEVEL: level must be between negative 10V and 15V.

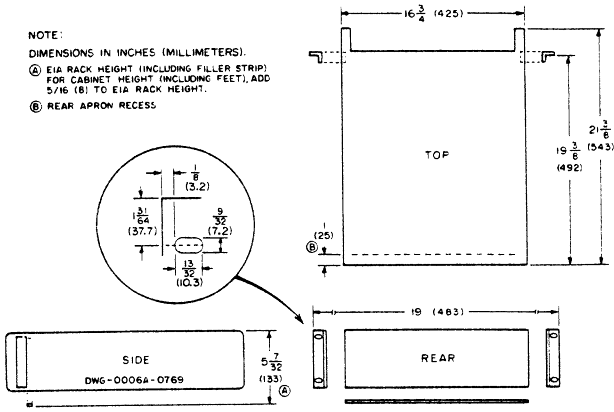
REMOTE PROGRAMMING: eight front-panel functions can be remotely controlled by external contact closure to ground with impedance less than 400Ω..Programmable functions are RESET, FREQUENCY, RANGE MODE, TEST VOLTAGE, LOSS MEAS, RANGE STEP, DC BIAS RANGE, BIAS VERNIER.

OPERATING TEMPERATURE: 0°C to 50°C

POWER REQUIREMENTS: 115 or 230V ac ±10%, 50 to 60Hz, approx. 110W.

WEIGHT: 34lb (15.5kg)

DIMENSIONS:



ACCESSORIES AVAILABLE

16011A TEST FIXTURE, Binding post type direct BNC coupling to 4270A.

16012A TEST FIXTURE, for axial lead type capacitors, direct coupling to 4270A.

16013A TEST FIXTURE, for Perpendicular type capacitors, direct coupling to 4270A.

16015A TEST FIXTURE, with RESET BUTTON, coaxial cable coupling to 4270A.

16016A and 16017A TEST FIXTURES, same as 16012A and 16013A, respectively, except that blocking capacitor inserted between HIGH terminal of fixture and 4270A. BNC terminal provided for monitoring DC bias voltage.

NOTE: Especially useful when measuring small diode capacitances including external DC-biasing and bias monitoring at measurement frequencies of 100kHz and 1MHz.

16018A BLOCKING CAPACITOR, for DC biasing and for blocking DC voltage from unknown to be measured at HIGH terminal when MEAS CKT is in L-GND mode. Blocking capacitor is 1nF ±10%, 200 VOLTS max.

OUTPUT CABLES:

NOTE: See Figure A below for cable connections

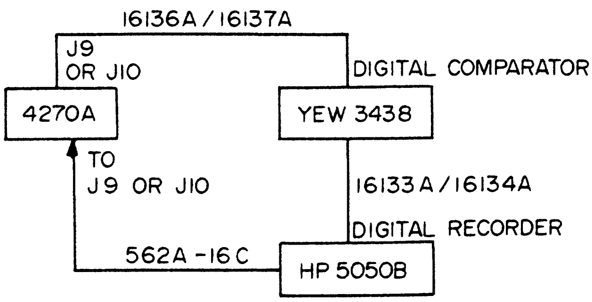


Figure A. Cable Connections

Table 1-1. Specifications. (Cont'd)

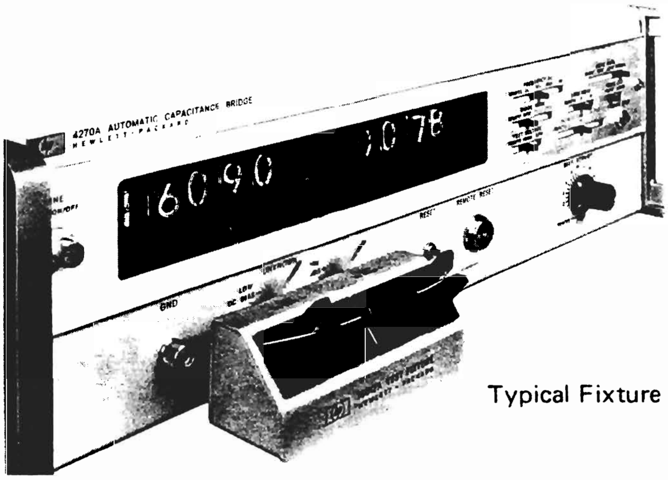
16133A OUTPUT CABLE, from YEW 3438 to Hp 5050B —output is 4 highest digits of 4270A Capacitance Display (See also 16134A)

16134A OUTPUT CABLE, from YEW 3438 to Hp 5050B —output is 4 lowest digits of 4270A Capacitance Display or 4 output digits of DISSIPATION FACTOR/CONDUCTANCE Display.

16136A OUTPUT CABLE, from 4270A to YEW 3438 —output is 4 highest digits of 4270A Capacitance Display.

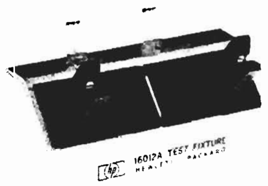
16137A OUTPUT CABLE, from 4270A to YEW 3438 —output is 4 lowest digits of 4270A Capacitance Display or 4 output digits of DISSIPATION FACTOR/CONDUCTANCE Display.

562A–16C RECORDER OUTPUT MATCHING CABLE, for connecting 4270A to 5050B Digital Recorder.

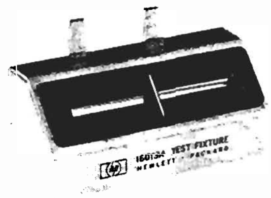


Typical Fixture Attached to 4270A

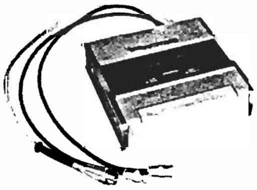
16011A



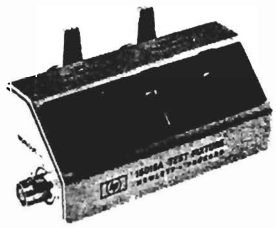
16012A



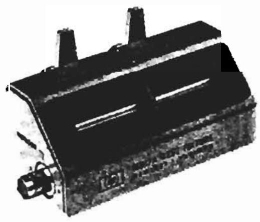
16013A



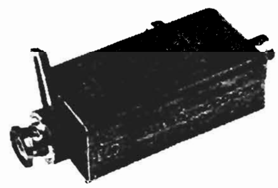
16015A



16016A



16017A



16018A

Figure B. Accessories

SECTION II
INSTALLATION

2-1. INTRODUCTION

2-2. This section contains information for unpacking, inspection, repackaging, storage, and installation of the Model 4270A.

2-3. UNPACKING AND INSPECTION

2-4. If the shipping carton is damaged, ask that the carrier's agent be present when the instrument is unpacked. Inspect the instrument for damage(scratches, dents, broken knobs, etc.). If the instrument is damaged or fails to meet specifications, notify the carrier and the nearest Hewlett-Packard field office (see list at back of this manual). Retain the shipping carton and the padding material for the carrier's inspection. The field office will arrange for the repair or replacement of your instrument without waiting for the claim against the carrier to be settled.

2-5. PERFORMANCE CHECKS

2-6. The electrical performance of the Model 4270A should be verified upon receipt. Performance checks suitable for incoming inspection are given in Section V, Maintenance.

2-7. STORAGE AND SHIPMENT

2-8. PACKAGING. To protect valuable electronic equipment during storage or shipment always use the best packaging methods available. Your Hewlett-Packard field office can provide packing material such as that used for original factory packaging, Contract packaging companies in many cities can provide dependable custom packaging on short notice. Here are a few recommended packaging methods:

a. RUBBERIZED HAIR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument securely in strong corrugated container (350 lb/sq in. bursting test) with 2-inch rubberized hair pads placed along all surfaces of the instrument. Insert fillers between pads and container to ensure a snug fit.

b. EXCELSIOR. Cover painted surfaces of instrument with protective wrapping paper. Pack instrument in strong corrugated container (350 lb/sq in. bursting test) with a layer of excelsior about 6 inches thick packed firmly against all surfaces of the instrument.

2-9. PACK INSTALLATION

2-10. The Model 4270A is ready for bench operation as shipped from the factory. Additional parts necessary for rack mounting are packaged with the instrument. To convert for rack installation, refer to Figure 2-1 and proceed as follows:

a. Remove tilt stand.

b. Remove feet (press the foot-release button, slide foot toward center of instrument, and lift off).

c. Remove adhesive-backed trim strips.

d. Attach filler strip along bottom edge of front panel.

e. Attach flanges to front end of sides (larger corner-notch toward bottom of instrument). Instrument is now ready to mount in standard rack.

CAUTION

Ambient temperature in rack during operation should not exceed a maximum of 122° F (50° C). Be sure instrument position in rack permits air circulation to intake in center area of rear panel and that nearby instruments do not discharge hot air near intake.

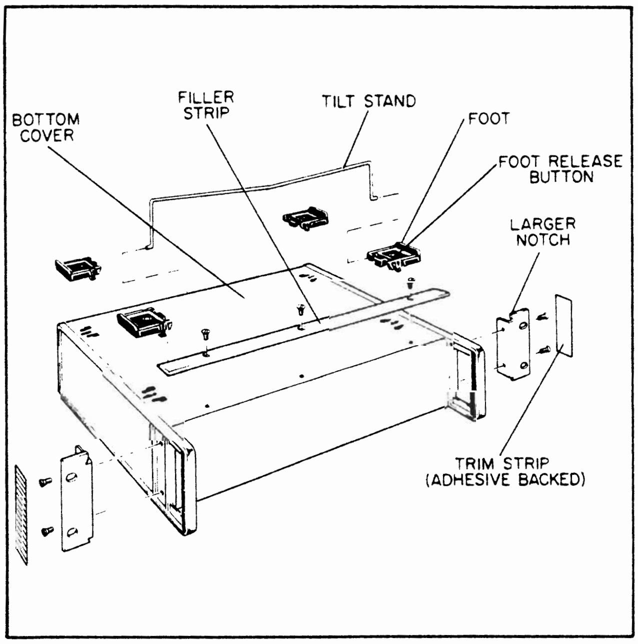


Figure 2-1. Conversion for Rack Mounting

2-11. POWER CONNECTION

2-12. LINE VOLTAGE. The Model 4270A may be operated from either 115- or 230-volt (±10%) 50 or 60Hz power lines, which can supply approximately

110 watts. A slide switch on the rear panel permits quick conversion for operation from either voltage. Insert a narrow-blade screwdriver in the switch slot and slide the switch down for 230-volt operation("230" marking exposed) or up for 115-volt operation("115" marking exposed). The Model 4270A is supplied with 115-volt fuse; be sure to replace this fuse for 230-volt operation; see Table 2-1.

Table 2-1. AC Line Fuse

Conversion	115-volt	230-volt
Slide Switch	UP ("115")	Down ("230")
AC Line Fuse	1.25 amperes Slow-Blow 2110-0305	0.6 amperes Slow-Blow 2110-0339

CAUTION

To avoid damage to the instrument, before connecting the power cable, set the 115/230 switch for the line voltage to be used.

2-13. POWER CABLE. To protect operating personnel the National Electrical Manufacturers' Association (NEMA) recommends that instrument panels and cabinets be grounded. Accordingly, the Model 4270A is equipped with a detachable three-conductor power cable which, when plugged into an appropriate receptacle, grounds panel and cabinet. The offset pin of the three-prong connector is the ground pin. Proceed as follows for power cable installation.

a. Connect flat plug(3-terminal connector) to LINE Jack at rear of instrument:

b. Connect plug (2-blade with round grounding pin) to 3-wire(grounded) power outlet. Exposed portions of instrument are grounded through the round pin on the plug for safety; when only 2-blade outlet is available, use connector adapter (HP Part No. 1251-0048) then connect short wire from side of adapter to ground to preserve the protection feature.

2-14. COOLING

2-15. The Model 4270A uses forced-air cooling. The air intake and filter are located on the rear panel of the instrument. Leave adequate clearances (at least 2 inches) behind and at both sides of the instrument for free movement of air. The clearances provided by the plastic feet in bench stacking and the filler strips in rack mounting are adequate for the top and bottom cabinet surfaces. The path of air flow is through the filter and intake fan, then out of the perforated side covers. It is important to keep the air intake area free of dust and small particles which could clog the filter. In a rack installation, ensure that recirculation of warm air within the rack cabinet does not produce an ambient temperature high enough to affect instrument operation.

2-16. AIR FILTER

2-17. Application of filter coating materials is not required or recommended for this metal filter. Inspect the filter regularly, clean the filter before it becomes dirty enough to restrict air flow. Proceed as follows:

a. Remove top cover.

b. Remove the outer filter by taking out four screws holding filter in place.

c. Remove the inner filter by taking out two screws and a nut. Nut can be loosened by rotating the screw on the rear panel.

d. Wash filters in warm water and detergent.

e. Allow filters to dry completely.

SECTION III
OPERATION

3-1. INTRODUCTION

3-2. This section contains detailed instructions and general information necessary for operation of the HP 4270A Automatic Capacitance Bridge. Front and rear panel controls, connectors and indicators are detailed in Figures 3-1 and 3-2. The following paragraphs contain preoperation check, description of each of the major operating characteristics, and special features of the instrument. Reference to the specifications in Section I and information in this section will provide all that is required to correctly operate the model 4270A.

3-3. APPLICATIONS

3-4. The model 4270A has been designed to meet the requirements of capacitance measurement for simple capacitors, semiconductors, cables and other capacitive devices. Table 3-1 lists typical applications and prominent features.

3-5. MEASUREMENT LIMITS

3-6. Certain combinations of capacitance, conductance at a given frequency, dissipation factor or dc bias may limit the ability of the instrument. It is recommended that the operator be reasonably familiar with the loss component of capacitor and with the instrument specifications if tests be made on capacitors at limiting values of capacitance, conductance, dissipation factor, bias and frequency.

Typical Unknown	Features
Capacitors	
Ceramic	1 V test voltage at 1 kHz.
Plastic, Mica	D with .001 resolution, 2 digit repeatability.
Paper	Wide, auto range.
Air	18pF, 180pF full-scale ranges.
Cables Input Capacitance of Amplifiers	L-GND
Materials	4 frequencies, loss measurement.
Semiconductors	
Diode Varactor FET, IC	100mV test voltage, 18pF range, dc bias, 100kHz, 1 MHz.

Table 3-1. Typical Applications

3-7. PREOPERATION CHECK

3-8. The following steps indicate the operating precautions prior to turn-on.

a. Set 115V/230V slide-switch on rear panel to correct position for the applied voltage. Check that proper fuse for voltage used is inserted in fuse holder.

b. Check to be sure that shorting strap on the rear panel interconnects PROGRAM RESISTOR and GUARD terminals.

c. Connect power line to a power outlet, assuring that a power line ground is provided and that the voltage and frequency meet requirements.

d. Set front panel controls as follows:

FREQUENCY . . . . . . 1 kHz
MEAS RATE. . . . . . . SHORT
RANGE MODE . . . . . . AUTO
LOSS MEAS . . . . G
MEAS CKT . . . . FLOAT
TEST VOLTAGE . . . . . NORM
DC BIAS RANGE . . . . . OFF
DC BIAS VERNIER . . . . REMOTE

e. Push LINE switch to ON. Allow about 15 minutes warm-up time to achieve specified measurement accuracy.

f. Connect capacitance to be measured to UNKNOWN terminals and read display.

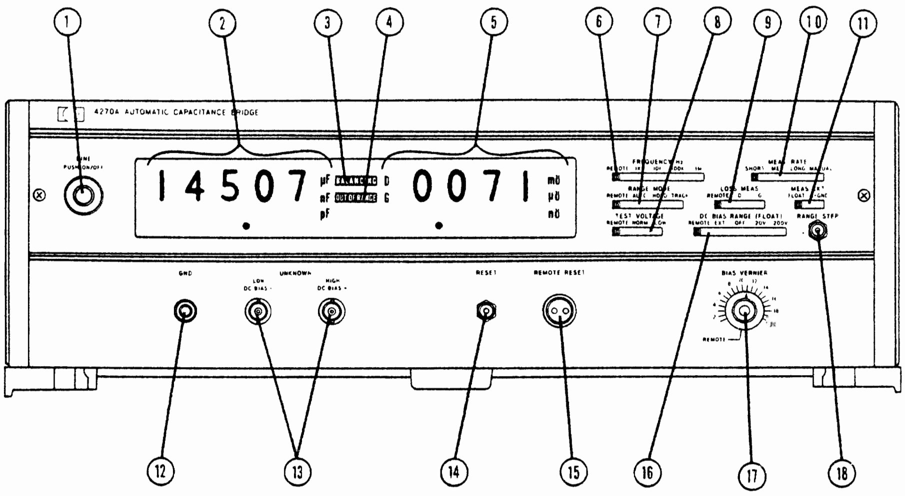
3-9. CONNECTIONS AT "UNKNOWN" TERMINALS

3-10. MEASURING CIRCUIT

3-11. The instrument measures capacitance with terminals floating from ground, or with one terminal grounded. The MEAS CKT slide switch on the front panel selects the desired connection. Most measurements will be made in the "FLOAT" configuration as unmounted circuit components are not connected to ground. In L-GND operation, the LOW side of the UNKNOWN terminal is grounded. This is particularly useful for measurement of components mounted in-circuit, such as grounded cables and the input capacitance of amplifiers.

3-12. GUARD

3-13. Three-terminal measurement is provided to eliminate errors introduced by stray capacities. The inner conductors of the UNKNOWN BNC connectors are terminals for the unknown capacitor. The outer conductor is a third terminal, that is, guard. For accurate measurement, use coaxial cable between front



1. LINE applies power to instrument; illuminated, push on-off.

2. Capacitance display with units and decimal point.

3. BALANCING illuminates during the measuring operation.

4. OUT OF RANGE when illuminated, indicates that either capacitance or loss or both exceed the specified maximums, or that an incorrect combination of range and frequency has been selected in HOLD and TRACK modes.

5. Loss component display with units and decimal point. Either D or G is illuminated.

6. FREQUENCY slide-switch selects frequency of measurement at one of 4 frequencies between 1kHz and 1MHz.

7. RANGE MODE selects ranging mode and balancing operation. AUTO provides automatic range selection. In HOLD, range is held fixed, and balance begins with 10^3 digit (fourth from right). In TRACK, range is held fixed and balance begins with the 10^0 digit. Change RANGE MODE while BALANCING lamp ③ is off.

8. TEST VOLTAGE determines test voltage across unknown.

9. LOSS MEAS selects which loss parameter is measured, dissipation factor or conductance.

10. MEAS RATE controls length of time intervals between balancing operations. Three time intervals (70 ms, 2 sec and 5 sec) are selectable. Repetition period equals balancing time (approximately .5 secs) plus the selected time between balancing operations. In MANUAL position, the display is held indefinitely, after a single balance operation, unless reset by RESET, or by switching to LONG, MED or SHORT.

11. MEAS CKT sets conditions between unknown terminals and ground. In FLOAT the terminals of the unknown are floating from ground. In L-GROUND, "LOW" side of unknown terminal is grounded.

12. GND terminal to be used in the absence of suitable power-line grounding.

13. UNKNOWN connectors: Inner conductors of BNC's are connected to unknown capacitor. Outer conductor is guard terminal which guards measurement against effects of stray capacities.

14. RESET push button returns both display and bridge to zero, except in TRACK mode. After releasing, a new balance operation starts.

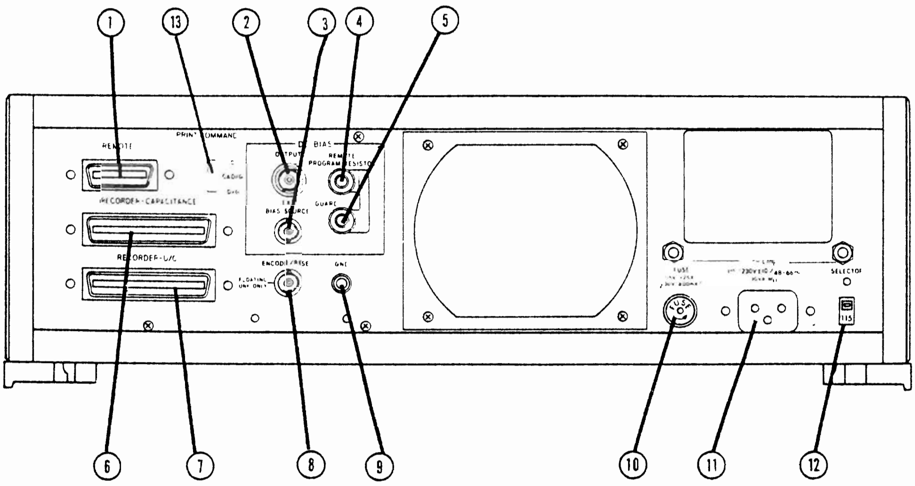
15. REMOTE RESET provides remote control of reset function.

16. DC BIAS RANGE (FLOAT) applies desired DC bias to unknown. Two internally provided ranges are selectable (0-20V, 0-200V). See Paragraph 3-30.

17. DC BIAS VERNIER controls the internal dc bias supply with the selected range 20V or 200V.

18. RANGE STEP push button when depressed, range steps down to lower range in HOLD mode.

Figure 3-1. Front Panel Controls, Connectors and Indicators



1. REMOTE connector contains remote programming connections to internal switching circuits. See Table 3-7 for actual pin designations. Programming control inputs are applied at these pins as external contact closure to control front panel functions.

2. OUTPUT: DC bias applied to capacitor under test may be monitored. Output impedance is 100kΩ. When measuring unknown with internal dc bias supply at L-GND, this connector supplies dc bias to unknown. See Figure 3-5.

3. EXT BIAS SOURCE: Input connector accepts dc voltage to be applied to unknown capacitor when DC BIAS RANGE control is set to EXT. Input impedance is 100kΩ in series with unknown.

4. REMOTE PROGRAM RESISTOR terminal to be used with GUARD terminal (5) when using external control of dc bias.

5. GUARD to be connected to the outer conductor of UNKNOWN connectors. The short strap should be tied to REMOTE PROGRAM RESISTOR terminal (4) except when using remote controller for dc bias.

6. RECORDER-CAPACITANCE connector provides the displayed capacitance data in binary coded decimal form to recorder, analog converter, or data processing equipment. See Paragraph 3-46.

7. RECORDER - D/G connector provides the displayed loss component data.

8. ENCODE/RESET provides connection for remote reset. This is valid only when unknown is floating.

9. GND connector to be used in the absence of suitable power-line grounding.

10. FUSE provides overload protection. Use 1.25 amp slow-blow fuse for 115 V ac operation, 1 amp normal-blow fuse for 230V ac operation.

11. LINE receptacle accepts female connector.

12. Line voltage slide-switch permits selection of either 115 V ac or 230 V ac line voltage.

13. Print Command Selector switch connects Print Command signal to pin 23 of J9 (Recorder Output connector for capacitance) in C-position, or to pin 23 of J10 (Recorder Output Connector for D/G) in D/G or to both of these in parallel in C & D/G-position.

Figure 3-2. Rear Panel Controls and Connectors panel and unknown, and provide guard shield between terminals of any test fixtures. The direct connection to the guard is available at the binding post terminal labeled GUARD, and at the REMOTE connector on the rear panel. The guard terminal is grounded when in FLOAT, but is floating when L-GND is used. The guard chassis which surrounds most of the circuits in the instrument is circuit common in the remote programming circuit and digital signal output.

3-14. LOSS MEASUREMENT

3-15. The instrument measures an unknown as a capacitance (C) with parallel conductance, and displays the conductance (G) or dissipation factor (D). Where (D) is given as:

$$D = \frac{G}{\omega C}$$

Figure 3-3 represents conversion between these parameters. The value of capacitance measured as in a parallel equivalent circuit differs from that measured in a series equivalent. The relationship between a capacitance given in parallel (C_{PL}) with a conductance and a capacitance (C_{SR}) in series with resistance is as follows:

$$C_{SR} = (1 + D^2)\, C_{PL}$$

where D is the measured D value. The difference between C_{PL} and C_{SR} is large when D is greater than 0.1, but it is within 1% of C_{PL} if D is 0.1 or less. Most capacitors for practical applications have D values less than 0.1.

3-16. RANGING

3-17. CAPACITANCE RANGE

3-18. Capacitance measurements are made on six ranges from 18pF to 1.2μF full scale. Available full scale ranges, which depend on the measuring frequency selected and the setting of the MEAS CKT switch, are shown in Table 3-2. The instrument provides two methods of ranging: automatic range selection and manual range selection. The RANGE MODE switch selects one of four available range modes. In AUTO position, the optimum range is automatically selected, with downranging at displays of approximately 1600, and upranging at approximately 16000. In HOLD, manual ranging is selected; by depressing the RANGE STEP push button the instrument is downranged and may be cycled from 18pF full scale range through the 1.2μF range in selecting the desired setting. If an incorrect range is selected (e. g. 18pF range at 1kHz), the OUT OF RANGE lamp will illuminate. In TRACK, range is not selectable but fixed at the range setting previously selected in AUTO or HOLD mode.

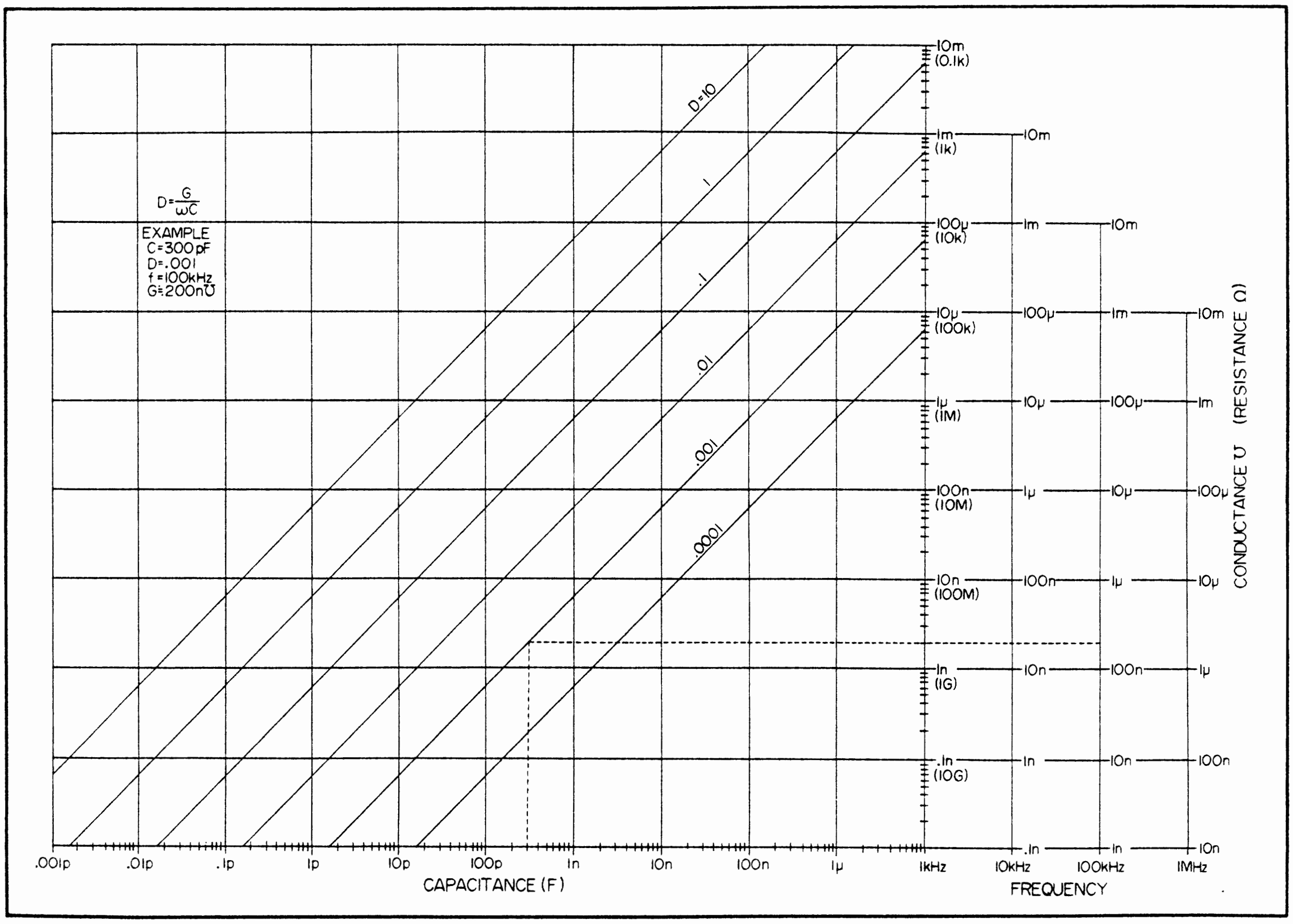


Figure 3-3. Conversion Chart for Dissipation Factor & Conductance

RANGE \ FREQ.	1 kHz	10 kHz	100 kHz	1 MHz	STANDARD CAPACITANCE
1		17.999pF 999.9n℧	17.999pF 9.999μ℧	17.999pF 99.99μ℧	10pF
2	179.99pF 999.9n℧	179.99pF 9.999μ℧	179.99pF 99.99μ℧	179.99pF 999.9μ℧	100pF
3	1799.9pF 9.999μ℧	1799.9pF 99.99μ℧	1799.9pF 999.9μ℧	1199.9pF 9.999m℧	1nF
4	17.999nF 99.99μ℧	17.999nF 999.9μ℧	17.999nF 9.999m℧		10nF
5	179.99nF 999.9μ℧	179.99nF 9.999m℧			100nF
6	1.1999μF 9.999m℧				100nF

Note 1: Upper figures are full scale capacitance values. Lower figures are full scale conductance values.

Note 2: Heavy line encloses available full scale ranges in L-GND.

Table 3-2. Available Full Scale Ranges and Standard Capacitance

Range Mode	Capacitance Full Display		Conductance Full Display	Dissipation Factor Full Display
	Full Scale 17999	Full Scale 11999		
Auto	17900 at max. range 16000 except max. range	11900	See Para. 3-19	See Figure 3-4
Hold	17900	11900		
Track	17999	11999	9999	9999

Table 3-3. Full Display

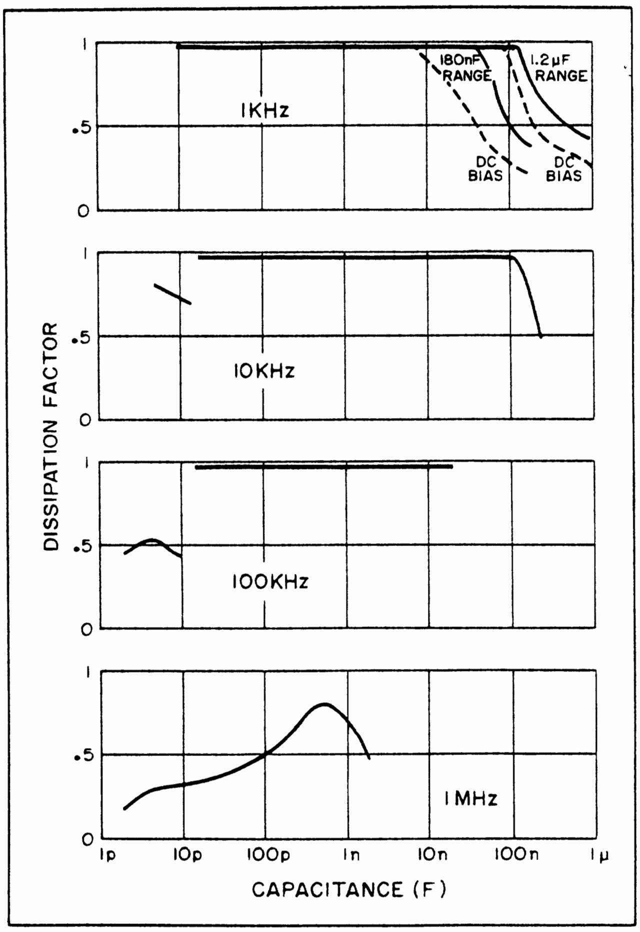


Figure 3-4. Full Display Limit of Dissipation Factor in Auto or Hold Mode

3-19. CONDUCTANCE RANGE

3-20. Conductance ranges are automatically defined by the combination of capacitance range and frequency as shown in Table 3-2. In AUTO and HOLD, dissipation factor of the unknown should be less than 1 (even if the conductance parameter is measured). If dissipation factor is larger than 1, the OUT OF RANGE lamp will illuminate.

3-21. FULL DISPLAY

3-22. Certain combinations of capacitance, conductance, frequency and dc bias may limit full display value as shown in Table 3-3 and Figure 3-4.

3-23. MEASURING RATE

3-24. BALANCING TIME

3-25. Balancing time is typically 0.5 secs and increases at dissipation factors of more than 0.1. Certain combinations of capacitance, conductance and measuring frequency may limit the ability of the instrument to balance within a reasonable time. Table 3-4 gives limits of dissipation factor in conjunction with capacitance and frequency when the unknown may be measured within approximately 1.5 secs in AUTO or HOLD mode.

	D Measurement				G Measurement			
C \ f	1k Hz	10k Hz	100k Hz	1M Hz	1k Hz	10k Hz	100k Hz	1M Hz
10pF		0.7	0.4	0.2		0.9	0.9	0.2
100pF	0.9 (0.9)	0.9	0.9	0.5	0.9 (0.9)	0.9	0.9	0.9
1 nF	0.9 (0.9)	0.9	0.9	0.5	0.9 (0.9)	0.9	0.9	0.9
10nF	0.9 (0.8)	0.9	0.9		0.9 (0.8)	0.9	0.9	
100nF	0.4 (0.2)	0.9			0.4 (0.15)	0.9		
1 µF	0.4 (0.2)				0.35 (0.15)			
Note: parentheses indicate limits when dc bias is applied.								

Table 3-4. Measuring Limit of Dissipation Factor

3-26. AUTOMATIC RESET

3-27. If the unknown changes value during a balance operation, or other changes shift the unknown outside of the balance range, unlike conventional bridges which will require a long time to balance, or are unable to balance, the 4270A resets automatically after 1.5 secs and balances at the new value. If dissipation factor of unknown is larger than the limit shown in Table 3-4, the bridge in AUTO or HOLD may be reset at intervals of approximately 1.5 secs by automatic reset circuit because requirement of balancing time is more than 1.5 secs. Therefore the bridge may not balance. In this case, measure the unknown in TRACK mode.

3-28. REPETITION PERIOD

3-29. Repetition period equals the balancing time plus time interval between balancing operations. Length of the time interval is 70ms in SHORT, 2 s in MED or 5 s in LONG as determined by MEAS RATE switch. In MANUAL position, the display is held indefinitely, after a single balance operation, unless reset by RESET, or by switching to LONG, MED or SHORT.

3-30. DC BIAS

3-31. INTERNAL BIAS

3-32. Dc bias, applicable to test capacities, may be derived from the 4270A internally, or externally from other dc sources. Dc bias may only be used in HOLD and TRACK modes. See Paragraph 3-17 for selection of desired ranges. Figure 3-5 outlines the procedure for using internally-provided dc bias operation using the L-GND MEAS CKT. Internal dc bias may be controlled down to 100mV and up to 200V by the VERNIER control on the front panel and by an external programming resistor. See Paragraph 3-44 for remote control. Dc bias polarity applied to the unknown is plus (+) at HIGH UNKNOWN terminal and minus (-) at LOW.

3-33. EXTERNAL BIAS

3-34. External bias is recommended if a minus polarity is required on the HIGH terminal, if bias will change polarity without a corresponding change in polarity of the UNKNOWN connection, if bias less than 100mV is required, or if greater bias-setting accuracy is required. Ripple of bias supply should be less than the limits listed in Table 3-5 to retain specified repeatability. External dc bias may be grounded regardless of MEAS CKT selected.

Full Scale Range (pF)	Frequency (Hz)	Maximum of 60Hz or 120Hz Ripple (Vrms)
180	1k 10k 100k 1M	1m 10m 100m 1
18	10k 100k 1M	1m 10m 100m

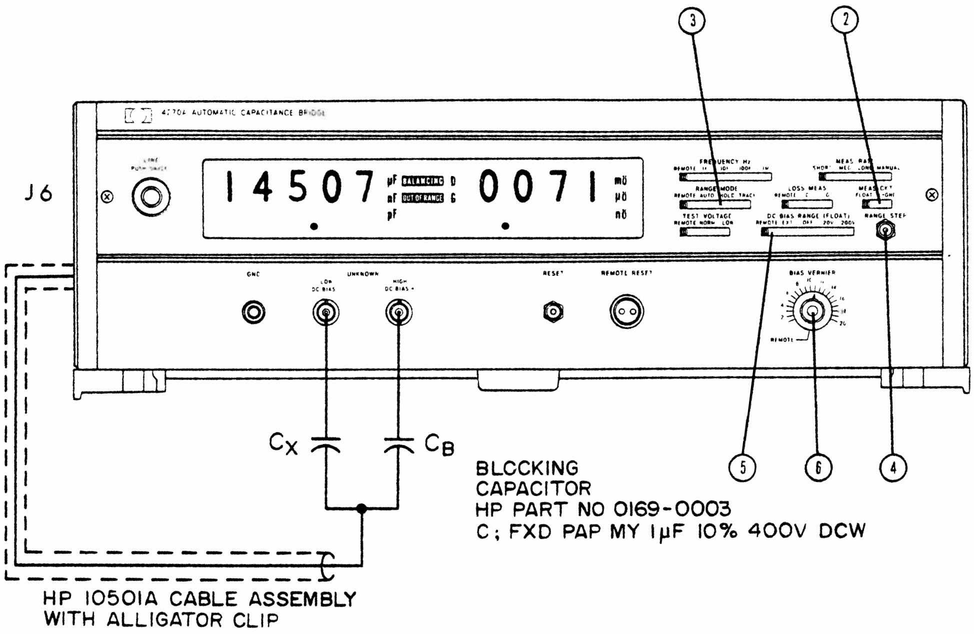
Table 3-5. Maximum Limits of Ripple on Ext. DC Bias Supply

3-35. MONITOR

3-36. The source voltage of dc bias applied to the unknown may be monitored at OUTPUT BNC connector on the rear panel. See Figure 3-6.

3-37. RESET

3-38. When RANGE MODE is set to AUTO or HOLD, both the display and the internal bridge circuit are turned to zero by depressing the RESET button, or by contact closure connected to remote connector. Immediately after the RESET push button or the re-



1. Connect unknown capacitor Cx, blocking capacitor C_B and coaxial cable as shown above.
2. Set MEAS CKT slide switch to L-GND.
3. Set RANGE MODE to HOLD.
4. Operate RANGE STEP push button to select desired range.
5. Set DC BIAS RANGE to 20V or 200V.
6. Adjust BIAS VERNIER to desired value.
7. Set FREQUENCY control, MEAS RATE control, LOSS MEAS control and TEST VOLTAGE control as desired.

Figure 3-5. L-GND Measuring Circuit

mote contact closure is released, the bridge will start to rebalance. Connectors for remote reset are provided on both front and rear panels. The front panel connector is an AMPHENOL 80-MC2F (HP Part No. 1251-0711) microphone connector with two inner conductors. See Figure 3-7. Mating connector is AMPHENOL 80-PC2M (HP Part No. 1251-0710). On the rear panel, the reset contact is located in the REMOTE jack, BNC connector, labeled ENCODE/RESET. This contact may be used for reset only if the MEAS CKT selector is in FLOAT. A pulse signal or semiconductor switch (see Figure 3-7) may be used to operate remote electronic reset in FLOAT MEAS CKT. In TRACK mode, both the display and the bridge are not reset to zero. Releasing the RESET push button or remote contact closure controls the start of rebalancing. When the instrument continuously repeats the measurement controlled by the internal measuring rate trigger generator (rate is set by MEAS RATE control), the display is not reset to zero but stored until completion of the succeeding balancing operation.

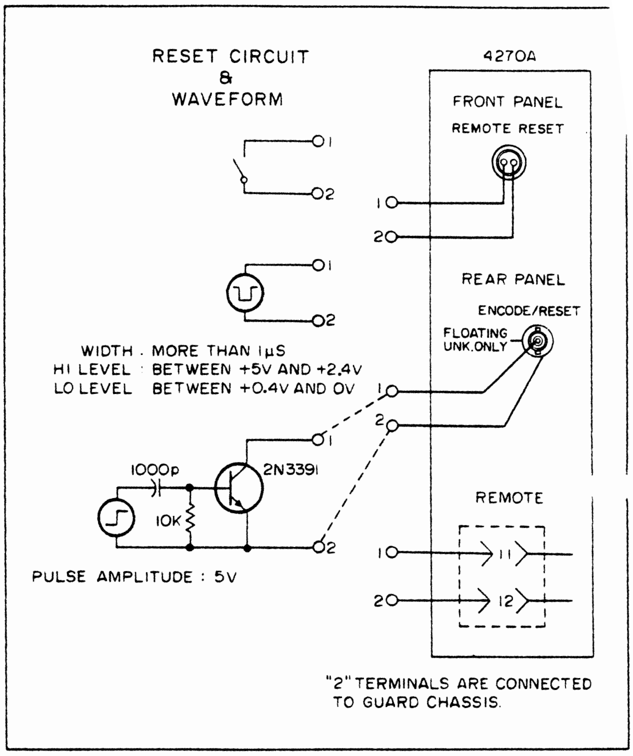


Figure 3-7. External Reset Circuit

3-39. WARNING DISPLAY

3-40. "OUT OF RANGE" INDICATOR

3-41. The OUT OF RANGE warning lamp indicates that the displays are invalid and that the instrument is in one or more of the following conditions:

a. AUTO

① Capacitance value exceeds maximum full scale defined by measuring frequency as follows:

Frequency	1 kHz	10kHz	100kHz	1 MHz
Max. Full	1.1999μF	179.99nF	17.999nF	1199.9pF

② Conductance exceeds full scale which depends on the combination of capacitance range and frequency as shown in Table 3-2.

③ Dissipation factor is greater than 1 (applies to conductance mode also).

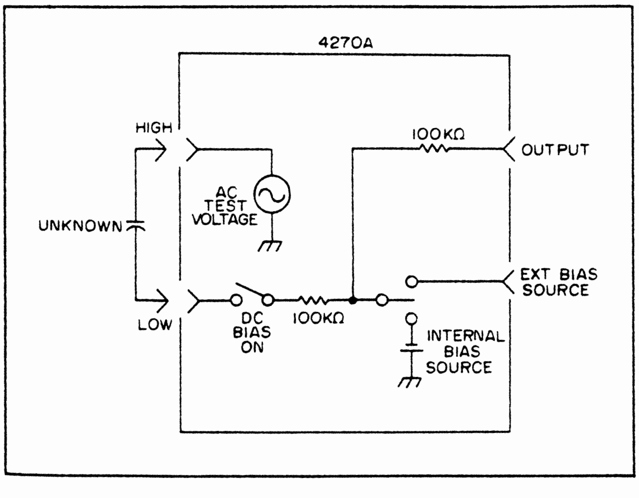


Figure 3-6. Dc Bias Monitor

b. HOLD

① Capacitance, conductance or dissipation factor exceeds the selected full scale value.

② An incorrect range as shown in Table 3-6 has been selected by the RANGE STEP, FREQUENCY or MEAS CKT controls.

c. TRACK

① Capacitance, conductance or dissipation factor exceeds the selected full scale value.

② An incorrect range as shown in Table 3-6 has been selected by FREQUENCY or MEAS CKT controls.

Note

If capacitance, conductance or dissipation factor exceeds full scale value in balancing period, OUT OF RANGE illuminates. For example, when unknown capacitance to be measured at D LOSS MEAS is less than approximately 0300 in display, dissipation factor may possibly exceed full scale .9999 during balance operation, and then OUT OF RANGE turns on. In this case, set the LOSS MEAS to G.

3-42. "BALANCING" INDICATOR

3-43. The BALANCING indicator lamp illuminates during the internal automatic balance operation. When balance is completed, this lamp extinguishes and the resultant measurement is displayed. The display will be stored until completion of succeeding balance operation.

3-44. REMOTE CONTROL

3-45. FREQUENCY, RANGE MODE, LOSS MEAS, TEST VOLTAGE, DC BIAS RANGE, RANGE STEP and RESET controls can be remotely controlled by external contact closure to guard with impedance less than 400Ω. MEAS RATE may be controlled by remote reset, when set to MANUAL. See Paragraph 3-37. BIAS VERNIER can be stepped, or digitally controlled by an external resistor with a conversion rate of 250Ω/V for the 20V range, or 25Ω/V for the 200V range. When programming DC BIAS, open the connection between REMOTE PROGRAM RESISTOR and GUARD and connect the appropriate resistor between the binding post terminals, or between pin 22 and 23 at the REMOTE jack. Pin location is indicated in Table 3-7 Mating connector for the REMOTE jack is an Amphenol 57-30240, HP part No. 1251-0293, 24-pin male.

CAUTION 1

The binding post terminals should always be shorted with the shorting strap unless using external dc bias control.

CAUTION 2

When functions are controlled remotely using L-GND MEAS CKT, a continuous guard connected to pin 12 in J11, which is shielded, should be provided as indicated in Figure 3-8.

CAUTION 3

When using REMOTE PROGRAM RESISTOR, the dc bias voltage is determined by the resistor connected across REMOTE PROGRAM RESISTOR and GUARD terminals, according to the conversion rate above. If no resistor is connected, the dc bias voltage will slightly exceed the full scale voltage of the selected range.

3-46. DIGITAL RECORDER OUTPUT

3-47. For system applications where automatic recording or computing control is required, binary coded decimal equivalents of capacitance and dissipation factor/conductance measured are provided at RECORDER connector J9 (upper) and J10 (lower) on the rear panel. To supply display information to the HP Model 5050B or 5055A Digital Recorder or Model 580A/581A Digital-to-Analog Converter, use interconnecting cable HP Part No. 562A-16C: 50 contact and 50 contact male on each end, 6 feet long. Two cables are required for recording both capacitance and loss component. Cables can be fabricated for connection to other equipment using an Amphenol 57-30500 connector HP Part No. 1251-0086, 50-pin male to mate with the RECORDER jack. Signals available and external signals required are given in Table 3-8 and 3-9. Tables 3-10, 3-11 and 3-12 provide output information for decimal point and measurement units recording.

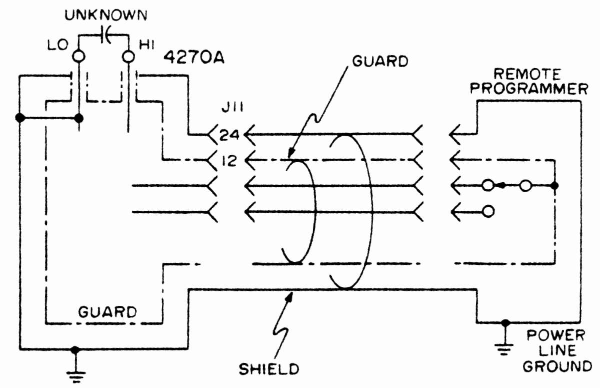


Figure 3-8. Remote Control Connection using L-GND

CAUTION

Circuit ground of recorder output connected to the guard chassis will be floating when using L-GND MEAS CKT. At L-GND, therefore, do not use a conventional recorder which has its common connected to power line ground.

	FREQUENCY	1 kHz	10 kHz	100 kHz	1 MHz
FLOAT	DECIMAL POINT & UNIT	00.000pF	0.0000μF	000.00nF 0.0000μF	00.000nF 000.00nF 0.0000μF
L-GND	DECIMAL POINT & UNIT	00.000pF	00.000pF 0.0000μF	00.000pF 000.00nF 0.0000μF	00.000pF 00.000nF 000.00nF 0.0000μF

Table 3-6. Incorrect Range in HOLD and TRACK Mode

CONTROLS & SIGNAL		J11
FUNCTION	POSITION	PIN NO.
FREQUENCY	1k 10k 100k 1 M	4 5 16 17
RANGE MODE	AUTO HOLD TRACK	2 3 14
LOSS MEASUREMENT	D G	6 18
TEST VOLTAGE	NORM LOW	7 No connection
DC BIAS RANGE	EXT OFF 20V 200V	8 9 20 21
RANGE STEP		13
RESET (ENCODE)		11
GUARD, circuit ground for above functions		12
BIAS VERNIER		22, 23
GND, connected to chassis ground		24
Non Connection		1, 10, 15, 19

Table 3-7. Remote Pin Locations

Function		J9
Display, Signal & Level	BCD Weight	Pin No.
Display 10^0 Digit Units	1 2 4 8	1 2 26 27
Display 10^1 Digit Tens	1 2 4 8	3 4 28 29
Display 10^2 Digit Hundreds	1 2 4 8	5 6 30 31
Display 10^3 Digit Thousands	1 2 4 8	7 8 32 33
Display 10^4 Digit Ten Thousands	1 2 4 8	9 10 34 35
Decimal Point	1 2 4 8	11 12 36 37
Measurement Units & Out of Range Signal	1 2 4 8	13 14 38 39
Hold off input; -10V min, -15V max supplied from external source to prevent reset; causes measurement to hold.		47
Print command output; 0V to +5V step, DC-coupled, signals that completed measurement is available for readout.		23
Reference output; about +5V dc indicates "1" level for BCD output.		25
Reference output; 0V indicates "0" level for BCD output, connected to guard chassis.		24
Ground; connected to guard chassis.		50
Encode (Reset)		21
No connection.		15-20, 22 40-46 48, 49

Table 3-8. Summary of Capacitance Information at Digital Recorder Output Connector

Function		J10
Display, Signal & Level	BCD Weight	Pin No.
Display 10^0 Digit Units	1 2 4 8	1 2 26 27
Display 10^1 Digit Tens	1 2 4 8	3 4 28 29
Display 10^2 Digit Hundreds	1 2 4 8	5 6 30 31
Display 10^3 Digit Thousands	1 2 4 8	7 8 32 33
Decimal Point	1 2 4 8	9 10 34 35
Measurement Units	1 2 3 4	11 12 36 37
Hold off input; -10V min, -15V max supplied from external source to prevent reset; cause measurement to hold.		47
Print command output: 0V to +5V stop, DC-coupled, signals that completed measurement is available for readout.		23
Reference output; about +5V dc indicates "1" level for BCD output.		25
Reference output; 0V indicates "0" level for BCD output, connected to guard chassis.		24
Ground; connected to guard chassis.		50
Encode (Reset)		21
No connection		13-20 22 38-46 48, 49

Table 3-9. Summary of Loss Component Information at Digital Recorder Output

DISPLAY	J9 (J10) Output Volts				Printed Digit
	Pin 37 (35)	Pin 36 (34)	Pin 12 (10)	Pin 11 (9)	
0 0 0 0.0	0	0	0	+5	1
0 0 0.0 0	0	0	+5	0	2
0 0.0 0 0	0	0	+5	+5	3
0.0 0 0 0	0	+5	0	0	4

Table 3-10. Decimal Points BCD Output Digits for capacitance, Dissipation Factor or Conductance.

DISPLAY	J9 Output Volts				Printed Digit
	Pin 39	Pin 38	Pin 14	Pin 13	
μF	0	0	0	0	0
nF	0	0	0	+5	1
pF	0	0	+5	0	2
Out of Range	+5	0	0	0	8

Table 3-11. BCD Output Digits for Capacitance Units.

DISPLAY	J10 Output Volts				Printed Digit
	Pin 37	Pin 36	Pin 12	Pin 11	
D	0	0	0	0	0
m	0	0	0	+5	1
μ	0	0	+5	0	2
n	0	0	+5	+5	3

Table 3-12. BCD Output Digits for Loss Units.

3-48. ACCURACY

3-49. BASIC ACCURACY

3-50. The accuracy is determined by many factors such as frequency, measuring circuit, dissipation factor of unknown, test voltage, dc bias, digital error of ±1 count, test fixture and test cables. The chart in Figure 3-9 shows basic accuracy in FLOATING, DC BIAS OFF, RANGE MODE AUTO and TEST VOLTAGE NORMAL for capacitance measurement.

3-51. ACCURACY WHEN DC BIAS APPLIED

a. FLOAT

Errors in dc bias are increased slightly by the blocking capacitor built into the instrument. A formula for determining the error is given in the specifications in Section I. For DC BIAS measurements on low-value capacitors, use of 10 kHz or greater for 180pF full-scale ranges and 100kHz or greater for 18pF ranges is recommended for best accuracy and repeatability.

b. L-GND

Errors in dc bias are increased by the admittance of the blocking capacitor and the dc bias source resistance connected in series with the coaxial cable.

3-52. EFFECT OF TEST CABLES

3-53. Length of test cables will affect accuracy due to series impedance and parallel admittance in the cables. Figure 3-10 shows additional error for capacitance and dissipation factor. For example (See Fig. 3-10), a 2 meter cable introduces an additional .1% error when measuring 100nF at 10kHz. Conductance error is given approximately as follows:

$$\Delta G \doteqdot \omega C \ \Delta D$$

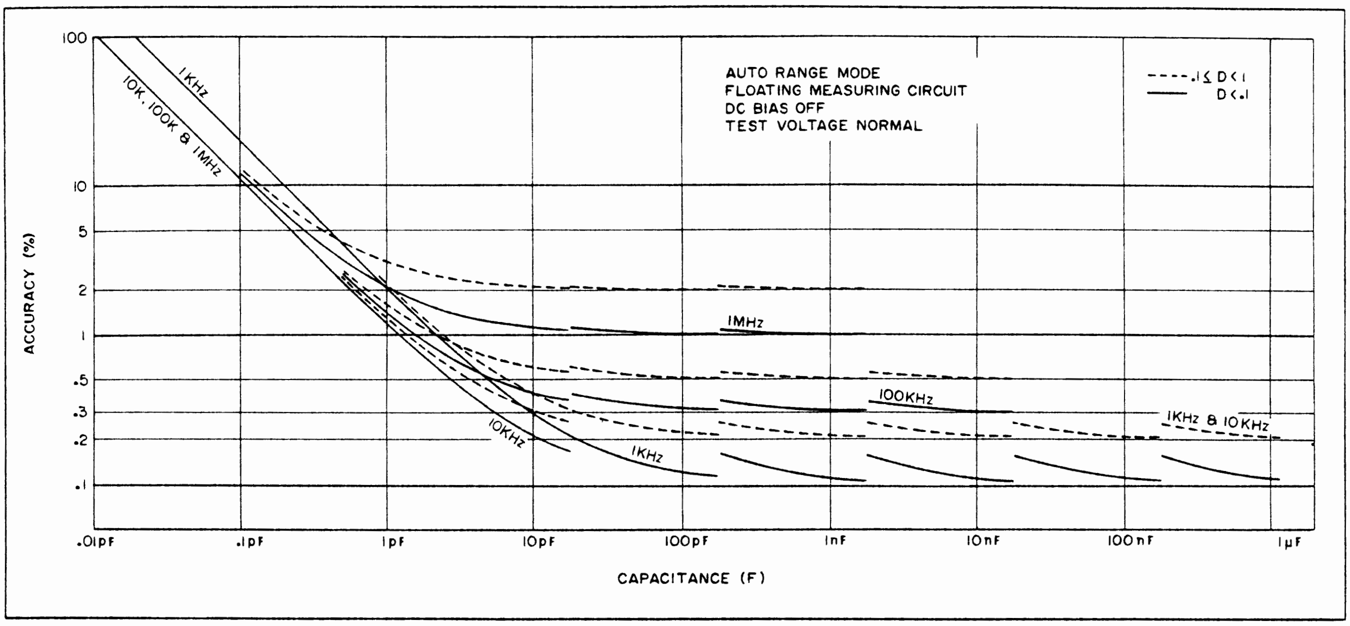


Figure 3-9.. Basic Accuracy of Capacitance Measurement

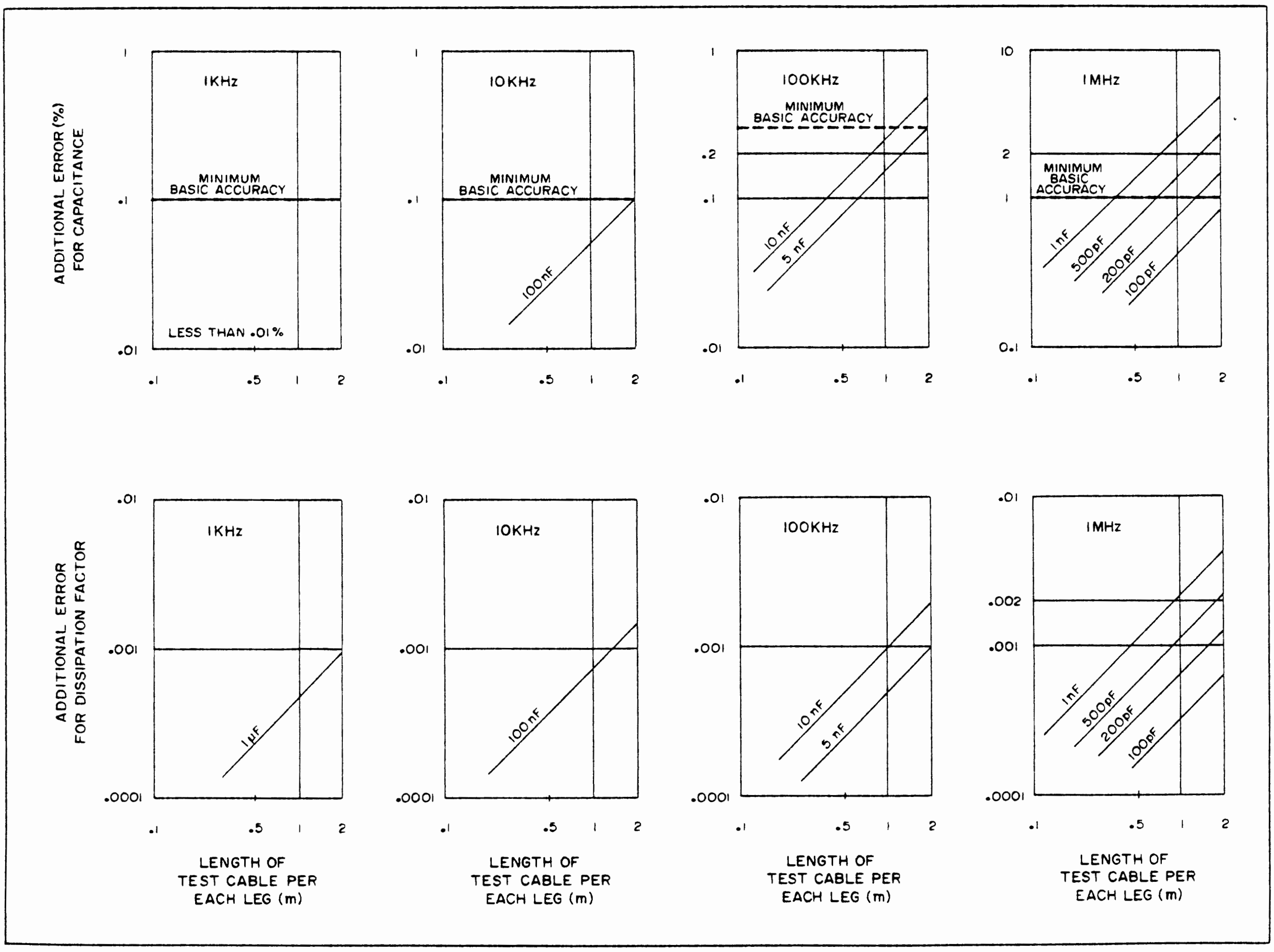


Figure 3-10. Effect of Test Cables (RG-58A/U)

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION

4-2. This section provides circuit theory analysis of the model 4270A Automatic Capacitance Bridge. Due to the complexity of the instrument the discussion is divided into two parts, the bridge section and the logic section. The bridge section contains the basic principle of Bridge Circuitry, block diagram description including the circuit details. The logic section description provides the block diagram description, logic symbols explanation, description of major signals and the sequence of balancing operation.

4-3. BASIC CONSTRUCTION

4-4. The 4270A Automatic Capacitance Bridge consists of three groups. The first group is an analog admittance bridge which includes an oscillator and a detector. The second is a digital circuit which controls the bridge balancing operation and displays the measured data automatically. The third is a group of power supply circuits which provide necessary power to both the first and second group as well as the necessary d. c. bias voltage to a capacitor under test.

4-5. BASIC PRINCIPLE OF THE BRIDGE CIRCUITRY

4-6. Figure 4-1 shows the basic principle of the bridge circuit in the 4270A. A capacitor under test is represented by a parallel circuit of capacitance C_X and its conductance (loss) component G_X. C_S is a standard capacitor while G_S is a standard conductance and both of them are installed in the 4270A.

4-7. The measuring signal voltage E of frequency f is fed to the capacitor under test resulting in the current $\dot{I}_X$ to the Detector while the same signal is fed to C_S and G_S through Attenuators and inverting unity gain amplifiers resulting in the combined current $\dot{I}_S$. Note that the direction of $\dot{I}_X$ and $\dot{I}_S$ is opposite because of the inverting amplifiers.

4-8. When the bridge is balanced, the following relations are satisfied.

$$I_X = I_S$$

where $I_X = I_{GX} + j\cdot I_{CX} = I_S = I_{GS} + j\cdot I_{CS}$

thus $I_{GX} = I_{GS}$ and $I_{CX} = I_{CS}$

where $\begin{cases} I_{GX} = E\cdot G_X \\ I_{CX} = 2\pi f\cdot E\cdot C_X \end{cases}$

and $\begin{cases} I_{GS} = E_{GS}\cdot G_S \\ I_{CS} = 2\pi f\cdot E\cdot C_S \end{cases}$

thus $\begin{cases} E\cdot C_X = E_{CS}\cdot C_S \\ E\cdot G_X = E_{GS}\cdot G_S \end{cases}$

or $\begin{cases} C_X = \dfrac{E_{CS}}{E}\cdot C_S \\ G_X = \dfrac{E_{GS}}{E}\cdot G_S \end{cases}$

Now the values C_X and G_X are expressed by the attenuation factors E_{CS}/E and E_{GS}/E. These attenuation

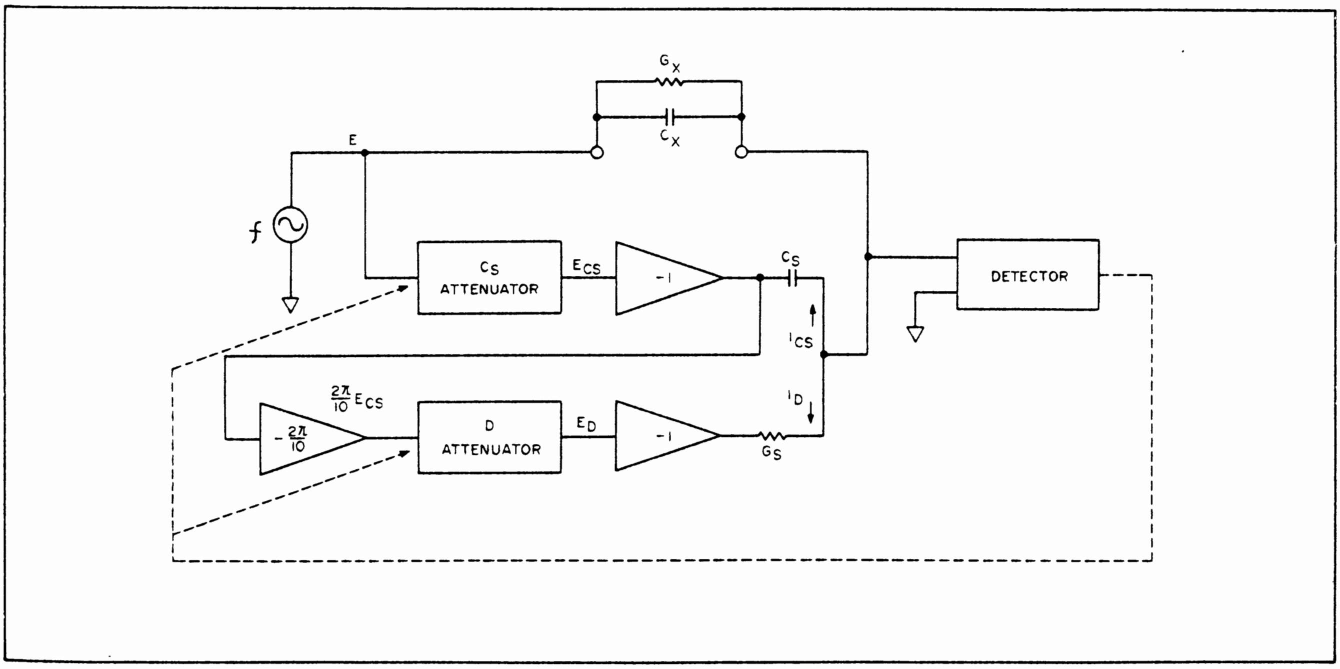


Figure 4-1. Basic Principles of Bridge Circuitry

factors are displayed numerically by digital circuitry in a manner to show C_X and G_X directly in micro (nano or pico) Farads and milli (micro or nano) mhos.

4-9. DISSIPATION FACTOR MEASUREMENT

4-10. When the bridge circuit is slightly modified by inserting an amplifier of $-2\pi/10$ gain as shown in Figure 4-2, the dissipation factor can be measured directly. The balancing equations in this case are the followings:

$$I_{CX} = 2\pi f \cdot E \cdot C_X = I_{CS} = 2\pi f \cdot E_{CS} \cdot C_S$$

$$I_{GX} = E \cdot G_X = I_D = E_D \cdot G_S$$

Thus

$$C_X = \frac{E_{CS}}{E} \cdot C_S$$

$$D = \frac{G_X}{2\pi f \cdot C_X} = \frac{G_S \cdot E_D/E}{2\pi f \cdot C_S \cdot E_{CS}/E} = \frac{G_S}{2\pi f \cdot C_S} \cdot \frac{E_D}{E_{CS}}$$

The 4270A is designed so that the ratio $G_S/2\pi f \cdot C_S$ is always $10/2\pi$. Therefore,

$$D = \frac{10}{2\pi} \cdot \frac{E_D}{E_{CS}} = \frac{E_D}{\frac{2\pi}{10} \cdot E_{CS}}$$

Now the attenuation factor $E_D/(2\pi/10 \cdot E_{CS})$ of the D/G Attenuator shows the dissipation factor D directly, while the attenuation factor E_{CS}/E of C_S Attenuator shows C_X value relative to the C_S value.

4-11. EFFECT OF STRAY CAPACITANCE

4-12. Capacitance between terminals of a capacitor under test and the ground can be expressed as C_A or C_B in Figure 4-1. C_A is in parallel to the output of the oscillator and C_B shunts the input of the detector. It means that both C_A and C_B are out of the main bridge and have no effect on the balancing condition nor the measured data of C_X or G_X. Too large value of C_A or C_B, however, have some effect on the practical operation. Large C_A may load the oscillator excessively resulting in reduced output voltage or even an unstable output. Large C_B reduces the current sensitivity of the detector and makes the null condition ambiguous. The effect of the capacitance is frequency dependent and far smaller capacitances are allowed for normal operation at 1MHz than at 1kHz. Any direct capacitance between terminals A and B (C_{AB}) can be measured as a part of C_X resulting in erroneous reading of C_X. A pair of coaxial connectors (BNC type) is used as terminals A and B to reduce C_{AB} down to almost zero at the front panel of the 4270A. Any connections between the 4270A and a capacitor under test must be shielded to avoid error caused by the shielding.

4-13. EFFECT OF SERIES IMPEDANCE OF THE CAPACITOR UNDER TEST

4-14. Any series impedance can be measured as a part of C_X and G_X resulting in erroneous indication. Since series inductance has significant effect at higher frequencies, minimum length of coaxial cables should be used to connect a capacitor under test to the 4270A. Refer to paragraph 3-53 and Figure 3-10 for practical relationship between cable length and error.

4-15. BLOCK DIAGRAM DESCRIPTION

4-16. The following paragraphs (4-17 to 4-68) contain a brief outline of function of the major circuit groups in the 4270A. Reference is made to the Simplified Block Diagram, page 8-3 and the Detailed Block Diagram, page 8-4.

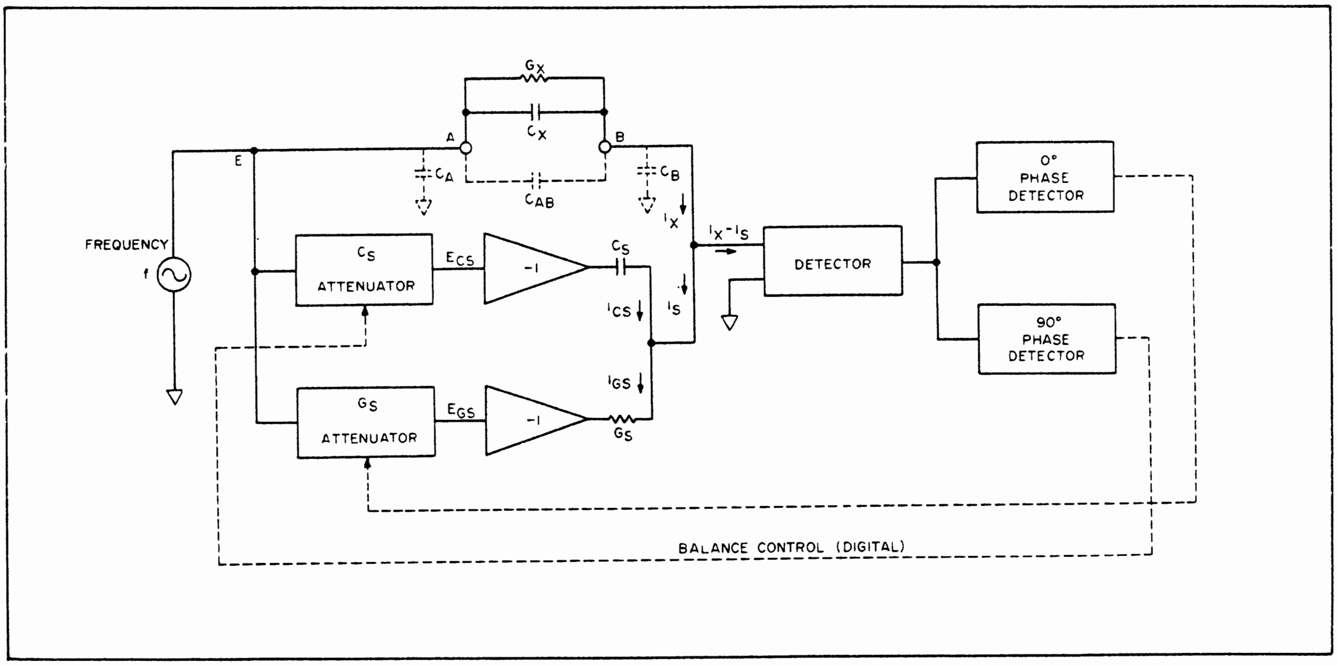


Figure 4-2. Bridge Circuit for Dissipation Factor Measurement

4-17. OSCILLATOR AND BUFFER ASS'Y (A13)

4-18. The Oscillator and Buffer Assembly is the driving source of the bridge circuit. The output of Oscillator and Buffer Assembly is connected to:

(1) A6 C_X Amp. Ass'y to drive a current through a capacitor under test.

(2) A14 C_S Attenuator and then A7 C_S Amp. to drive a current through the standard capacitance C_S.

(3) A15 D/G Attenuator and then A8 D/G Amp. to drive a current through the standard conductance G_S.

(4) A10 Phase Detector to provide the switching signal.

4-19. Transistors Q1 through Q6 and associated components form the oscillator circuit driving the bridge; it is an RC type circuit with positive feedback from Q4 emitter to Q1A base to maintain oscillations. Operating frequency is determined by the capacitors C1(A13) to C5(A13) and selectable resistors R1(A13) to R8(A13). Variable capacitor C1 permits frequency adjustment, R30 controls the output level, R24 permits the adjustment of distortion level.

4-20. The oscillator is coupled to the buffer stage via the attenuator circuit consisting of relays K5, k6 and transistors Q7 and Q8. When the FREQUENCY control on the front panel is set to 1kHz, pin 13R connected to XA25(5R) is shorted to ground causing relay K5 to be energized and transistor Q7 to be turned OFF. Thus the test voltage at 1kHz is twice as large as that at 10kHz, 100kHz or 1MHz. Pin 14R is shorted to ground when the TEST VOLTAGE is set to NORM, causing relay K6 to be energized and transistor Q8 to be turned OFF. LOW of the TEST VOLTAGE makes Q8 turn on and K6 to open to provide 1/5 attenuation. The switching of pin 13R and pin 14R is done by Switching Control Ass'y A25.

4-21. The Buffer amplifier is a four-stage amplifier with feedback. Transistors Q9A, Q9B, Q11 and Q12 form a high gain two-stage differential amplifier. Q10 is the current source for Q9A and Q9B. Cascaded emitter followers Q13 and Q14 provide high input impedance to Q11 and Q12 and low output impedance drive current to (J15), CS Attenuator, C_X amplifier and G_S attenuator. Negative feedback R58 stabilizes the amplifier gain. R54 is the DC output control which is normally set to 0 ±10mV.

4-22. C_X AMPLIFIER ASS'Y (A6)

4-23. C_X Amplifier is a wide band, unity gain amplifier which receives the oscillator output signal from the buffer amplifier and provides a low output impedance test signal to the capacitor under test. There is no phase shift between input and output of the C_X Amplifier. The attenuation at the input network of Q1A/B is approximately -33dB and -13dB depending on the relay K1. Since the pin (9. 0. 1) is connected to XA22 (15L), it is open (from ground) when 1 μF range is selected and is shorted ground causing the relay K1 closed when a C_S ranged other than the 1 μF range is selected. Thus the 20dB attenuation is provided by resistors R1 through R4 when 1 μF range is selected.

4-24. Cs AMPLIFIER ASS'Y (A7)

4-25. Cs Amplifier receives the output of the Cs Attenuator where the oscillator output is given a logic controlled attenuation, and provides a drive current through the standard capacitor. This amplifier is identical to the C_X Amplifier (described in paragraphs 4-22 and 4-23) except that there is a 180° phase shift from input to output. The base of Q3 is connected to the collector of Q1A instead of Q1B. The feedback loop from Q5 is connected to the base of Q1A. The output signal at Q5 collector is supplied to the standard capacitors through the relays which are controlled by the command signal from the Range Selector A22.

4-26. D AMPLIFIER ASS'Y (A8)

4-27. D Amplifier works as an operational amplifier with a gain of $-2\pi/10$. For the Dissipation Factor measurement shown in paragraph 4-9, the output of this amplifier is connected to the D/G attenuator through K1 and J17. When the LOSS MEAS control is set to G, the relay K1 is open and K2 is closed so that the output signal of Oscillator and Buffer Amplifier (A13) through J16 is supplied to the D/G Attenuator A15.

4-28. D/G AMPLIFIER ASS'Y (P/O A12)

4-29. The D/G Amplifier is identical to the Cs Amplifier. Transistors Q6 through Q25 (in groups of four each) provide selective switching for the five conductance ranges and minimize stray capacitance of relays' (K1 - K5) open contacts and associated circuits. The conductance range switching transistors, for example Q18 to Q21 (see Figure 8-11) form such a group as described above. In the absence of a control signal (in other words, when the pin 11R is not grounded), Q18, Q19 and Q20 are OFF and Q21 is ON providing a low impedance path from the junction of Q20 emitter and R42 to ground. When 1m℧ range is selected in the Range Selector A22, where the Gs range is determined according to the combination of frequency and Cs range, pin 11R is grounded, relay K4 is energized, transistors Q18, Q19, Q20 are turned on and Q21 is turned off. The signal is then coupled through Q20, R42 and the closed contact of K4. The output signal in connected to LOW terminal of UNKNOWN through the relay K7 and R49 when DC BIAS control is set to OFF. When DC BIAS is used, the DC BIAS ON RELAY DRIVE signal is applied to pin 14R (pin 14R grounded) to make K6 close and to make K7 open. Then the signal is rechanneled via K6 contacts and blocking capacitor C7 and R48.

4-30. STANDARD CAPACITORS (C1 through C9) AND STANDARD CONDUCTANCE (P/O A12)

4-31. The internal standards which basically determine the accuracy and stability of the bridge are a 0.1 μF silvered mica capacitor with a temperature coefficient of only a few parts per million/°C to be used at 1kHz and 10kHz, a 0.01 μF silvered mica used at 1kHz, 10kHz and 100kHz, a 1000pF gas-filled mica capacitor used at 1kHz, 10kHz, 100kHz and 1MHz, a

100pF gas-filled mica capacitor used at 1kHz, 10kHz, 100kHz and 1MHz, a 10pF air capacitor used at 10kHz, 100kHz and 1MHz. The conductance standards are metal film precision resistors with an initial tolerance of better than 0.1% and a temperature coefficient of only a few parts per million/°C.

4-32. CURRENT DETECTOR ASS'Y (A11)

4-33. The Current Detector gets the unbalance current (i_d) from the bridge circuit and provides a corresponding voltage error signal to the phase detector. The phase of the output voltage signal is maintained constant with respect to the phase of the input current (i_d). The Current Detector used in the 4270A is a kind of a feedback amplifier. The feedback admittance is a function of the capacitance and conductance range providing a 45° phase shift to the input current at all test frequencies, and eliminates the low frequency noise caused by the power line and its harmonics. The Current Detector has a very low input impedance which is essential in eliminating the effect of "terminal to ground capacity" in a guarded three terminal method measurement.

4-34. Among the feedback networks of capacitors C3 through C7 and resistors R1 through R5, an appropriate combination of capacitor and resistor is determined by the Range Selector Ass'y A22. The Range Selector A22 determines a G_s range with the FREQUENCY information at pins XA22(AR), (BR), (CR), (DR) and the information of selected C_s range at the shift register consisting of A22IC2A/B through A22IC 4A/B. Then the corresponding transistor among Q27 through Q33 is turned on to ground one of the pins XA22 (MR), (LR), (RR), (PR) and (NR). Since the pins XA22 (LR), (RR), (PR) and (NR) are connected to XA11 (1R), (2R), (3R) and (4R) respectively, the appropriate relay is energized for the selection of a resistor among R1 through R5. The information of selected C_s range at the shift resistor consisting of A22IC 2A/B through A22IC 4A/B is transferred to the pins XA22 (10L), (11L), (12L) and (13L). An appropriate capacitor among C3 through C6 is selected in a similar way.

4-35. PHASE DETECTOR ASS'Y (A10)

4-36. The basic function of the Phase Detector is to resolve the error signal into two components; one is in phase with the bridge driving source and the other is 90° out of phase. When the error signal e_d is out of phase by θ with respect to the bridge driving source e_o, the integration of e_d during half a cycle of e_o gives the in phase component of e_d. The integration during 90°-lag half of a cycle gives the quadrature component of e_d. The following equations will show this clearly:

$$e_o = E_o \sin\omega t \quad \ldots\ldots (1)$$

$$e_d = E \sin(\omega t - \theta) \quad \ldots\ldots (2)$$

$$\int_0^{\frac{\pi}{\omega}} e_d \, d_t = \int_0^{\frac{\pi}{\omega}} E \sin(\omega t - \theta) \, d_t = \frac{2E}{\omega} \cos\theta \quad \ldots (3)$$

$$\int_{\frac{\pi}{\omega}}^{\frac{3\pi}{\omega}} e_d \, d_t = \int_{\frac{\pi}{\omega}}^{\frac{3\pi}{\omega}} E \sin(\omega t - \theta) \, d_t = \frac{2E}{\omega} \sin\theta \quad \ldots (4)$$

4-37. The above-mentioned integration is performed by the switching circuit, Q7 through Q10 for 90° phase signal and Q16 through Q19 for in phase signal. The current detector output e_d is connected to emitter followers Q6 and Q15 via pin XA10(7R). The switching circuit is gated by the switching signal at CR2-R13 junction and CR4-R39 junction which is derived from the oscillator output at XA13(12R). The oscillator output is shifted by 45° at the junction of R3 and R4, and is coupled into two operational amplifiers. One operational amplifier consisting of Q2, Q3 and Q4 has a resistor R4 at its input while the other consisting of Q11, Q12 and Q13 has capacitors C19, C20, C21 and C22 which are controlled by the relay drive signal from the switching control assembly A25. Therefore the outputs of these two operational amplifiers are 90° out of phase with respect to each other, shaped into square wave by comparator circuits IC1 and IC3, and are connected to bases of transistors Q7-Q10 and Q16-Q19 through resistors R16-R19 and R41-R44. Waveforms of error signal and switching signal are shown in Figure 4-3. The outputs at Q7/Q8 emitter and Q9/Q10 emitter are smoothed by filters R21/C12 and R23/C13, coupled to d. c. amplifiers IC2 and IC4, and are connected to the integrator circuits in the Gate Ass'y A19.

4-38. LOGIC CIRCUIT

4-39. OVERALL DESCRIPTION

4-40. Many digital circuits of various functions are packed in the 4270A. Their major functions are as follows:

1. Automatic Ranging: proper selection of C_s and G_s automatically according to the value of capacitor under test.
2. Switching of various circuits: enabling disabling, and/or altering internal circuits according to manual settings of front panel controls or remote control signals.
3. Control of timing and sequence: various operations should be done automatically and in good timing.
4. Control of C_s Attenuator and D/G Attenuator to make the bridge balance.
5. C_s and D/G reversible counter: counts the pulses which control the setting of C_s and D/G counters, i. e. the settings of C_s and D/G attenuators, and displays the results with proper unit and decimal point.
6. Judgement of the bridge balance: since the attenuators are controlled digitally, the true balancing condition will never be met except by very lucky chance. Thus the judgement of "very close to null" is important to stop balancing action in order to prevent unnecessary iteration.
7. Reset: three kinds of reset signal are provided for logic and timing circuit, for range selector circuit and for C_s and D/G counters.

8. Automatic Resetting: automatically resets necessary circuit to proper conditions whenever any unexpected disturbances or abnormal results come along.

9. Data transfer to external devices: transfer measured data to printer, computer and/or other auxiliary equipment with proper transfer control signals.

4-41. BLOCK DIAGRAM DESCRIPTION

4-42. Figure 8-4 in page 8-5 shows the simplified block diagram. Each block should be discussed in relation to the sequence of balancing operation. Blocks in Figure 8-4 can be divided into eight groups:

1. Integrator............ P/O A19

2. Gate Control Circuits .... A19: COMPARATOR, C and D/G SAMPLING GATE, C and D/G GATE CONTROL (1) and A20: C and D/G GATE CONTROL (2), PARAMETER CONTROL, C and D/G GATE, NULL CKT P/O A20.

3. Timing Circuits........ ONE SHOT P/O A21, TIMING CKT P/O A21 and INTEGRATOR SWITCH DRIVER P/O A21.

4. C_S and D/G Reversible Counter & Driver...... A16, A4, A18, A5 and P/O A1.

5. Reset Circuit..... A24: MAIN GATE, AUTOMATIC RESET CKT, INITIAL RESET PULSE GENERATOR, RESET CKT, SAMPLE RATE GENERATOR, OUT OF RANGE DETECTOR.

6. Function Switch

7. Range Selector..... A22: RANGE SELECTOR DIODE MATRIX, RELAY DRIVER and A23 DISPLAY CONTROL CKT

8. Display Circuit......... P/O A1 NUMERICAL DISPLAY, A2 UNITS ETC DISPLAY and P/O A25 STORAGE ON/OFF SWITCH.

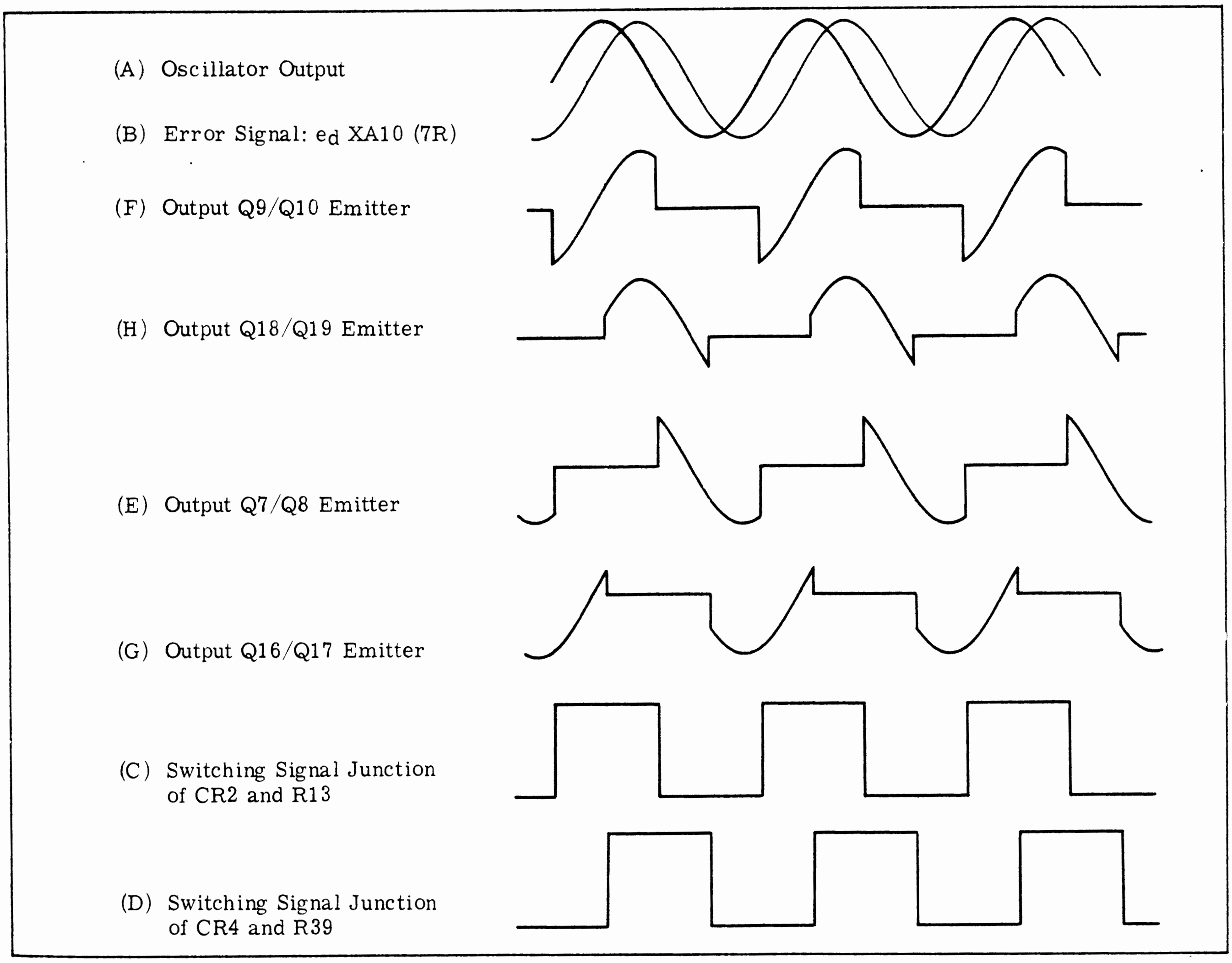


Figure 4-3. Waveforms of Error Signal, Switching Signal and Output (A10 Phase Detector Ass'y)

4-43. Figure 8-4 also contains various signal flows. Detailed description of these signals is provided in Paragraphs 4-44 through 4-68.

4-44. INTEGRATOR, COMPARATOR, C & D/G SAMPLING GATE

4-45. The output of the phase detector is fed to the integrator in A19, which consists of an operational amplifier with a resistor at its input and a capacitor in its feedback network. The integrator capacitor is switched short and open by the diode switch. The period of integration is about 1 mS or 20 mS when the diode switch is open. The output of the integrator is fed to the comparator and is compared with positive and negative reference voltages. When the integrator output goes higher than the positive reference or lower than the negative reference, the comparator provides an output for C and D/G Sampling Gate. A 20 mS integration, high sensitivity integration is actuated by the control of the Timing Circuit when the integrator output exceeds neither the positive nor negative reference voltage of the comparator.

4-46. The output of the comparator is sampled at the C and D/G Sampling Gate with sampling Pulse 1 and Timing Pulse PL2, therefore the output of the C and D/G Sampling Gate is a pulse with duration from Sampling Pulse 1 to PL1, and is named U1 or D1 for capacitance and U2 or D2 for D/G. Signals U1, D1, U2 or D2 are gated by the Timing Pulse PL1 and are used for producing signals: UP1, DOWN 1, C GATE CONTROL SIGNAL or K1 for capacitance and UP2, DOWN 2, G GATE CONTROL SIGNAL or K2 for D/G. The C or G GATE CONTROL SIGNAL is produced when the Sampling Gate output changes from U1 (U2) to D1(D2) or from D1 (D2) to U1 (U2) with the same timing as PL2. K1(K2) signal is produced when neither U1 (U2) nor D1 (D2) is provided by the Sampling Gate.

4-47. C & D/G GATE CONTROL (2), C & D/G GATE PARAMETER CONTROL (A20)

4-48. The Gate Control Circuits group has two major functions:

1. To determine the destination of the Counter Driving Pulse, in other words, to determine-
   a. which (C_S or D/G) counter is to be selected......... Parameter Control
   b. which digit of the counter to be driven...... C or D/G Gate
   c. which direction to be driven... UP or DOWN
2. To detect the bridge balance.... Null Circuit

All of these functions are performed by the combination or sequence of the above mentioned signals from the C and D/G Gate Control.

4-49. TIMING CIRCUIT (A21)

4-50. The Timing Circuits provides the clock pulses which advance the balancing operation in 1 ms or 20 ms period steps. At each cycle of the clock pulse the following signals are produced:

Sampling Pulse 1.....	Samples the comparator output at C and D/G Sampling Gate for producing U1, D1, U2, D2.
Sampling Pulse 2.....	Samples the comparator output at C and D/G Sampling Gate for determining the integrator sensitivity 1 mS or 20 mS.
PL1	Gate Control Timing Pulse (1)
PL2	Gate Control Timing Pulse (2)
PL3	Counting Control Timing Pulse.

4-51. The Counting Control Timing Pulse PL3 is gated by C or D/G Gate and C, D/G Gate Control (2) and is led to the proper digit of the C or D/G Reversible Counter as the driving pulse.

4-52. The timing circuits also provide an originator of the initial set pulses for the Set Pulse Generator in A24 which produces set pulses, Ps2 for Range Selector (A22), Ps3 for C_S Driver (A16) and Ps4 for initial setting of C Gate Control (A20).

4-53. C_S AND D/G REVERSIBLE COUNTER & DRIVER (A16, A18, A4, A5 and A1)

4-54. The Counter and Driver receive the driving pulses (synchronous with the Timing Pulse PL3) and count them upwards or downwards according to the Direction Control Signal from the Gate Control circuits. The result of the counting is transmitted to the C_S or D/G Attenuator Switch Driver to provide an identical setting of the attenuator, and also gives the BCD information to the C_S or D/G Display Driver through the Buffer Storage circuit. The Buffer Storage circuit, on the other hand, provides the BCD output for external devices.

4-55. RESET CIRCUITS (A24)

4-56. The Main Gate in A21 is enabled after a 10mS delay on receiving the Reset signal, it remains open during the balancing operation and closes when the Null circuit in A20 detects the bridge balance and produces the balancing out signal PN. The timing diagram of the Main Gate signal and its relevant signals are shown in Figure 4-4.

4-57. Reset signal is classified into three kinds;

RESET (1):	for Gate Control circuits and Timing circuits.
RESET (2):	for Range Selector (only in AUTO RANGE).
RESET (3):	for C_S and D/G counter (only in AUTO and HOLD RANGE).

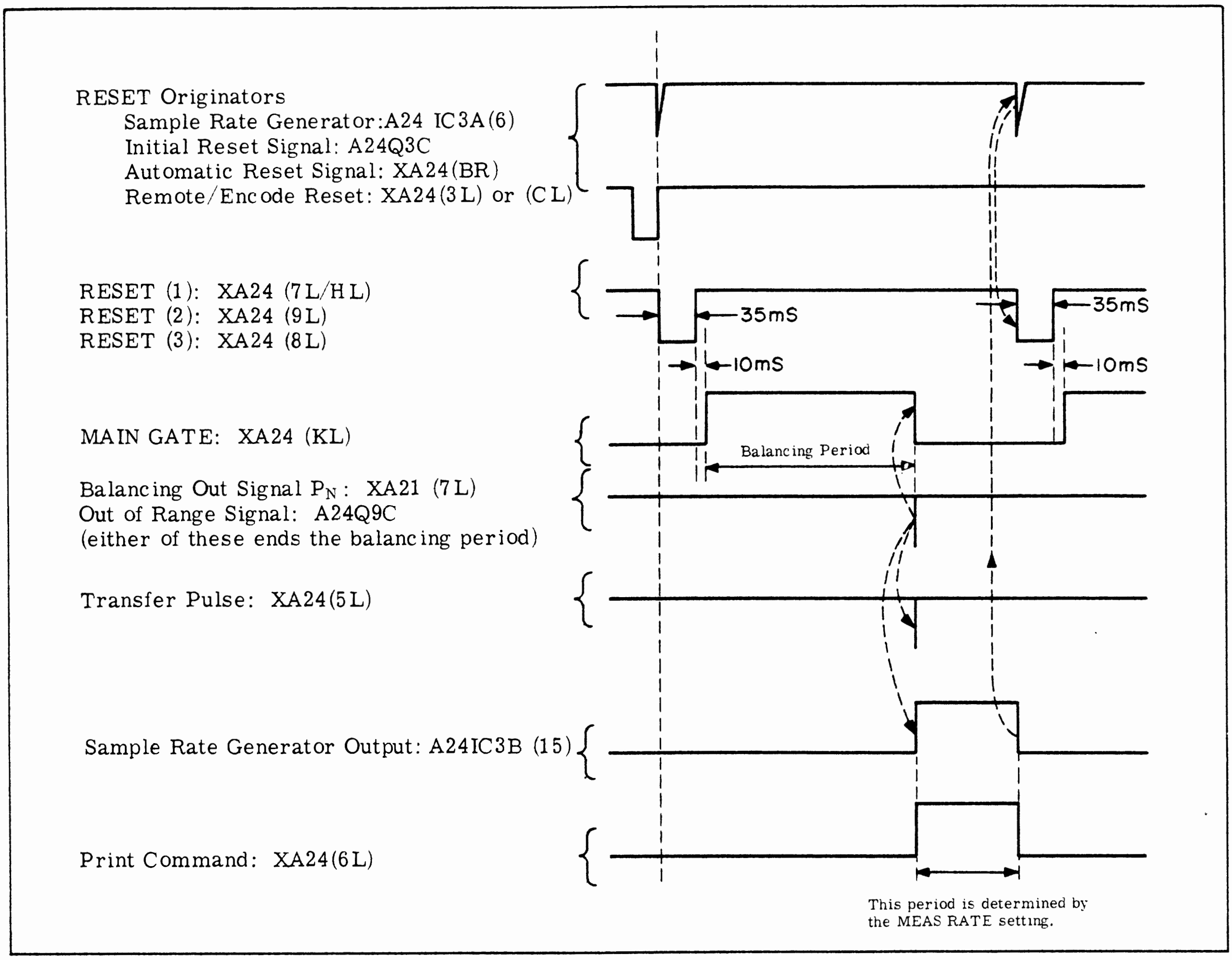


Figure 4-4. Timing Diagram

and is originated by one of the following signals; Sample Rate Generator output, Initial Reset signal, Automatic Reset signal and Reset signal provided by RESET and REMOTE RESET on the front panel or by REMOTE and ENCODE/RESET on the rear panel.

4-58. The Sample Rate Generator receives the Main Gate signal and is triggered by the trailing edge of the Main Gate signal or by the Out of Range Detector output. The duration of the Sample Rate signal is determined by the time constant of CR network involved in the feedback loop. The resistor of this CR network is changed by the MEAS RATE of the Function Switch. Thus the Measurement Rate i. e. the period between adjacent measurement is set at about 70mS by SHORT, 2S by MED and 5S by LONG. The Sample Rate signal is also used to generate the Print Command signal at the same timing.

4-59. The Initial Reset Circuit provides a reset signal at the application of power for producing RESET(1) RESET (2), RESET (3) and besides Psl the Set Pulse for Range Selector and C_S G_S counter.

4-60. The Automatic Reset signal is produced by the Time Limit Pulse Generator in A21, if 1.5 seconds passed while the Main Gate is open. As indicated in paragraph 3-26, a change in unknown value during the balancing operation or a larger values of dissipation factor requires a longer balancing time than 1.5 sec. In this case, the balancing operation is reset at 1.5 seconds from the beginning of the Main Gate signal.

4-61. The Reset signal is otherwise provided by the push button or connectors on the front and rear panels as shown in paragraph 3-37 and Figure 3-7.

4-62. FUNCTION SWITCH (A3) AND SWITCHING CONTROL CIRCUIT (P/O 24 and A25)

4-63. The setting of the Function Switch (A3) on the front panel provides the switching Control circuit(A25) with information on the following eight items as listed Table 4-1.

4-64. RANGE SELECTOR (A22)

4-65. The C_S range is determined by the shift register in the Range Selector whose clock pulses are provided by Range Selector Driving Pulse from A20 Gate Ass'y or Range step signal from A25. And the initial condition of this shift registor is set by Psl, Initial Set Pulse for Range Selector and C_S G_S counter when

Table 4-1. Function Switch (A3) Description

Function	Control in A3 is connected to	Signals from A25 or A24 goes to	Function and Purpose
FREQUENCY(Hz) 1 k, 10 k, 100 k, 1 M	XA25 PL, XA25 NL, XA25 RL, XA25 SL	A10 Phase Detector Ass'y 1k:XA10(2L), 10k:XA10(3L) 100k:XA10(4L)	To provide a correct phase shift of 45° for all the frequencies by selecting capacitor.
		A13 Osc. & Buffer Ass'y 1k:XA13(6L), 10k:XA13(5L) 100k:XA13(4L), 1M:XA13(3L) 1k: XA13(13R)	To provide a proper feedback network of the oscillator for the correct frequency. To turn K5 ON, providing 1V rms test voltage at 1kHz.
	Fig. 8-32 Page 8-61	A22 Range Selector Ass'y 1k:XA22(DR), 10k:XA22(CR) 100k:XA22(BR), 1M:XA22(AR)	To control the Range Selector Shift register to determine the destination of Ps2 (Set Pulse for Range Selector), i. e. the maximum Cs range for the selected frequency. To provide the frequency information for the diode matrix to select a proper Gs range with another information of Cs range.
MEAS RATE SHORT, MED, LONG	No relay is used. Direct switching of the resistor across XA24(SL) and XA24(FL). Fig. 8-29, Page 8-55		To change the duration of the Sample Rate Generator output by changing the time constant of the CR network in the Sample Rate Generator.
RANGE MODE AUTO, HOLD, TRACK	XA25 (AL), XA25 (BL), XA25 (CL)	A20 Gate Ass'y AUTO:XA20(RR) HOLD:XA20(PR) TRACK:XA20(NR)	To gate the Initial Set Pulse Ps4 for a proper digit in the shift registers of C and D/G GATE.
		A21 Timing Circuit Ass'y TRACK:XA21(6L)	To disable Time Limit Pulse Generator in TRACK mode.
	Fig. 8-32 Page 8-61	A24 Reset and DC Bias Control Ass'y AUTO:XA24(11R) XA24(11L) TRACK:XA24 (10L)	To disable the DC Bias in AUTO mode. To gate for Ps2 (Set Pulse for Range Selector) and RESET (2) (Reset for Range Selector). To disable RESET (3) (Reset for Cs, Gs Counter) in TRACK mode.

Table 4-1. Function Switch (A3) Description (Cont'd)

LOSS MEAS D G	 XA25(BR) XA25(AR) Fig. 8-32 Page 8-61	A8 D Amp Ass'y D: XA8(15) G: XA8(14) A23 Display Control Ass'y D: XA23(SR) D:XA23(AR), G:XA23(2R) A5 D/G Buffer Storage Ass'y D:XA5(5R), G:XA5(6R)	To turn D Relay (K1) ON, G Relay (K2) OFF at D,and D Relay (K1) OFF, G Relay (K2) ON at G. To disable the unit and decimal point display for Conductance. To provide the BCD output. To make +170V path for "D" "G" display
TEST VOLTAGE NORM LOW	 XA25(CR) NO. CON. Fig. 8-32 Page 8-61	A13 Osc. & Buffer Ass'y NORM:XA13(14R)	To turn NORM Relay (K6) ON.
DC BIAS RANGE EXT OFF 20 V 200 V	 XA24(HR) XA24(JR) XA24(FR) XA24(ER) Fig. 8-30 Page 8-57	A12 D/G Amp and Gs Ass'y EXT, 20V, 200V:XA12(14R) OFF :XA12(13R) A26 DC Bias Supply Ass'y EXT:XA26(12L) OFF:XA26(10L) 20V:XA26(5R) 200V:XA26(6R)	To turn DC BIAS ON Relay (K6) ON at 20V, 200V and EXT for blocking the DC current through D/G Amp and Gs Ass'y when DC Bias is applied. To provide proper relay drive.
MEAS CKT FLOAT L-GND	 XA3(13) XA3(R) Fig. 8-7 Page 8-11	 XA22(DL) K1(13)	To gate for determining the minimum Cs range. To energize the relay K1 for making the bridge circuit LOW grounded.
RANGE STEP	XA25(6L) Fig. 8-32 Page 8-61	A22 Range Selector XA22(5L)	To advance the Cs range selection by sending clock pulses to the shift register in the Range Selector.

the instrument is turned on or by Ps2 coming through the gates controlled by Frequency information from A25. The information of the selected C_S range is transmitted to the Relay Drives for driving relays in:

A7 C_S AMP ASS'Y.... selection of the standard capacitor.

A6 C_S AMP ASS'Y.... providing attenuation for the oscillator output at 1μF range.

A11 CURRENT DETECTOR ASS'Y..... selection of the feedback network of the Current Detector.

and for controlling

A23, DISPLAY CONTROL ASS'Y... control of the unit and decimal point for capacitance display.

4-66. The Diode Matrix determines the G_S range with the information of the selected C_S range and the frequency and its outputs are coupled to A23 Display control Ass'y for the proper unit and decimal point of the D/G display and to another relay driver for G_S Range. This relay driver controls A11 Current Detector and A12 D/G Amp & G_S Ass'y

4-67. DISPLAY CIRCUIT (A1, A2)

4-68. The Display Circuits consist of the numerical display (A1) and the Units, etc display. The Numerical display is performed by five nixie tubes for capacitance and four for D/G, with decimal converted signals from C_S and D/G driver and +170 V supply as the driving source. The Units, etc. display is performed by neon tubes, with the same DC driving source of +170V. The units and decimal point are controlled by the Display Control Ass'y A23, while BALANCING and OUT OF RANGE display is controlled by the Sample Rate Generator circuit and the Out of Range Detector circuit in A24. The Storage On/Off Switch in A25 provides the transfer pulse from the Sample Rate Generator to C_S & D/G Buffer Storage in A4 and the Display Control circuit in A23 for storing the results of the preceeding measurement until the end of the balancing operation.

4-69. POWER SUPPLY CIRCUITS

4-70. GENERAL DESCRIPTION

4-71. This group of circuits includes the power transformer T1, its primary and secondary circuits including rectifier and regulator circuits Ps1 through Ps8. These circuits are packed in the assemblies A26, A27 and A28 shown in Figure 8-33 (Page 8-63) and 8-34 (Page 8-65).

4-72. POWER TRANSFORMER

4-73. The Model 4270A can be used in a LOW-GROUNDED mode which maintains the guard effect to the unknown. For this LOW-GROUNDED use, the induction from the power line to the secondary circuits of the transformer is strictly suppressed by using a unique shield on the Power Transformer. As the Figure 8-34 shows in schematic diagram of the Power Transformer and its primary circuits, all the parts of the primary circuit are shielded at the power line ground potential and the interconnection between the transformer and the primary circuit is made by shielded cables. Similar technique is applied to the secondary windings of the transformer.

4-74. POWER SUPPLY ASSEMBLIES (A27/A28)

4-75. Power supplies Ps-2 through Ps-5 are all essentially identical. Ps-4 has its positive side referred to ground, establishing the negative output. Description of power supply operation will be referred to Ps-1, Ps-2 and part of Ps-5. For the negative supply, operation will be identical but with reversed polarities.

4-76. Ps-1 SUPPLY

4-77. Rectifiers CR1-CR4 form a full wave bridge rectifier for the Ps-1 supply. In this arrangement, two rectifiers operate in series on each half of the cycle, one rectifier being in the lead to the load, the other being in the return lead. C1 sets ac output impedance and CR5 (A28) provides partial regulation. The Ps-1 supply is referred to the Ps-2 (+15 volt line) and a voltage of +24 volts with respect to ground is developed at the 10R (A28) connector and is used as a current source for the CR1 (A27) zener diode.

4-78. Ps-2 SUPPLY

4-79. Pulsating (rectified) dc at the output of the four-diode rectifier bridge is applied to the collector of the series regulator transistor Q1 (A28). The output voltage is applied across R5 (A28), R6 (A28) and R7 (A28) a voltage divider, such that some fraction of this voltage will be applied to the base of Q3. Should the voltage at the Q3 base exceed the Q3 emitter value by more than 0.6V (amount needed to forward bias Q3) transistor Q3 will turn on, and its collector will go more negative. This negative-going signal will be applied through emitter follower Q1 (A27) and turn off Q1 (A28). Subsequently, the signal at the (Q2 base) will increase the effective resistance of the series regulator. This tends to reduce the amount of voltage available to the output, by dropping a portion of the total across Q1 (A28). Basically, this is how the supply would regulate a shift in level at the rectifier output. In actual fact the rectifier output signal is continually changing, as it is a pulsating signal. Thus the amplifier chain feeding the series regulator is continually compensating for this pulsation, effectively smoothing the rectifiers output. C2 sets ac output impedance, CR1 is the dc reference for the supply and Q2 provides current overload protection. If the current increases to overrated values due to faults in the instrument circuitry outside the supply, the drop across R2 increases enough to turn on Q2 and drive the Q2 collector towards ground. This represents a turn-off signal to the series regulator, which then limits the current in the overload. Transistors Q4, Q5, Q6 and CR5 supply the +12 volt line.

4-80. Ps-5 SUPPLY

4-81. Ps-5 power supply as previously stated is identical to the others except an additional protection circuit is provided besides the current limiting circuit consisting of transistor Q16, silicon control rectifier (SCR) CR6 and zener diode CR7. In the event of loss of regulation or shorted series regulator, transistor Q16 (normally off) will turn on due to a large voltage drop across R36. The silicon control rectifier (SCR) CR6 would conduct heavily as a result of Q16 collector triggering action, thereby providing adequate protection to the voltage sensitive integrated circuits.

4-82. DC BIAS SUPPLY A26

4-83. Pulsating (rectified) dc at the output of the four-diode rectifier bridge (refer to para. 4-170 thru 4-171) is applied to the emitter of series regulator Q1 (ps-7). Transistor Q2 further amplifies and inverts the phase of the error signal from the high gain operational amplifiers Q3A/B, Q4A/B, and a regulated 0 to -20V or 0 to -200 V are supplied to Xa 12 pin 5R. Diodes CR1 and CR2 protect transistor Q2 from the large voltage drop and establish a fixed reference at Q1 base. Operational amplifiers Q3A/B and Q4A/B amplify the error voltage across the divider circuit R17, R18 and R19. The variable resistor R14 provides for "zero-adjust" when DC bias vernier control R1 is set to a minimum (counterclockwise). Transistor Q5 supplies a constant current source to Q4A/B. Transistors Q8 and Q9 provide for the "200V-adjust" on REMOTE or internal functions respectively. With R1 set at its minimum value, transistor Q4A base is grounded. Control R14 is adjusted to supply zero output to XA 12 (5R). Capacitor C3 sets output impedance. Ps6 supplies the +170 volt output with transistor Q1 as a series regulator and Q2 as error amplifier. P-s-8 supplies the -12V with transistor Q6 providing some regulation and also the return path to ground of the supply positive side. Transistor Q7 is used as error amplifier. Junction R17 and R18 supplies 0V to 20V when K2 is energized and K1 is de-energized. Diode CR3 is back-biased by -6V reference (maximum bias applied to Q4A base when R1 is set fully clockwise), in order to prevent the output voltage from exceeding the maximum value set by R1 on internal when REMOTE function is used and the connection between J4 and J5 is not terminated.

4-84. LOGIC SYMBOLS

4-85. Logic symbols used in the schematic diagrams are shown in Table 4-2 with the description of their function.

4-86. The description of AND, OR, NAND, NOR gates in Table 4-2 are based on the positive true signal (true level is +5V). Where ground is the true signal (true level is 0V), NOR gate works as AND gate and NAND gate works as OR gate. The followings are examples for these cases picked up from the schematic diagram.

a. NOR gate working as AND gate: page 8-45, Figure 8-24 IC7A.

Input Pin 2: Parameter "G" signal from IC17A (15): +5V while the parameter "G" is selected, and 0V while the parameter "C" is selected.

Pin 3: C Gate Control Signal from XA19 (9R), negative going pulse (ground true signal).

Therefore the output of IC7A goes high when both of two inputs are low, in other words, when C Gate Control Signal comes to Pin 3 while Parameter "C" is selected. This means just the AND gate for the two input signals C Gate Control Signal and Parameter "C" signal.

b. NAND gate working as OR gate (page 8-45, Figure 8-24 IC3B):

Input Pin 1: output of NAND gate IC3A: ground true signal, $\overline{\mathrm{CsMIN \cdot PL2}}$.

Pin 2: output of inverter IC1C: ground true signal, $\overline{\mathrm{K1}}$.

Output Pin 3 goes high when one or two of IC3B inputs goes low i.e. $\overline{\mathrm{CsMIN \cdot PL2}}$ signal and/or $\overline{\mathrm{K1}}$ signal come to the IC3B inputs. Therefore this gate works as OR gate for input signals $\overline{\mathrm{CsMIN \cdot PL2}}$ and $\overline{\mathrm{K1}}$.

4-87. SEQUENCE OF BALANCING OPERATION

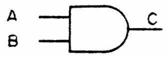
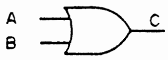
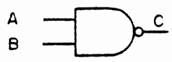
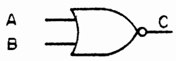
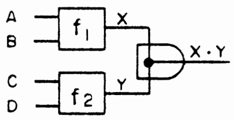
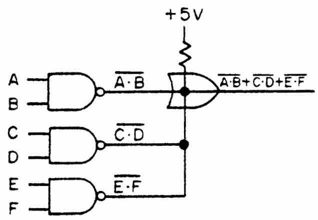
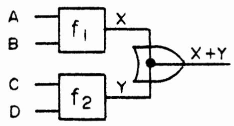
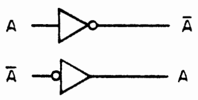
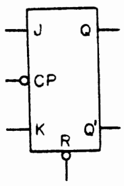
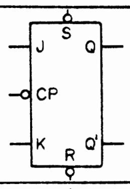
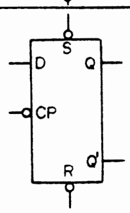
4-88. The 4270A acts as an automatic controller which operates a conventional manual bridge manipulating controls of capacitance and loss components. It sets the initial condition of the bridge and logic circuits, compares the current through the unknown with that through the standard capacitance and conductance, analyzes the error signal using the phase detector, integrates the outputs of the phase detector to produce two kinds of information for control of Cs and D/G Attenuators, changes the attenuator settings by this information for the bridge balance, after repeating this step of attenuator setting, and finally detects the bridge balance and provides the transfer pulse for the resultant display and the reset for a next balancing operation. The sequence of these performances is carried out in proper order and timing. Paragraphs 4-89 through 4-105 describe the sequence of the balancing operation.

4-89. The Timing Circuit Assembly (A21) and the Reset Assembly (A24) supply the various synchronization, sampling, reset and timing pulses for the timing operation of the bridge. Figure 4-4 in paragraph 4-55 shows a simplified timing diagram for one balancing cycle. Figures 4-5 and 4-6 illustrate the detailed timing sequence of one balancing period on AUTO and on HOLD and TRACK. Figure 4-7 shows a magnified waveforms Sampling Pulse 1 and Timing Pulses.

4-90. SIMPLIFIED SEQUENCE DESCRIPTION

4-91. Each balancing period is initiated by an internal trigger generated by the Sample Rate Generator in conjunction with the MEAS RATE switch setting, or an external reset pulse provided through REMOTE RESET or ENCODE RESET. The internal trigger is developed at the reset input to the Sample Rate F/F (A24IC3B) and toggles Reset F/F (A24IC3A) when the

Table 4-2. Logic Symbols

<table>
<tr><th>Symbol</th><th>Name</th><th>Function</th></tr>
<tr><td></td><td>AND gate</td><td><table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table></td></tr>
<tr><td></td><td>OR gate</td><td><table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>0</td><td>0</td><td>0</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>1</td><td>1</td></tr></table></td></tr>
<tr><td></td><td>NAND gate</td><td><table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>1</td></tr><tr><td>0</td><td>1</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td></tr>
<tr><td></td><td>NOR gate</td><td><table><tr><th>A</th><th>B</th><th>C</th></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>0</td><td>0</td></tr><tr><td>0</td><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table></td></tr>
<tr><td></td><td>WIRED AND gate</td><td rowspan="2">The logic functions f1 and f2 have a faculty that makes AND (OR) gate for outputs of f1 and f2 by simply connecting two outputs. For example, the WIRED OR gate appears in the circuit of 4270A as shown on the right.
</td></tr>
<tr><td></td><td>WIRED OR gate</td></tr>
<tr><td></td><td>INVERTER</td><td>The logic state of the input signal is inverted at the output, i. e. the positive true signal is inverted to the ground true signal and vice versa.</td></tr>
<tr><td></td><td>MASTER-SLAVE FLIP FLOP</td><td>1. Leading edge of clock pulse acknowledges (stores) the input information at J and K; trailing edge of clock pulse sets or resets the flip-flop according to the table below.<table><tr><th>J</th><th>K</th><th colspan="2">Initial State</th><th colspan="2">Resulting State</th></tr><tr><th></th><th></th><th>Q</th><th>$\bar{Q}$</th><th>Q</th><th>$\bar{Q}$</th></tr><tr><td>1</td><td>0</td><td></td><td></td><td>1</td><td>0</td></tr><tr><td>0</td><td>1</td><td></td><td></td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td><td>1</td><td>1</td><td>0</td></tr><tr><td>1</td><td>1</td><td>1</td><td>0</td><td>0</td><td>1</td></tr><tr><td>0</td><td>0</td><td></td><td></td><td colspan="2">No change</td></tr></table>2. Low input to R resets the flip-flop, ($Q = 0$ $\bar{Q} = 1$) independently of clock pulse.</td></tr>
<tr><td></td><td>MASTER-SLAVE FLIP FLOP WITH PRESET (SET) AND CLEAR (RESET)</td><td>1. Clock pulse performance is same as above shown MASTER-SLAVE FLIP-FLOP.
2. Low input to S sets the flip-flop, ($Q = 1$, $\bar{Q} = 0$) and low input to R resets the flip-flop, ($Q = 0$, $\bar{Q} = 1$) independently of clock pulse.
Set and reset are independent of clock.</td></tr>
<tr><td></td><td>D-TYPE FLIP FLOP</td><td>1. Input information at D is transferred to the outputs Q, $\bar{Q}$, at the positive going edge of the clock pulse, according to the truth table on the right.<table><tr><th>Input (D)</th><th>Q</th><th>$\bar{Q}$</th></tr><tr><td>0</td><td>0</td><td>1</td></tr><tr><td>1</td><td>1</td><td>0</td></tr></table>2. Low input to S (or R) sets (or resets) the flip-flop independently of clock.</td></tr>
</table>

positive going ramp developed by the integrating network exceeds the trigger level of A24IC4B. This CR time constant may be varied by the front panel MEAS RATE control and presents time intervals between balancing operations.

4-92. When an internal trigger or an external reset pulse sets Reset F/F (A24IC3A), a RESET pulse is initiated and a balancing period is started. The RESET (2) pulse is about 35 ms. At the end of the reset pulse the decade counter (A21IC15) starts counting the pulse train from the pulsed oscillator. At 10th pulse, the decade counter produces a positive going wavefront which sets the Main Gate F/F (A21IC1) and initiates the balancing period. The detailed balancing period is described in paragraphs 4-94 through 4-103.

4-93. When the bridge is balanced, Null Detector (A20) should produce the Balancing End pulse PN which resets Main Gate Control F/F (A21IC1). The Main Gate Control F/F output ends the balancing period and sets Sample Rate Generator F/F (IC3BQ) to LOW which makes the print command signal go positive and the transfer pulse go negative. A negative transfer pulse enables all counts contained in Cs and D/G Counter to be transferred to the front panel digital display and to the rear panel RECORDER output. F/F IC3BQ output (HIGH) develops a positive going ramp in conjunction with the time delay network. The time interval from the transfer pulse to the next balancing period is the display period. The display period is varied by the MEAS RATE switch for the intervals of 70ms, 2 sec, and 5 sec. With the MEAS RATE in MAN, the display period does not change until the RESET button is depressed or until a new balancing period is initiated by an external trigger. The front panel display and RECORDER output remain unchanged after completion of the display period until the next transfer pulse is received.

4-94. AUTO RANGE MODE TIMING

4-95. Detailed Timing Diagrams, Figure 4-5 and 4-6 illustrate two different timing conditions, (1) AUTO RANGE MODE (2) HOLD or TRACK RANGE MODE. The difference depends only on Go signal ("1" during range selection) which goes HIGH at the initial set pulse on AUTO.

4-96. AUTO RANGE MODE TIMING (refer to Fig. 4-5).

4-97. The period of the balance cycle is divided into three phases:

a. Relay settling time and initial condition set by Initial Set Pulse.

b. Range Selection Time.

c. Balancing time.

4-98. SETTLING Time: After Reset, the first pulse from pulsed oscillator toggles A21IC17A to produce Initial Set Pulse Ps4 via IC4C and IC4D in A24 Set Pulse Generator. This pulse is supplied to the C and D/G Gate Control for Auto Range Mode via IC18A and IC17B(A20). At the same time the Initial Set Pulse (1 μs width) is gated by FA signal and supplied to A22 and A16 which select the 1 μF Cs range and set the Cs counter 01600. The pulse train from the pulsed oscillator is coupled to the decade counter (A21IC15) and a positive going wavefront is generated for every 10th pulse from that gated train. This signal is used to set the main gate control flip/flop (A21IC1A) and provides reset signals for IC5B and IC7B in A21. The pulsed oscillator control F/F (IC5A) in synchronization with the initial main gate enable-signal inhibits the pulsed oscillation.

4-99. Range Selection Time: After the settling time the first pulse (0.6 μs width) through IC3A toggles IC5A$\overline{Q}$ to LOW and IC7AQ to HIGH. The IC5A$\overline{Q}$ LOW starts the pulsed oscillator to oscillate. IC7AQ(HIGH) opens the Diode Switch of Integrator A19. The integrator starts to integrate. The first pulse (3 μs width) from the pulsed oscillator resets IC5A$\overline{Q}$ to HIGH which inhibits the pulsed oscillator. After IC5A$\overline{Q}$ is reset to HIGH, the first synchronizing pulse from IC4A toggles IC5A$\overline{Q}$ to LOW, IC7AQ to LOW and IC8AQ to HIGH. This IC8AQ (HIGH) produces five synchronized pulses Sampling Pulse 1, PL1, PL2, PL3 and End Pulse, refer to Figure 4-7. The end pulse in conjunction with Go signal from A20 toggles IC5B$\overline{Q}$ to LOW and provides reset for IC8A/B, IC9A/B, and IC17B. During this interval a generated sampling pulse 1 compares the unknown capacitor with .1600 μF.

a. If the unknown capacitor is larger than .1600 μF, Timing Pulse PL1 and PL2 produce C gate control signal which causes Go signal to go LOW. This ends the Range Selection.

b. If the unknown capacitor is smaller than .1600 μF, C Gate control signal is not produced and the range is stepped down to 16.00nF. This cycle repeats itself until a suitable range is obtained. C Gate control signal or $\overline{\text{CsMIN}}$ causes the Go signal to go LOW. This ends the Range Selection. After the correct range has been selected one Sampling Pulse 1, one Timing pulse PL1, PL2 and PL3 are automatically generated (as described above). This begins balancing operation.

4-100. Balancing Time: $\overline{\text{Go}}$ (LOW) signal inhibits the End pulse to toggle IC5B$\overline{Q}$ to LOW. The IC5B$\overline{Q}$(HIGH) enables the first pulse from the pulsed osc. to reset IC5A. (Now, IC5B$\overline{Q}$ and IC5A$\overline{Q}$ are HIGH). The synchronizing pulse through IC4A toggles IC5A$\overline{Q}$ to LOW and IC7A$\overline{Q}$ to HIGH. This IC7A$\overline{Q}$ output toggles IC5B$\overline{Q}$ to LOW and makes the Integrator Diode Switch open. The Integrator starts to integrate. After IC5A$\overline{Q}$ goes LOW, the first pulse from pulsed osc. toggles IC17A$\overline{Q}$ to HIGH and then the synchronizing pulse through IC3A produces Sampling Pulse 2 (3 μs width) which is provided to A19 (C, D/G SAMPLING GATE) and resets IC17A. The Sampling Pulse 2 detects the comparator output level. When the Integrator output is above the (positive or negative) reference level, one of the Comparators is HIGH. The Sampling Pulse 2 detects both comparator outputs at the same time and produces

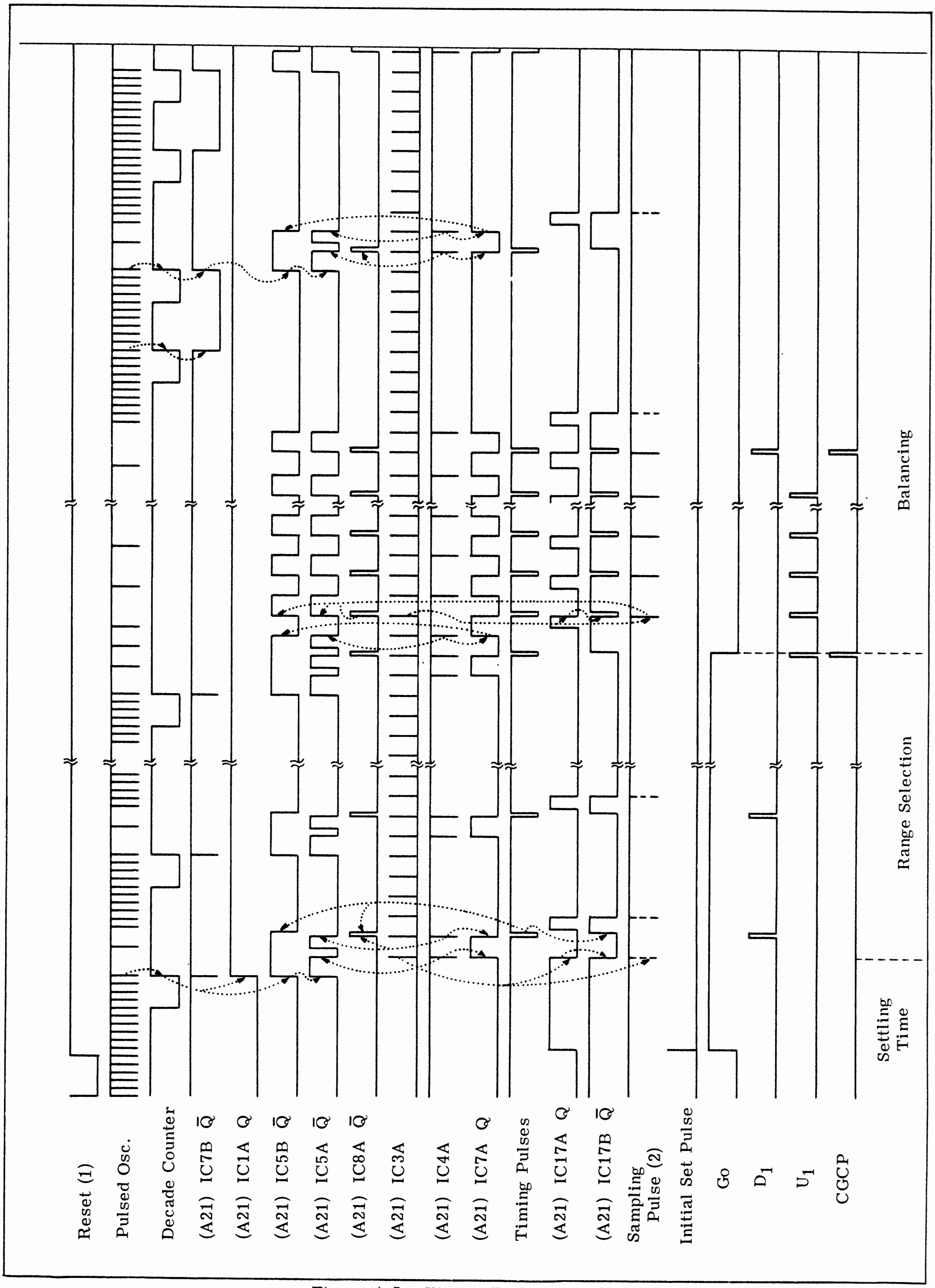


Figure 4-5. Timing Diagram on AUTO

H→L switching signal to A21.

a. When the Integrator output is above the (positive or negative) reference level, and the bridge is far from balance, the Sampling Pulse 2 is present to A21 as H→L switching signal. The H→L switching signal resets IC5A, IC5B, IC7A and IC7B, and sets IC8A. This IC8AQ HIGH produces Sampling Pulse 1, Timing Pulse PL1, PL2, PL3 and End Pulse. The Sampling Pulse 1 detects the polarity of the unbalance signal in A19. At the end of the Sampling Pulse 1, the Integrator Diode Switch is closed. The End Pulse resets IC8A/B, IC9A/B and IC17B.

b. When the bridge is near balance, the Integrator output falls below the (positive or negative) reference level so that the Sampling Pulse 2 does not produce H→L switching signal. The IC5A$\bar{Q}$ LOW makes the pulsed osc. continue to oscillate. The IC17B$\bar{Q}$ LOW disables the pulse from the pulsed osc. to toggle IC17A and to produce next Sampling Pulse 2. The decade counter counts the pulse train from the pulsed osc. and produces a positive going wavefront and a negative going wavefront for every 10th pulse. This positive going wavefront has no effect because Go signal is LOW. The negative going wavefront toggles IC7B$\bar{Q}$ to LOW. The second nega-

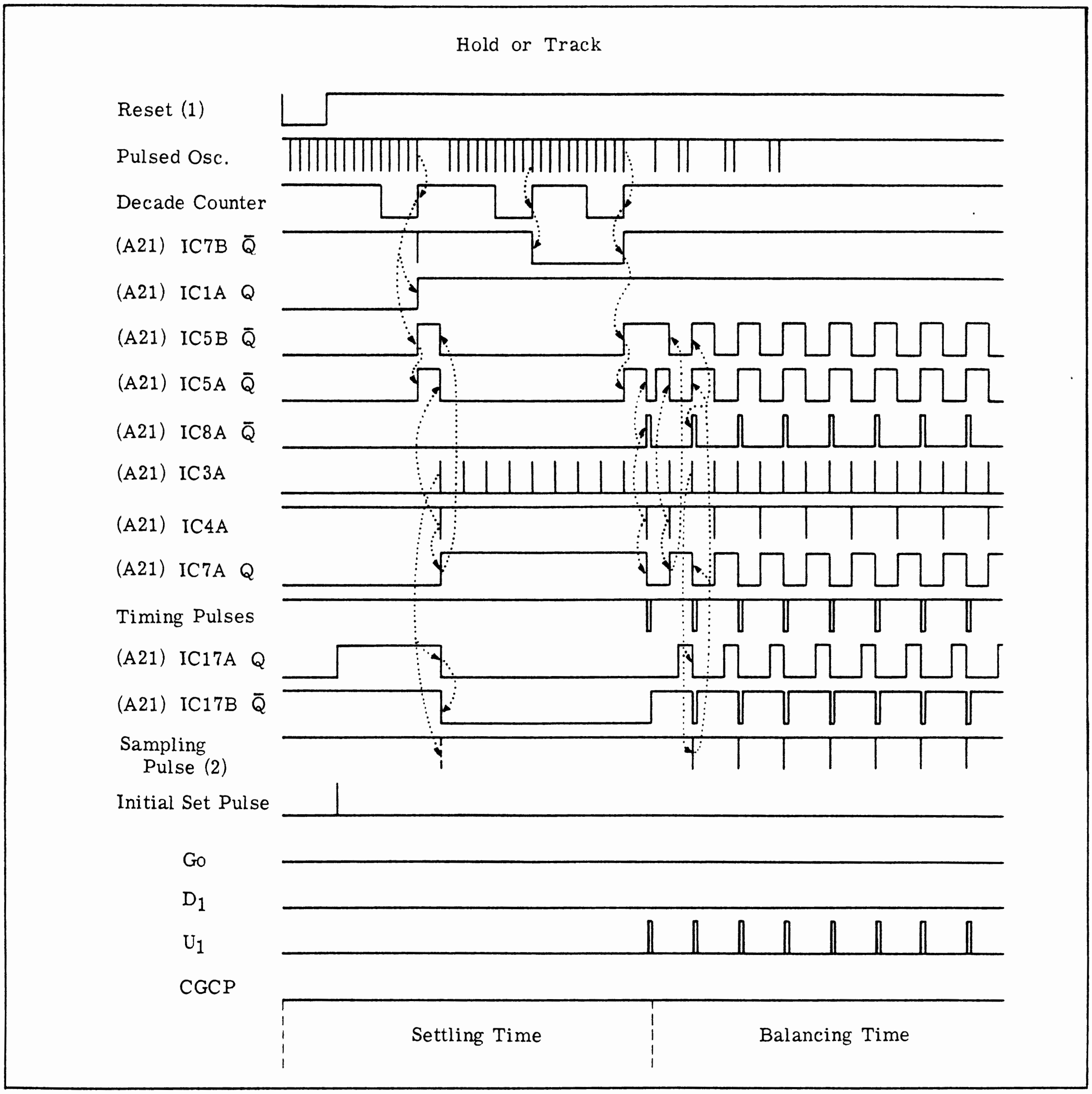


Figure 4-6. Timing Diagram on HOLD and TRACK

tive going wavefront toggles IC7B$\overline{Q}$ to HIGH which resets IC5B. The IC5BQ resets IC5A to stop the pulsed oscillator. The synchronizing pulse through IC4A is enabled by IC5AQ HIGH to toggle IC5A, IC7A and IC8A, and to produce Sampling Pulse 1. At this time, the logic circuits are in the same states as they were at the end of Range Selection. The timing at which the next Sampling Pulse 1 and Timing Pulses are produced depends on the Integrator output as described above.

4-101. HOLD AND TRACK RANGE MODE TIMING

4-102. The period of the balance cycle is divided into two phases:

a. Relay settling time and initial condition set by initial set pulse.

b. Balancing time.

4-103. Settling Time: After Reset, IC1AQ, IC5A$\overline{Q}$ and IC5B$\overline{Q}$ go HIGH as same as described in AUTO. During that time, the initial set pulse is supplied to Counter Gate Selector A20. The first pulse through IC4A toggles IC5A$\overline{Q}$ to LOW and IC7A$\overline{Q}$ to HIGH. This positive going output from IC7A is enabled by Go (LOW) to toggles IC5B$\overline{Q}$ to LOW. IC5B$\overline{Q}$ LOW inhibits the pulsed osc. output to reset IC5A so that the pulsed osc. continues to oscillate. The decade counter counts the pulse train and produces positive and negative going wavefront for every 10th pulse. IC7B$\overline{Q}$ goes LOW at the 10th pulse and goes HIGH at the 20th pulse. This positive going output from IC7B resets IC5B$\overline{Q}$ to HIGH. The IC5BQ resets IC5A which stops the pulsed oscillation. After IC5B$\overline{Q}$ and IC5A$\overline{Q}$ go HIGH, the first synchronizing pulse through IC4A toggles IC5A$\overline{Q}$ to LOW, IC7AQ to LOW, and IC8AQ to HIGH, so that the first Sampling Pulse 1 and Timing Pulses are produced. At the end of the Timing Pulses, the logic circuits are in the same states as they were at the end of Range Selection on AUTO. This begins balance operation Timing of Balancing time of HOLD or TRACK is same as that of AUTO.

4-104. EXAMPLE OF SEQUENCE OF BALANCING OPERATION

4-105. A detailed description of the sequence of balancing operation is given by Table 4-3, 4-4 and Figures 4-8 through 4-10. Table 4-3 shows a series of changes in Capacitance and D/G Attenuator (and Counter) setting, and functions of Logic Circuits which are originated by the detection of the Comparator output in A19 at each setting. Figures 4-8 through 4-10 show the signal flow in Logic Circuits at each step of the balancing operation. Table 4-4 shows a series of operations in the Null Circuit.

4-106. MAJOR FUNCTIONS OF LOGIC CIRCUIT

4-107. This paragraph contains description of conditions for major functions of Logic Circuit, 1 digit shift down, parameter change and nulling.

a. 1 digit shift down in Capacitance Gate: is enabled by a positive going pulse from A20IC8A, which works as a clock pulse for the capacitance digit-selecting shift register (IC18A/B, IC19A/B, and IC20A).

b. 1 digit shift down in D/G Gate: is enabled by a positive going pulse from A20IC10A, which works as a clock pulse for the D/G digit-selecting shift register (IC17B, IC22A/B and IC20B).

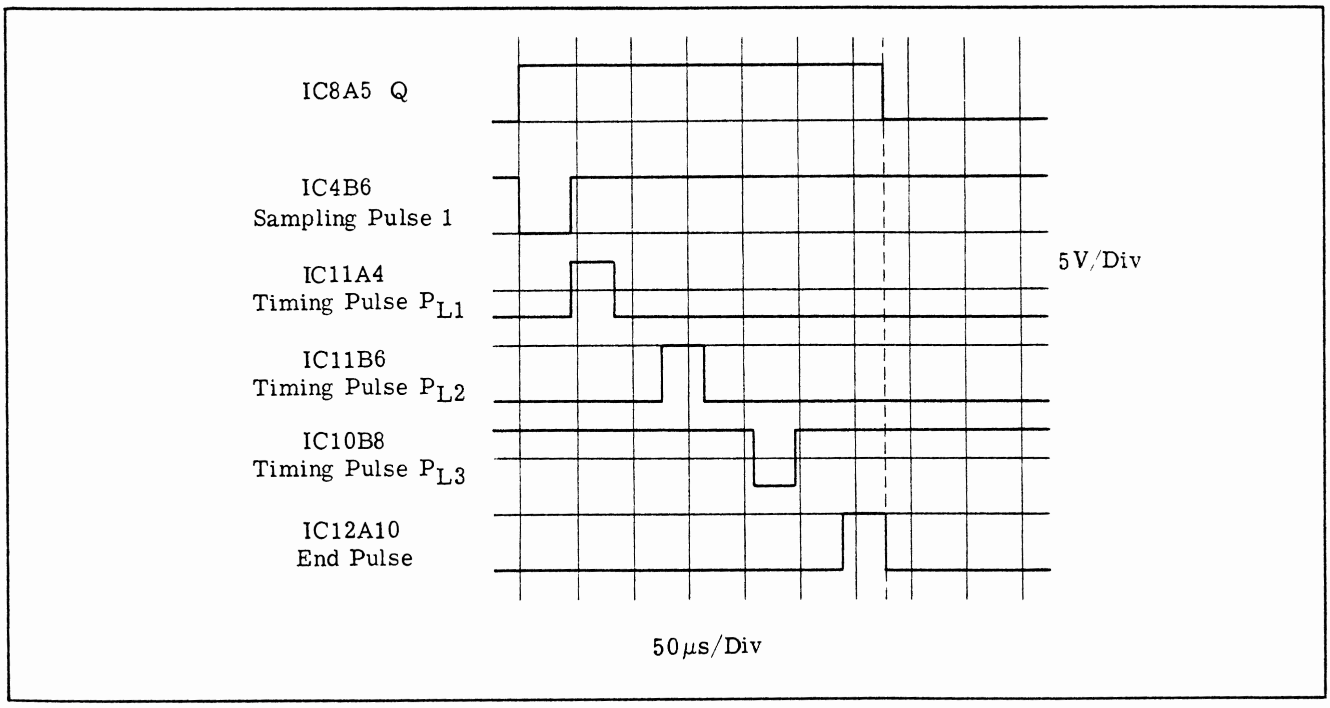


Figure 4-7. Sampling Pulse 1 and Timing Pulse (PL1, PL2, PL3)

Table 4-3. Sequence of Balancing Operation

This chart shows steps of change in Attenuator (Counter) setting and the relevant logic functions during a balancing operation for a capacitance value of 4270pF and conductance of 3.5µ . Function Switch settings are listed below.

FREQ	RANGE MODE	LOSS MEAS	MEAS RATE	MEAS CKT	TEST VOLTAGE	DC BIAS RANGE
10kHz	AUTO	G	SHORT	FLOAT	NORM	OFF

Step	Counter and Attenuator Setting		Gate Control(1) Output		Function of Logic Circuit (Details of each step are described in Table 4-4.
	Capacitance	D/G	Capacitance	D/G	
1	00000	0000			*Initial Set Pulses set the logic circuits.
2	016.00 nF	00.00 µ℧	DOWN 1	UP 2	*Range down(Cs⟶10nF range.)
3	01.600 nF	000.0 µ℧	UP 1	UP 2	*Range selection completed
4	02.600 nF 03.600 nF	000.0 µ℧ 000.0 µ℧	UP 1 UP 1	UP 2 UP 2	*1 count (up) in 10^3 digit of Capacitance Counter and Attenuator
5	04.600 nF	000.0 µ℧	DOWN 1	UP 2	*1 digit down in C GATE CONTROL *1 count (down) in 10^2 digit of capacitance
6	04.500 nF 04.400 nF 04.300 nF	000.0 µ℧ 000.0 µ℧ 000.0 µ℧	DOWN 1 DOWN 1 DOWN 1	UP 2 UP 2 UP 2	*1 count (down) in 10^2 digit of Capacitance Counter and Attenuator
7	04.200 nF	000.0 µ℧	UP 1	UP 2	*1 digit shift down in C GATE CONTROL · *Parameter Change *1 count (up) in 10^3 digit of D/G
8	04.200 nF	100.0 µ℧	UP 1	DOWN 2	*1 digit shift down in D/G GATE CONTROL *1 count (down) in 10^2 digit of D/G
9	04.200 nF ⋮ 04.200 nF	090.0 µ℧ ⋮ 010.0 µ℧	UP 1 ⋮ UP 1	DOWN 2 ⋮ DOWN 2	*1 count (down) in 10^2 digit of D/G Counter and Attenuator
10	04.200 nF	000.0 µ℧	UP 1	UP 2	*1 digit shift down in D/G GATE CONTROL *Parameter Change *1 count (up) in 10^1 digit of Capacitance
11	04.210 nF ⋮ 04.260 nF	000.0 µ℧ ⋮ 000.0 µ℧	UP 1 ⋮ UP 1	UP 2 ⋮ UP 2	*1 count (up) in 10^1 digit of Capacitance Counter and Attenuator
12	04.270 nF	000.0 µ	DOWN 1	UP 2	*1 digit shift down in C GATE CONTROL *Parameter Change *1 count (up) in 10^1 digit of D/G
13	04.270 nF 04.270 nF 04.270 nF	001.0 µ℧ 002.0 µ℧ 003.0 µ℧	DOWN 1 DOWN 1 DOWN 1	UP 2 UP 2 UP 2	*1 count (up) in 10^1 digit of D/G Counter and Attenuator
14	04.270 nF	004.0 µ℧	DOWN 1	DOWN 2	*1 digit shift down in D/G GATE CONTROL *1 count (down) in 10^0 digit of D/G
15	04.270 nF ⋮ 04.270 nF	003.9 µ℧ ⋮ 003.6 µ℧	DOWN 1 ⋮ DOWN 1	DOWN 2 ⋮ DOWN 2	*1 count (down) in 10^0 digit of D/G Counter and Attenuator
16	04.270 nF	003.5 µ℧	DOWN 1	K 2	*Parameter Change *1 count (down) in 10^0 digit of Capacitance
17	04.269 nF	003.5 µ℧	UP 1	K 2	*Parameter Change *1 count (down) in 10^0 digit of D/G
18	04.269 nF	003.4 µ℧	UP 1	UP 2	*Parameter Change *1 count (up) in 10^0 digit of Capacitance
19	04.270 nF	003.4 µ℧	DOWN 1	UP 2	*Parameter Change *1 count (up) in 10^0 digit of D/G
20	04.270 nF	003.5 µ℧	DOWN 1	K 2	*Null is obtained

c. Parameter Change: is performed by the inversion of the flip-flop IC17A which is actuated at the trailing edge of clock pulse from IC14C. IC14C works as OR gate for output of WIRED OR gate (IC9A/B/C) and output of IC10D. As IC10D is OR gate for output of IC10B and output of IC10C, the output of IC4C is equivalent to the output of an OR gate whose inputs are WIRED OR gate output, IC10B output and IC10C output. Conditions for these three inputs are individually shown in Figure 4-11.

d. Nulling: Two conditions are necessary for balancing out signal P_N. One is that pin 6 of IC5D (AND gate for ground true signal) should be low. The other is the condition for the output of WIRED OR gate IC6B/C/D.

Step	IC16A. J IC20A. Q	IC16A, CP IC10B, 13	IC16A, Q IC16B, CP	IC16B, J IC21D. 13	IC16B, Q IC6B, 8	IC6B, 9 IC10C, 1	IC6B, 10 IC5D, 5	IC5D, 6 IC13B, Q'	IC5D, 4 IC8C, 12	IC8C. 13	IC8C. 11
16	HIGH	LOW	LOW	HIGH	LOW	HIGH	HIGH	LOW	LOW	PL2	No output
17	HIGH	("C"· G_{LC}· CGCS)	HIGH	HIGH	LOW	LOW	HIGH	LOW	LOW	PL2	No output
18	HIGH	LOW	HIGH	HIGH	LOW	HIGH	HIGH	LOW	LOW	PL2	No output
19	HIGH	("C"· G_{LC}· CGCS)	LOW	HIGH	HIGH	LOW	HIGH	LOW	LOW	PL2	No output
20	HIGH	LOW	LOW	HIGH	HIGH	HIGH	LOW	LOW (PL2)	HIGH	PL2	P_N output

Table 4-4. Nulling Process of Null Circuit.

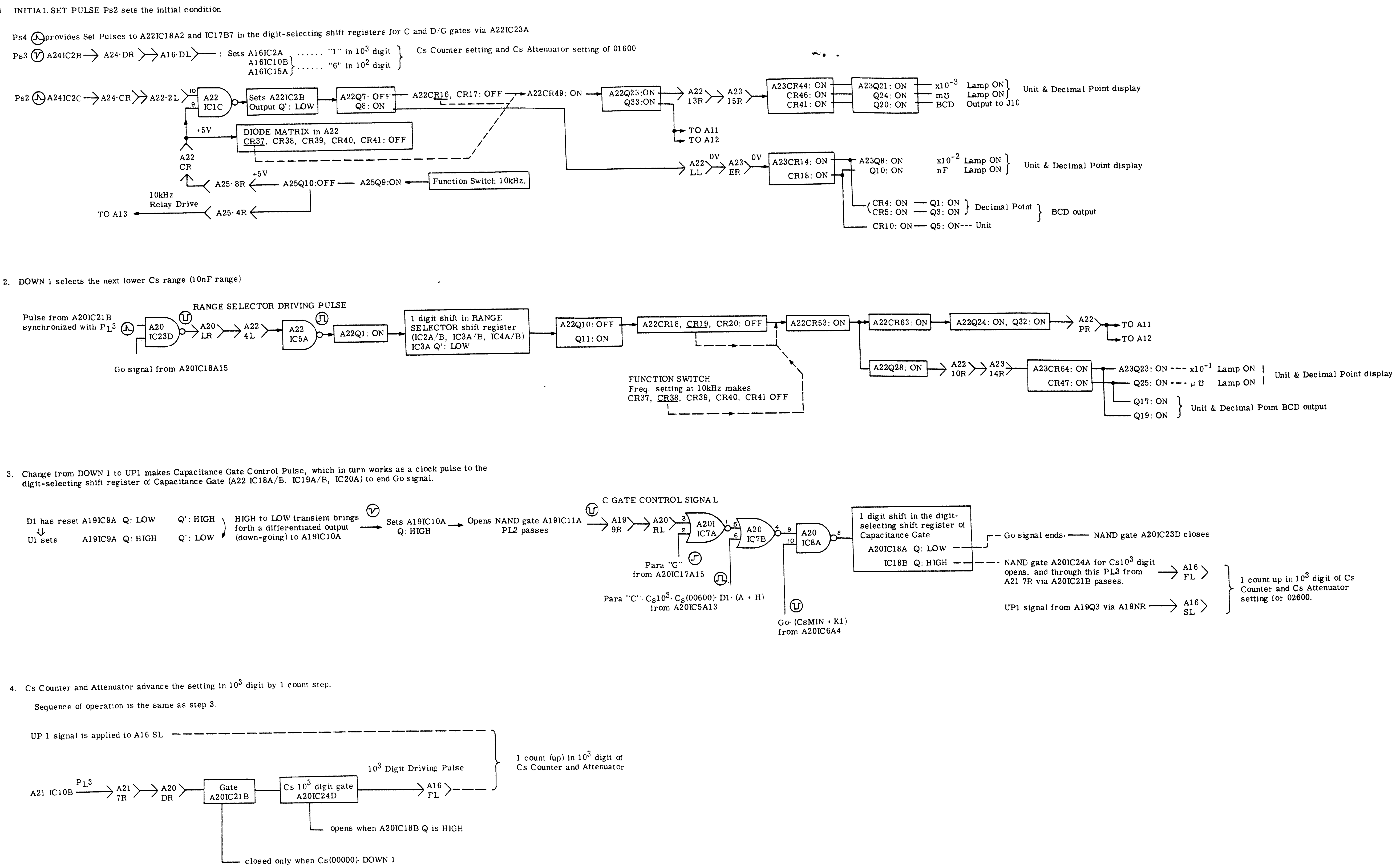
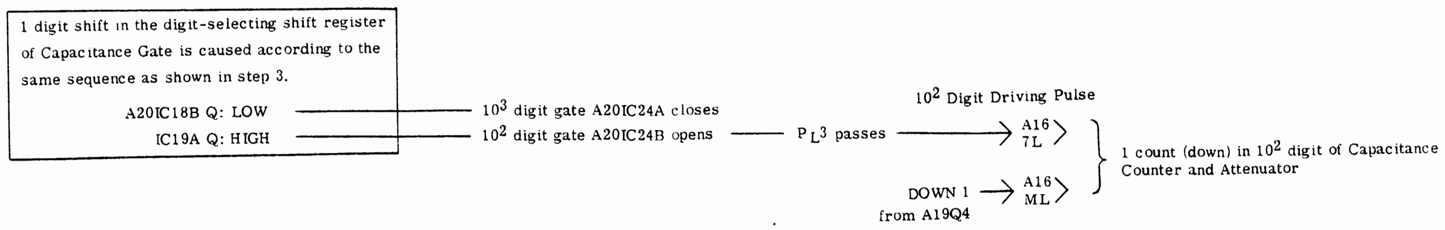


Figure 4-8. Signal Flow in Logic Circuits (Step 1 to Step 4)

5. Change from UP 1 to DOWN 1 produces C GATE CONTROL SIGNAL, which in turn causes 1 digit shift in the digit-selecting shift register of Capacitance Gate to open the 10^2 digit gate A20IC24B.

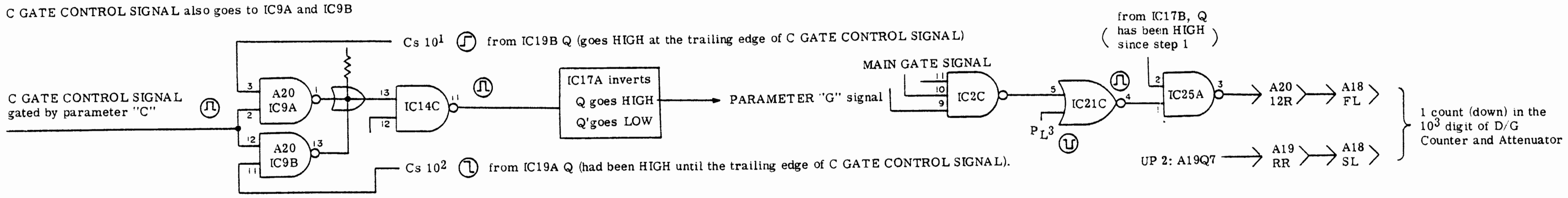


6. 10^2 Digit Cs Counter counts down in the same way as shown in step 4 with DOWN 1 signal at A16ML.

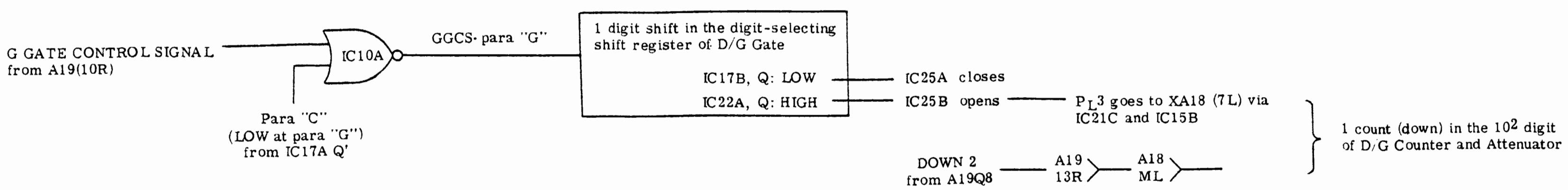
7. Change from DOWN 1 to UP 1 produces C GATE CONTROL SIGNAL, which in turn causes 1 digit shift in the digit-selecting shift register of Capacitance Gate to open the 10^1 digit gate A20IC24C and causes Parameter Change from capacitance to conductance.

A20IC19A Q: LOW —— 10^2 digit gate A20IC24B closes
IC19B Q: HIGH —— 10^1 digit gate A20IC24C opens

C GATE CONTROL SIGNAL also goes to IC9A and IC9B



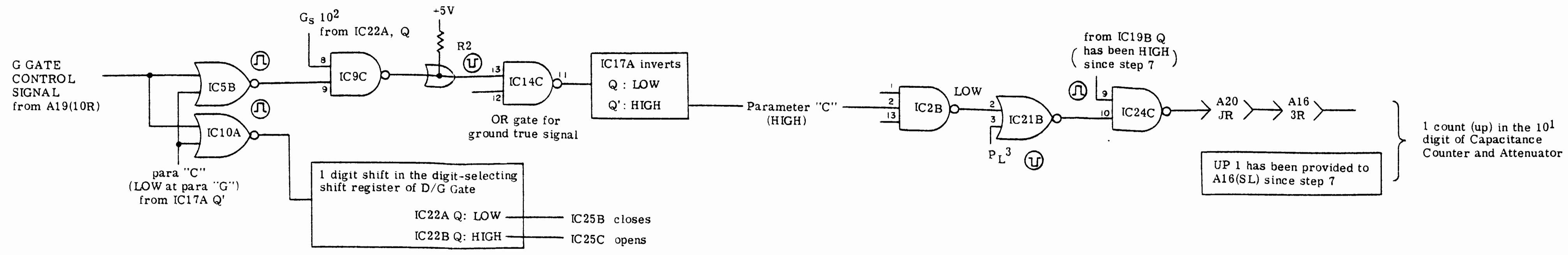
8. Change from UP 2 to DOWN 2 produces G GATE CONTROL SIGNAL, which in turn causes 1 digit shift in the digit-selecting shift register of D/G Gate to open the 10^2 digit gate A20IC25B.



9. DOWN 2 signal at A18(ML) maintains counting down in the 10^2 digit of D/G Counter and Attenuator until UP 2 signal is obtained at the setting of 04. 200 nF and 000. 0μ℧.

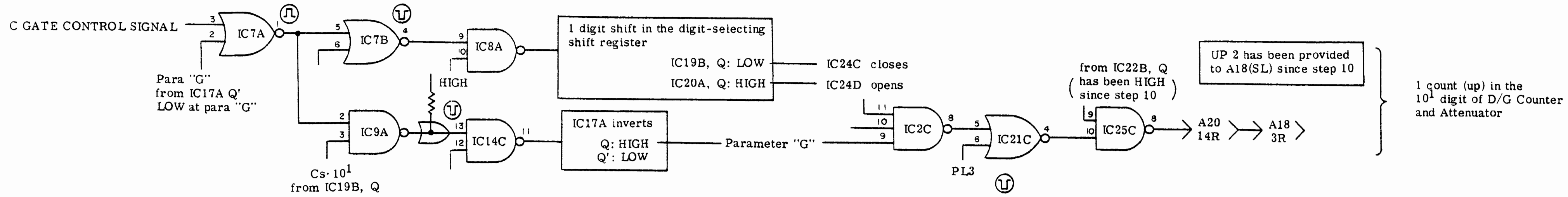
Figure 4-9. Signal Flow in Logic Circuits (Step 5 to Step 9)

10. Change from DOWN 2 to UP 2 produces G GATE CONTROL SIGNAL, which in turn causes 1 digit shift in the digit-selecting shift register of D/G Gate to open the 10^1 digit gate A20IC25C and causes Parameter Change from "G" to "C".



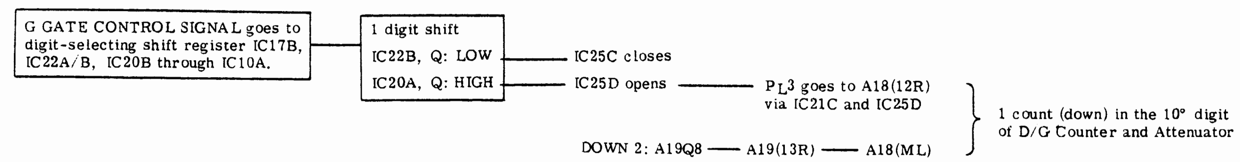
11. UP 1 signal at A16(SL) maintains 1 count step (up) in 10^1 digit of Capacitance Counter and Attenuator until DOWN 1 signal is obtained at the setting of 04.270 nF and 000.0 μ℧.

12. Change from UP 1 to DOWN 1 produces C GATE CONTROL SIGNAL, which in turn causes 1 digit shift in the digit-selecting shift register and Parameter Change from "C" to "G".



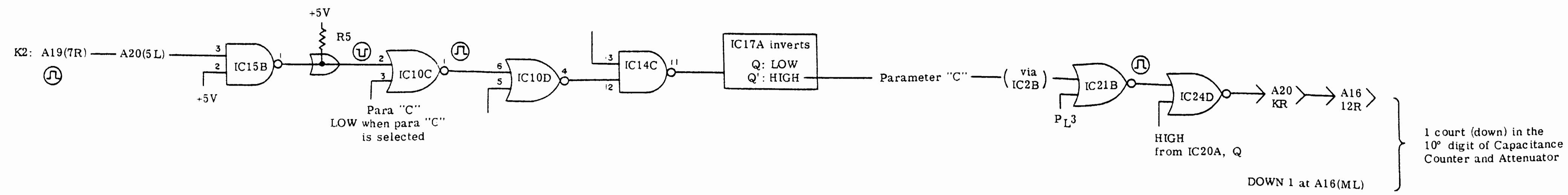
13. UP 2 signal at A18(SL) maintains 1 count step increase in 10^1 digit of D/G Counter and Attenuator until DOWN 2 signal is obtained at the setting of 04.270 nF and 004.0μ℧.

14. Change from UP 2 to DOWN 2 produces G GATE CONTROL SIGNAL, which in turn causes 1 digit shift in the digit-selecting shift register.



15. DOWN 2 signal at A18(ML) maintains 1 count step decrease in the 10° digit of D/G Counter and Attenuator until K2 signal is obtained at the setting of 04.270 nF and 003.5 μ℧

16. K2 causes Parameter Change from "G" to "C".



17. Change from DOWN 1 to UP 1 causes Parameter Change from "C" to "G".

Figure 4-10. Signal Flow in Logic Circuits (Step 10 to Step 17)

1. 1 digit shift down in Capacitance Gate : IC8A

Para "C"· C_s10^3· C_s(0600)· D1· (A + H) - Para "C"· CGCS + Go· (C_sMin + K1)

IC4C, IC2A, IC3B, IC5A, IC7A, IC7B, IC6A, IC8A

IC3B works as OR gate for CsMin signal and K1 signal.

IC6A is AND gate for Go signal and output signal from IC3B.

2. 1 digit shift down in D/G Gate : IC10A.

Para "G"· GGCS

IC10A

3. Parameter Change.

WIRED OR gate output: Para "C"· CGCS· C_s10^1 - Para "C"· CGCS · C_s10^2 + Para "G"· GGCS · G_s10^2

IC7A, IC7A, IC5B; IC9A, IC9B, IC9C

IC10B output : Para "C"· [K1 - C_s(00000)· D1· P_{L2} + Para "C"· C_s10^0· CGCS]

IC11B, IC15D, IC11A

IC10C output : Para "G"· [K2 - G_s(0000)· D2· P_{L2} - Para "G"· G_s10^0· GGCS]

IC15B, IC15A, IC15C

4. Nulling

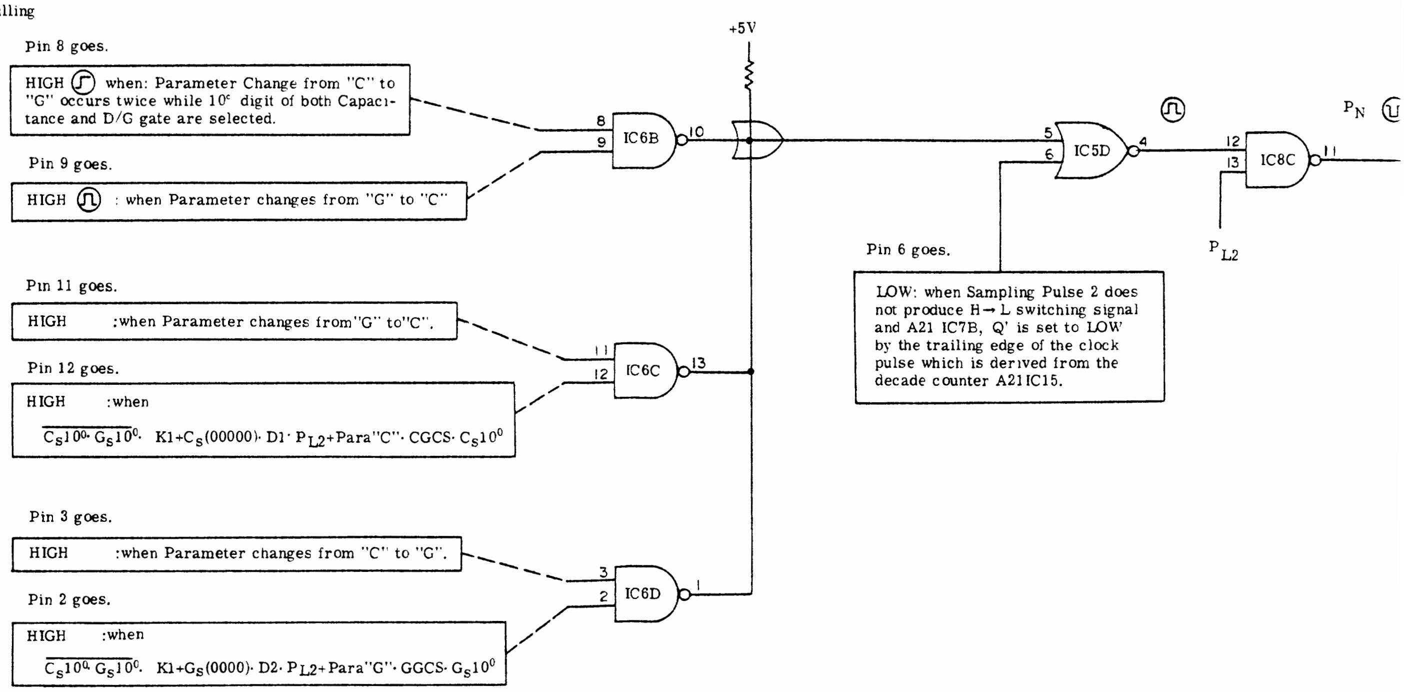


Figure 4-11. Major Function of Logic Cricuits

Instrument Type	Required Characteristics	Recommended Model	
		SOSHIN	General Radio
Standard Capacitor 10pF 100pF 1000pF 10nF 100nF 1 μF	Mica or Air Capacitor. D should be less than 0.002. See Paragraph 5-4.	SM228C	1403-G 1403-D 1403-A 1409-L 1409-T 1409-Y
Resistor 5M 2M 500k 200k 100k 20k 5k 2k 500Ω 333Ω 200Ω	met flm 0.5% 1/8W met flm 0.5% 1/8W met flm 0.5% 1/8W met flm 0.5% 1/8W met flm 0.5% 1/8W met flm 0.5% 1/8W met flm 0.5% 1/8W met flm 0.5% 1/8W met flm 0.5% 1/8W met flm 1% 1/8W met flm 0.5% 1/8W	HP part No. 0698-5516 0698-7317 0698-6020 0698-6376 0698-6358 0698-6014 0698-6338 0698-3342 0698-5991 0698-5941 0698-3186	
Decade Capacitor	Accuracy ±(0.25% + 3pF) 40pF-1.2μF with 40pF-180pF Vernier	HP Model 4440B	
Oscillator	Frequency 1kHz - 10MHz Output 10mV into 50Ω Load	HP Model 651B	
Counter	Accuracy 0.003% Frequency 10MHz	HP Model 5300A/5301A	
AC Volt Meter	Accuracy ±1% Frequency 10MHz	HP Model 400E	
Digital Voltmeter	Accuracy ±0.05% ± 1 count Input - Imp. 10MΩ	HP Model 3440A/3444A	
Decade Resistor	Resistor 100Ω - 10MΩ 100Ω step Accuracy ±0.2%	YEW Type 2793-03	
Digital Recorder	13 Columns + 1-2-4-8 BCD	HP Model 5050B	
Distortion Analyzer	5Hz to 600kHz	HP Model 333A	
Function Generator	Dial Accuracy ±1% Output 10V p-p Square Wave	HP Model 3300A/3301A	
Oscilloscope	Sensitivity 5mV/cm Frequency 10MHz	HP Model 180C/1801A/1820C	
Logic Probe	Input Imp; 10kΩ Trig. Level +1.4V Power Requirement +5V	HP Model 10525A	
Pulse Generator	Output 10V p-p Pulse Width 10 μS	HP Model 222A	
Service Aid Kit	See Section I Para. 1-12	04270-7501	

Table 5-1. Test Equipments Required

SECTION V
MAINTENANCE

5-1. INTRODUCTION

5-2. This section contains the necessary service information required to properly maintain the hp-Model 4270A Automatic Capacitance Bridge. Included are In-Cabinet Performance Checks, Adjustment and Calibration Procedures, Servicing and Troubleshooting.

5-3. TEST EQUIPMENT REQUIRED

5-4. The test equipment required to perform the operations outlined in this section is listed in Table 5-1. This table includes the type of instrument required, critical specifications, use, and recommended model. If the model recommended is not available, equipment which meets or exceed the critical specifications listed may be substituted.

NOTE

The Standard Capacitors including connecting cables should be traceable to NBS calibration, JEMIC, or equivalent. The calibrated data should be known and the accuracy should be within limits listed in Table 5-2.

5-5. IN-CABINET PERFORMANCE CHECKS

5-6. The performance checks described in paragraph 5-7 through 5-24 are front panel procedures designed to compare the MODEL 4270A with its published specifications. These tests may be useful in incoming inspection, periodic maintenance, calibration adjustment or repair. If specifications are found to be out of limits, check that the controls are properly set, and then proceed to calibration and adjustment.

NOTE

Allow a 15-minute warm-up and stabilization period before conducting any performance check.

<table>
<tr><th rowspan="2">STD CAP</th><th colspan="4">CAPACITANCE</th><th colspan="4">DISSIPATION FACTOR</th></tr>
<tr><th>1kHz</th><th>10kHz</th><th>100kHz</th><th>1MHz</th><th>1kHz</th><th>10kHz</th><th>100kHz</th><th>1MHz</th></tr>
<tr><td>10 pF</td><td colspan="2" rowspan="5">± 0.01%</td><td rowspan="4">±0.2%</td><td rowspan="3">±0.5%</td><td colspan="2" rowspan="3">±1 x 10^{-4}
*</td><td colspan="2" rowspan="3">±3 x 10^{-4}
*</td></tr>
<tr><td>100 pF</td></tr>
<tr><td>1000 pF</td></tr>
<tr><td>10 nF</td><td rowspan="3"></td><td rowspan="3"></td><td rowspan="2">*
±2 x 10^{-4}</td><td></td><td rowspan="3"></td></tr>
<tr><td>100 nF</td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>1 μF</td><td></td><td></td><td></td></tr>
</table>

* D should be less than 0.002.

Table 5-2. Accuracy Requirements for Standard Capacitors.

5-7. ACCURACY CHECK

5-8. CAPACITANCE ACCURACY CHECK WHEN D<.1

a. The Standard Capacitors listed in Table 5-1 should be used.

b. Set controls as shown in Figure a.

c. Figure 5-1 illustrates the recommended test set-up.

d. Connect the 100pF Standard Capacitor to the UNKNOWN Connectors as shown in Figure 5-1.

e. The Capacitance reading of the 4270A should be within the limits specified in Table 5-3 relative to the calibrated value of the STD Capacitor.

FOR EXAMPLE: Assume that the calibrated value of the 100pF STD Capacitor is 100.02pF, the Capacitance reading of the 4270A should be within±12counts, that is within 100.14pF and 99.90pF at 1kHz or 10kHz.

f. Disconnect 100pF STD Capacitor and connect 1000pF STD CAPACITOR to the UNKNOWN connectors.

g. The Capacitance reading should be within the limits specified in Table 5-3 relative to the calibrated value of the STD Capacitor.

h. Repeat steps f. and g. above using the STD Capacitors and FREQ listed in Table 5-3.

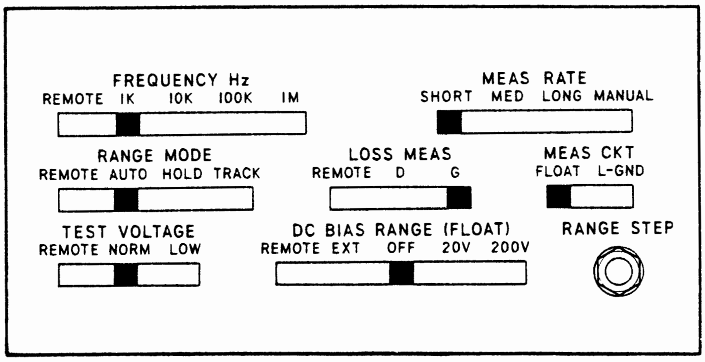


Figure a. Control Settings

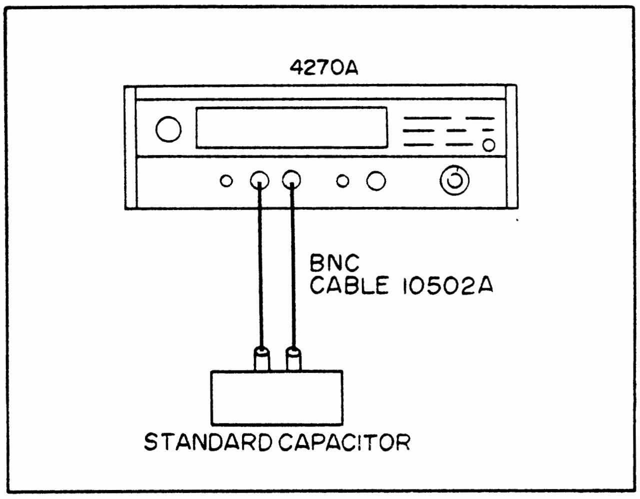


Figure 5-1. Capacitance Accuracy Check When D < .1

<table>
<tr><th rowspan="3">STD CAP</th><th colspan="8">CAPACITANCE</th></tr>
<tr><th colspan="4">TEST VOLTAGE IS NORMAL</th><th colspan="4">TEST VOLTAGE IS LOW</th></tr>
<tr><th>1 kHz</th><th>10 kHz</th><th>100 kHz</th><th>1 MHz</th><th>1 kHz</th><th>10 kHz</th><th>100 kHz</th><th>1 MHz</th></tr>
<tr><td>10 pF</td><td></td><td>±21 Counts</td><td>±41 Counts</td><td>±111 Counts</td><td></td><td>±36 Counts</td><td>±56 Counts</td><td>±126Counts</td></tr>
<tr><td>100 pF</td><td colspan="2">±12 Counts</td><td>±32 Counts</td><td rowspan="2">±101 Counts</td><td colspan="2">±27 Counts</td><td>±47 Counts</td><td>±117Counts</td></tr>
<tr><td>1000 pF</td><td colspan="2" rowspan="4">±11 Counts</td><td rowspan="2">±31 Counts</td><td colspan="2" rowspan="4">±26 Counts</td><td rowspan="2">±46 Counts</td><td>±116Counts</td></tr>
<tr><td>10 nF</td><td></td><td></td></tr>
<tr><td>100 nF</td><td></td><td></td><td></td><td></td></tr>
<tr><td>1 μF</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td>±36 Counts</td><td></td><td></td><td></td></tr>
</table>

Table 5-3. Capacitance Accuracy Check When D<.1

5-9. CAPACITANCE ACCURACY CHECK WHEN THE TEST VOLTAGE IS LOW

a. The Standard Capacitors listed in Table 5-1 should be used.

b. Figure 5-1 illustrates the recommended test set up.

c. Set controls as shown in Figure a, except:

TEST VOLTAGE ...... LOW

d. Repeat steps described in paragraph 5-8, d to h. The Capacitance readings should be within the limits specified in Table 5-3 relative to the calibrated value of the STD Capacitors.

5-10. CAPACITANCE AND D/G ACCURACY CHECK WHEN $.1 \leq D < 1$

a. The Standard Capacitors and the special resistors listed in Table 5-1 should be used. The stray capacities of the special resistors are compensated as shown in Figure 5-3.

b. Figure 5-2 illustrates the recommended test set up.

c. Set controls as shown in Figure a.

d. Connect the 100pF Standard Capacitor and the 2MΩ resistor to the UNKNOWN connectors as shown in Figure 5-2.

e. Note the reading of Capacitance and G.

f. Set LOSS MEAS to D. Note the reading of D.

g. Disconnect the 2MΩ resistor and note the reading of the Capacitance and D/G.

h. The difference in Capacitance between the readings in step e. and g. should be within the limits given in Table 5-4. G and D differences should be within the limits specified in Table 5-6.

i. Repeat steps d. through h. above using the STD Capacitors, the special resistors and FREQ. listed in Table 5-5.

FOR EXAMPLE: The STD Capacity is 1000pF and FREQ is 1MHz. The special resistor should be 500Ω. Assume that the Capacitance reading on step g. is 1003.1pF, the Capacitance reading in step e. should be between 993.1pF and 1013.1pF. The G reading should be between 1.930m℧ and 2.070m℧. The D reading should be between .3077 and .3289.

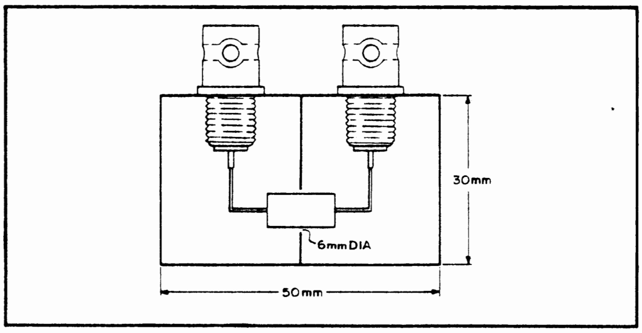


Figure 5-3. Special Resistor

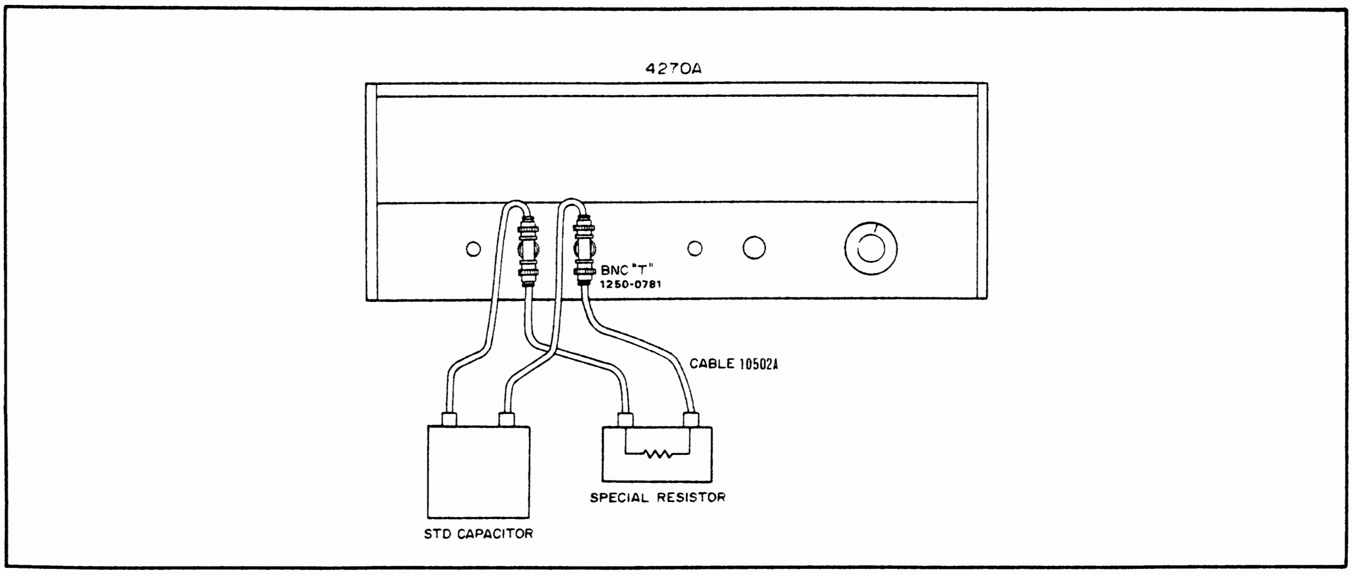


Figure 5-2. Capacitance and D/G Accuracy Check when $.1 \leq D < 1$

STD CAP	CAPACITANCE			
	1 kHz	10 kHz	100 kHz	1 MHz
10 pF			±20Counts +Stray Cap	±110Counts + S. C.
100 pF	±10Counts+Stray Cap			±101Counts + S. C.
1000 pF			±20Counts	±100Counts
10 nF	±10 Counts			
100 nF				
1 µF				

Table 5-4. Capacitance Accuracy Check When .1≤ D< 1.

STD CAP	RESISTOR			
	1 kHz	10 kHz	100 kHz	1 MHz
10 pF		5 MΩ	500 kΩ	100 kΩ
100 pF	2 MΩ	200 kΩ	20 kΩ	5 kΩ
1000 pF	200 kΩ	20 kΩ	2 kΩ	500 Ω
10 nF	20 kΩ	2 kΩ	200 Ω	
100 nF	5 kΩ	200 Ω		
1 µF	500 Ω			

Table 5-5. Resistors for Capacitance and G/D Accuracy Check When .1≤ D< 1.

STD CAP	G				D			
	1 kHz	10 kHz	100 kHz	1 MHz	1 kHz	10 kHz	100 kHz	1 MHz
10 pF		1970 to 2030		0960 to 1040		.3141 to .3225		.1533 to .1650
100 pF		4940 to 5060		1930 to 2070		.7867 to .8047		.3077 to .3289
1000 pF								
10 nF								
100 nF	1970 to 2030				.3141 to .3225			
1 µF								

Table 5-6. G/D Accuracy Check.

5-11. CAPACITANCE AND D/G ACCURACY CHECK WHEN D. C. BIAS ON.

a. The 100 nF STD Capacitor and the 5kΩ special resistor listed in Table 5-1 should be used.

b. Set controls as shown in Figure a, except:
MEAS RATE....... MED

c. Connect the 100nF Capacitor and the 5kΩ special resistor to the UNKNOWN connectors as shown in Figure 5-3.

d. Set RANGE MODE to TRACK when the BALANCING lamp goes off. Note the Capacitance and D/G values.

e. Set D.C. BIAS RANGE to 20V and BIAS VERNIER to 2 and note the readings of the capacitance and D/G values. Wait about 30 sec for the BALANCING lamp to go off.

f. The difference between the values in step d. and e. should be as specified in Table 5-7.

NOTE

If the RANGE MODE SW is set to TRACK when the BALANCING lamp comes on, the OUT OF RANGE lamp should come on.

STD Capacitor	Special Resistor	Frequency	Capacitance	D	G
100 nF	5 kΩ	1 kHz	-9.0 nF to -11.0 nF	+0.050 to +0.077	+16µ℧ to +24µ℧

Table 5-7. Capacitance and D/G Accuracy Check When D. C. Bias on.

5-12. RANGE MODE CHECK

5-13. AUTO RANGE MODE CHECK

a. The Decade Capacitor and the 10pF STD Capacitor listed in Table 5-1 should be used.

b. Set controls as shown in Figure b.

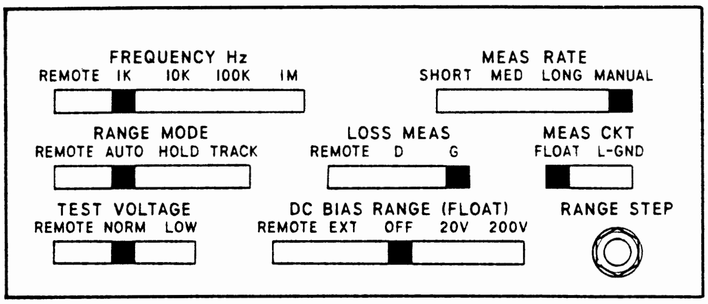


Figure b. Control Settings

c. Connect the Decade Capacitor to the UNKNOWN connectors.

d. Set the Decade Capacitor to 100pF.

e. Push the RESET button.

f. Note the reading. It should be 100.00pF and 000.0n℧. Verify decimal point position and the units display. Note that values of C and G are given only as typical values.

g. Set the Decade Capacitor to 180pF.

h. Push the RESET button.

i. The reading should be 180.0pF and 0.000μ℧. Verify the position of the decimal point and the units display.

j. Repeat steps g. and i. above using the Decade Capacitor sets listed in Table 5-8.

k. Disconnect the Decade Capacitor and connect the 10pF STD Capacitor to the UNKNOWN connectors.

l. Set FREQ to 10kHz

m. Push the RESET button. The reading should be 10.000pF and 000.0n℧.

CAP	C	G
100 pF	100.00 pF	000.0 n℧
180 pF	180.0 pF	0.000 μ℧
1800 pF	1.800 nF	00.00 μ℧
0.018 μF	18.00 nF	000.0 μ℧
0.18 μF	.1800 μF	0.000 m℧

Table 5-8. Auto Range Check

Note: Readings of C and G are given only as typical values.

5-14. HOLD RANGE MODE CHECK

a. The 10pF STD Capacitor listed in Table 5-1 should be used.

b. Set controls as shown in Figure b, except:

MEAS RATE .... MED
FREQUENCY 10kHz

c. Connect the 10pF Standard Capacitor to the UNKNOWN connectors.

d. Note the Capacitance and G readings.

e. Change the RANGE MODE to HOLD when the BALANCING LAMP goes off.

f. Note the reading. The difference between AUTO and HOLD should be within ±1 Count.

g. Push RANGE STEP button.

h. OUT OF RANGE should come on. But the decimal point and units display should change as shown in Table 5-9.

i. Repeat step g. The decimal point and units display should be as shown in Table 5-9.

j. Set LOSS MEAS to D and RANGE MODE to AUTO.

k. Repeat steps e. through i. The decimal point and units display should be as shown in Table 5-10.

NOTE

Readings of C and D/G in Table 5-9 and 5-10 are given only as typical values.

Range Control Steps	Capacitance	Out of Range	G
See para. 5-14 (f)	9.989 pF	off	000.0 n℧
1st Push*	.0000 µF	Out of Range	0.000 m℧
2nd Push*	00.02 nF	off	0.001 m℧
3rd Push*	0.010 nF	off	000.0 µ℧
4th Push*	010.1 pF	off	00.01 µ℧
5th Push*	10.01 pF	off	0.000 µ℧
6th Push*	9.989 pF	off	000.0 n℧

* Operate RANGE-STEP once

Table 5-9. Hold Range Check.

Range Control Steps	Capacitance	Out of Range	D
See para. 5-14 (k)	9.989 pF	off	.0000
1st Push*	.0000 µF	Out of Range	.0000
2nd Push*	00.00 nF	**	.0000
3rd Push*	0.000 nF	**	.0000
4th Push*	010.0 pF	**	.0050
5th Push*	10.00 pF	off	.0005
6th Push*	9.989 pF	off	.0000

** OUT OF RANGE goes on (Normal).

Table 5-10. Hold Range Check

5-15. TRACK RANGE MODE CHECK

a. The Decade Capacitor listed in Table 5-1 should be used.

b. Set controls as shown in Figure b, except:

MEAS RATE......... MED
RANGE MODE....... HOLD

c. Connect the Decade Capacitor to the UNKNOWN connectors.

d. Adjust the Decade Capacitor to 170pF. Select 100pF RANGE by depressing the RANGE STEP button.

e. Set the RANGE MODE to TRACK when the BALANCING lamp goes off, and set MEAS RATE to SHORT.

f. Slowly adjust the Decade Capacitor so that the reading of the 4270A indicates 179.99pF, and the OUT OF RANGE lamp comes on when the reading of 4270A indicates 180.00pF.

g. Adjust the Decade Capacitor to 1700pF.

h. Set the RANGE MODE to HOLD. Depress the RESET button. Select 1000pF RANGE by depressing the RANGE STEP button.

i. Set the RANGE MODE to TRACK and then slowly adjust the Decade Capacitor so that the reading of 4270A indicates 1799.9pF. The OUT OF RANGE lamp should come on when the reading of the 4270A indicates 1800.0pF.

j. Repeat steps g. and h. using the capacitance listed in Table 5-11.

Start Capacitance	Out of Range
170.00 pF	180.00 pF
1700.0 pF	1800.0 pF
17.000 nF	18.000 nF
170.00 nF	180.00 nF
1.1000 nF	1.2000 µF

Table 5-11. Track Range Mode Check.

5-16. INTERNAL OSCILLATOR CHECK

a. The Electronic Counter and the A.C. Voltmeter listed in Table 5-1 should be used.

b. Connect the equipment to HIGH UNKNOWN connector.

c. Set controls as shown in Figure b, except:

RANGE MODE...... HOLD

Select 1000pF RANGE.

d. The Counter should display between 990Hz and 1010Hz and the volt meter should indicate between 0.9 and 1.1 volts rms.

e. Operate the RANGE STEP button unitl the capacitance unit display shows µF. The Voltmeter should indicate between 90 and 110mV. rms.

f. Repeat step d. above using settings in Table 5-12.

5-12. RANGE MODE CHECK

5-13. AUTO RANGE MODE CHECK

a. The Decade Capacitor and the 10pF STD Capacitor listed in Table 5-1 should be used.

b. Set controls as shown in Figure b.

c. Connect the Decade Capacitor to the UNKNOWN connectors.

d. Set the Decade Capacitor to 100pF.

e. Push the RESET button.

f. Note the reading. It should be 100. 00pF and 000. 0n℧. Verify decimal point position and the units display. Note that values of C and G are given only as typical values.

g. Set the Decade Capacitor to 180pF.

h. Push the RESET button.

i. The reading should be 180. 0pF and 0. 000μ℧. Verify the position of the decimal point and the units display.

j. Repeat steps g. and i. above using the Decade Capacitor sets listed in Table 5-8.

k. Disconnect the Decade Capacitor and connect the 10pF STD Capacitor to the UNKNOWN connectors.

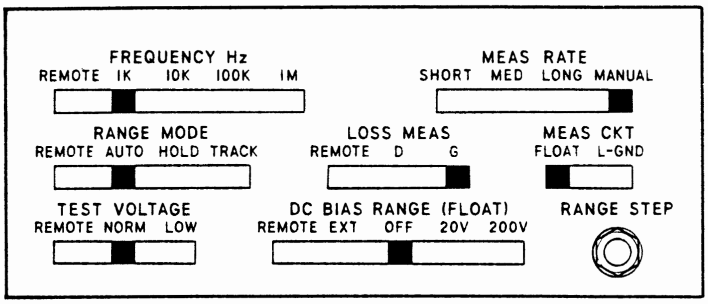


Figure b. Control Settings

l. Set FREQ to 10kHz

m. Push the RESET button. The reading should be 10. 000pF and 000. 0n℧.

CAP	C	G
100 pF	100. 00 pF	000. 0 n℧
180 pF	180. 0 pF	0. 000 μ℧
1800 pF	1. 800 nF	00. 00 μ℧
0. 018 μF	18. 00 nF	000. 0 μ℧
0. 18 μF	. 1800 μF	0. 000 m℧

Table 5-8. Auto Range Check

Note: Readings of C and G are given only as typical values.

5-14. HOLD RANGE MODE CHECK

a. The 10pF STD Capacitor listed in Table 5-1 should be used.

b. Set controls as shown in Figure b, except:

MEAS RATE . . . . MED
FREQUENCY 10kHz

c. Connect the 10pF Standard Capacitor to the UNKNOWN connectors.

d. Note the Capacitance and G readings.

e. Change the RANGE MODE to HOLD when the BALANCING LAMP goes off.

f. Note the reading. The difference between AUTO and HOLD should be within ±1 Count.

g. Push RANGE STEP button.

h. OUT OF RANGE should come on. But the decimal point and units display should change as shown in Table 5-9.

i. Repeat step g. The decimal point and units display should be as shown in Table 5-9.

j. Set LOSS MEAS to D and RANGE MODE to AUTO.

k. Repeat steps e. through i. The decimal point and units display should be as shown in Table 5-10.

NOTE

Readings of C and D/G in Table 5-9 and 5-10 are given only as typical values.

	TEST VOLTAGE	UNIT DISPLAY	FREQUENCY			
			1 kHz	10 kHz	100 kHz	1 MHz
FREQ	NORMAL	pF	990 to 1010 Hz	9.90 to 10.10kHz	99.0 to 101.0kHz	990 to 1010kHz
VOLT	NORMAL	pF or nF	0.90 to 1.10 V	450 to 550 mV		
		μF	90 to 110 mV			
	LOW	pF or nF	180 to 220 mV	90 to 110 mV		
		μF	18 to 22 mV			

Table 5-12. Internal Oscillator Operation Check.

5-17. D.C. BIAS CHECK

a. The Digital Voltmeter and the Decade Resistor listed in Table 5-1 are required for this check.

b. Connect the Digital Voltmeter to the rear BIAS OUTPUT connector and the Decade Resistor to the REMOTE PROGRAM terminals.

c. Set controls as shown in Figure b, except:
D.C. BIAS RANGE 20V
BIAS VERNIER ..... full CCW, not in detent
RANGE MODE .... HOLD

d. The Digital Voltmeter reading should be within ±0.100 volt.

e. Adjust BIAS VERNIER to 2. The Digital Voltmeter should read the values listed in Table 5-13.

f. Repeat step e. above using BIAS VERNIER and RANGE listed in Table 5-13.

g. Set BIAS VERNIER to REMOTE.

h. Set Decade Resistor as listed in Table 5-13. The Digital Voltmeter should read values listed in Table 5-13.

VERNIER LOCAL			VERNIER REMOTE		
PANEL DIAL	20 V	200 V	DECADE RESISTOR	20 V	200 V
0	-0.100 to +0.100V	-0.500 to +0.500V	0	-0.100 to +0.100V	-0.500 to +0.500V
2	-0.990 to -2.980V	-09.90 to -29.80V	0.5 kΩ	-1.590 to -2.390V	-15.90 to -23.90V
5	-3.960 to -5.950V	-39.60 to -59.50V	1 kΩ	-3.570 to -4.360V	-35.70 to -43.60V
10	-8.910 to -10.90V	-89.70 to -109.0V	2 kΩ	-7.530 to -8.320V	-75.30 to -83.20V
20	-18.80 to -20.80V	-188.0 to -208.0V	5 kΩ	-19.40 to -20.20V	-194.0 to -202.0V
			OPEN	<22	<220

Table 5-13. DC Bias Check.

	TEST VOLTAGE	UNIT DISPLAY	FREQUENCY			
			1 kHz	10 kHz	100 kHz	1 MHz
FREQ	NORMAL	pF	990 to 1010 Hz	9.90 to 10.10kHz	99.0 to 101.0kHz	990 to 1010kHz
VOLT	NORMAL	pF or nF	0.90 to 1.10 V	450 to 550 mV		
		μF	90 to 110 mV			
	LOW	pF or nF	180 to 220 mV	90 to 110 mV		
		μF	18 to 22 mV			

Table 5-12. Internal Oscillator Operation Check.

5-17. D.C. BIAS CHECK

a. The Digital Voltmeter and the Decade Resistor listed in Table 5-1 are required for this check.

b. Connect the Digital Voltmeter to the rear BIAS OUTPUT connector and the Decade Resistor to the REMOTE PROGRAM terminals.

c. Set controls as shown in Figure b, except:
   - D.C. BIAS RANGE 20V
   - BIAS VERNIER ..... full CCW, not in detent
   - RANGE MODE .... HOLD

d. The Digital Voltmeter reading should be within ±0.100 volt.

e. Adjust BIAS VERNIER to 2. The Digital Voltmeter should read the values listed in Table 5-13.

f. Repeat step e. above using BIAS VERNIER and RANGE listed in Table 5-13.

g. Set BIAS VERNIER to REMOTE.

h. Set Decade Resistor as listed in Table 5-13. The Digital Voltmeter should read values listed in Table 5-13.

VERNIER LOCAL			VERNIER REMOTE		
PANEL DIAL	20 V	200 V	DECADE RESISTOR	20 V	200 V
0	-0.100 to +0.100V	-0.500 to +0.500V	0	-0.100 to +0.100V	-0.500 to +0.500V
2	-0.990 to -2.980V	-09.90 to -29.80V	0.5 kΩ	-1.590 to -2.390V	-15.90 to -23.90V
5	-3.960 to -5.950V	-39.60 to -59.50V	1 kΩ	-3.570 to -4.360V	-35.70 to -43.60V
10	-8.910 to -10.90V	-89.70 to -109.0V	2 kΩ	-7.530 to -8.320V	-75.30 to -83.20V
20	-18.80 to -20.80V	-188.0 to -208.0V	5 kΩ	-19.40 to -20.20V	-194.0 to -202.0V
			OPEN	<22	<220

Table 5-13. DC Bias Check.

5-18. REMOTE OPERATION CHECK

Note: The Remote Control Cable referred to in this paragraph may be constructed with a 24 pin male connector (hp Part No. 1251-0293).

5-19. REMOTE FREQUENCY CHECK

a. The Counter listed in Table 5-1 should be used.

b. Set controls as shown in Figure c.

c. Connect Remote Control Cable to REMOTE Connector on rear panel.

d. Connect the Counter to HIGH UNKNOWN Connector.

e. Remotely set FREQUENCY by grounding the appropriate pin on REMOTE Connector as identified in Table 5-14.

f. Check the frequency using the counter.

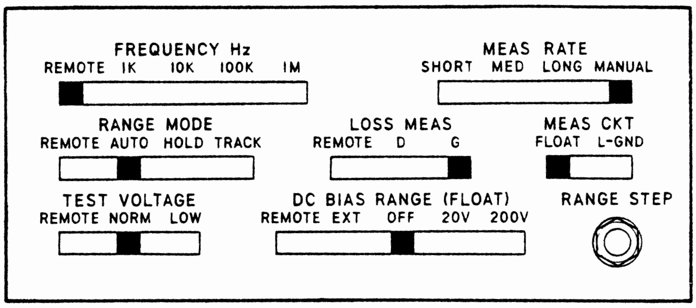


Figure c. Control Settings.

5-20. REMOTE TEST VOLTAGE CHECK

a. The AC Voltmeter should be used.

b. Set controls as shown in Figure c, except:

FREQUENCY 1k
TEST VOLTAGE .... REMOTE

c. Connect the AC Voltmeter to HIGH UNKNOWN Connector.

d. Remotely set TEST VOLTAGE by grounding the appropriate pin on the REMOTE Connector as identified in Table 5-14.

e. Check the test voltage using the Voltmeter.

5-21. REMOTE LOSS MEAS CHECK

a. No equipment is required for this check.

b. Set controls as shown in Figure c, except:

FREQUENCY 1k
LOSS MEAS .... REMOTE

c. Remotely set LOSS MEAS by grounding the appropriate pin on the REMOTE Connector as identified in Table 5-14.

d. Check the display of D or G.

FUNCTION	RANGE	PIN
FREQUENCY	1 kHz 10 kHz 100 kHz 1 MHz	4 5 16 17
RANGE MODE	AUTO HOLD TRACK	2 3 14
TEST VOLT	NORMAL LOW	7 OPEN
LOSS MEAS	D G	6 18
DC BIAS RANGE	EXT OFF 20 V 200 V	8 9 20 21

Table 5-14. Remote Operation Check.

5-22. REMOTE RANGE MODE CHECK

a. The Decade Capacitor should be used.

b. Set controls as shown in Figure c, except:

FREQUENCY 1k
RANGE MODE ...... REMOTE

c. Connect the Decade Capacitor to UNKNOWN Connectors.

d. Ground pin 2 by connecting pin 2 to pin 24 on the REMOTE Connector.

e. Repeat steps d. through i. in paragraph 5-13.

f. Disconnect the shorting cable from pin 2 and connect it to pin 3 on the REMOTE connector.

g. Depress the RANGE STEP button and verify that the position of the decimal point and unit display change.

h. Disconnect the shorting cable from pin 3 and connect it to pin 14 on the REMOTE Connector.

i. Repeat step i. in paragraph 5-15.

5-23. REMOTE D. C. BIAS RANGE CHECK

a. The Digital Voltmeter should be used.

b. Set controls as shown in Figure c, except:

FREQUENCY 1k
RANGE .... HOLD
DC BIAS RANGE ...... REMOTE
BIAS VERNIER 10

c. Remotely set D. C. BIAS RANGE by grounding the appropriate pin on the REMOTE CONTROL Connector as identified in Table 5-14.

d. Check the D. C. voltage using the Digital Voltmeter.

5-24. RECORDER OUTPUT CHECK

a. The Digital Recorder with +1-2-4-8 BCD, the Decade Capacitor, the Precision Variable Capacitor, and the Decade Resistor listed in Table 5-1 should be used.

b. Connect the Digital Recorder to MODEL 4270A RECORDER connector on the rear panel.

c. Set controls as shown in Figure c, except:

FREQUENCY 10kHz

d. Connect the Precision Variable Capacitor to the UNKNOWN connector. Adjust the Variable Capacitor for a 4270A capacitance display of 8.888pF.

e. Depress the RESET button. The Digital recorder should print information contained in Table 5-15.

f. Set FREQUENCY to 1kHz and RANGE MODE to HOLD. OUT OF RANGE should come on.

g. Digital Recorder should print information contained in Table 5-15.

h. Set FREQUENCY to 10kHz and RANGE MODE to AUTO. Disconnect the Precision Variable Capacitor and connect the Decade Capacitor to the UNKNOWN connectors.

i. Continue check of recorder output by adjusting the Decade Capacitor for 4270A capacitance displays listed in Table 5-15 and verify correct printout.

j. Connect the Decade Capacitor and the Decade Resistor to the UNKNOWN connectors. Adjust the Decade Capacitor and the Decade Resistor for 4270A D/G display listed in Table 5-16 and verify correct printout.

CAPACITANCE RANGE	4270A		DIGITAL RECORDER PRINTOUT						
	FREQUENCY	CAPACITANCE	7	6	5	4	3	2	1
10 pF	10 kHz	8.888 pF	0	8	8	8	8	3	2
100 pF	10 kHz	44.44 pF	0	4	4	4	4	2	2
1000 pF	10 kHz	222.2 pF	0	2	2	2	2	1	2
10 nF	10 kHz	1.111 nF	0	1	1	1	1	3	1
100 nF	10 kHz	100.00 nF	1	0	0	0	0	2	1
1 μF	1 kHz	.0555 μF	0	0	5	5	5	4	0
10 pF	1 kHz	8.888 pF	0	8	8	8	8	3	8

Table 5-15. Recorder Output Check.

Digital recorder columns in this table are identified as follows.

Column 1: UNIT DISPLAY and OUT OF RANGE
0 = μF 1 = nF 2 = pF 8 = OUT OF RANGE

Column 2: Decimal Location

Column 3 thru 8: Capacitance Display

D/G	CAPACITANCE	RESISTANCE	4270A		DIGITAL RECORDER PRINTOUT					
			FREQ	G/D DISPLAY	6	5	4	3	2	1
G	10 pF	*1.12 MΩ	10 kHz	888.8 n℧	8	8	8	8	1	3
	10 pF	*2.25 MΩ	10 kHz	444.4 n℧	4	4	4	4	1	3
	100 pF	*450 kΩ	10 kHz	2.222 μ℧	2	2	2	2	3	2
	1000 pF	90 kΩ	10 kHz	11.11 μ℧	1	1	1	1	2	2
	10 nF	5 kΩ	10 kHz	200.0 μ℧	2	0	0	0	1	2
	100 nF	50 kΩ	10 kHz	0.020 m℧	0	0	2	0	3	1
D	1000 pF	28.5 kΩ	10 kHz	.5555	5	5	5	5	4	0

Table 5-16. Recorder Output Check.

* If the DECADE RESISTOR is variable up to 100kΩ max., connect an appropriate resistor in series with the DECADE RESISTOR.

Digital recorder columns in this table are identified as follows.

Column 1: UNIT DISPLAY

0 = D 1 = m℧ 2 = μ℧ 3 = n℧

Column 2: Decimal Location

5-25. ADJUSTMENT AND CALIBRATION

5-26. The following is a complete adjustment and calibration procedure for the Model 4270A. These operations should be conducted only when the Model 4270A does not meet its published specifications.

NOTE

1. When RANGE MODE control is set to HOLD or TRACK from AUTO during balancing, OUT OF RANGE lamp will come on. In such a case, return RANGE MODE control to AUTO, and then switch it back to HOLD or TRACK when the BALANCING lamp goes off.

2. In this calibration procedure, it is assumed that STD Capacitors have no loss. If the STD Capacitor used has any loss figure given by the manufacturer, then it should be added to the value obtained in this procedure.

   For example: in paragraph 5-58, if the calibrated D value of STD Capacitor is .0004, A7C3 should be adjusted for D reading of .0084.

5-27. POWER SUPPLIES ADJUSTMENT

5-28. Power supplies are checked and adjusted to the values given in Table 1. The "MEAS CKT" control should be in "FLOAT". Use the digital voltmeter and the oscilloscope listed in Table 5-17.

Table 5-17. Power Supplies Adjustment

VOLTAGE	TEST POINT	PIN NO	DC VOLTAGE MIN - MAX	RIPPLE	ADJUSTMENT
+15	+15V	(XA27 3L to GND)	+14.90 - +15.10	3mVp-p	A27R7
+12	+12V	(XA27 5R to GND)	+11.90 - +12.10	"	A27R12
+10	+10V	(XA27 6L to GND)	+9.90 - +10.10	"	A27R19
-6	-6V	(XA27 7L to GND)	-5.90 - -6.10	"	A27R26
+5	+5V	(XA27 11L to GND)	+5.01 - +5.03	"	A27R33
+170		(XA28 DL to GND)	+165.0 - +180.0	3Vp-p	NO

5-29. DC OUTPUT LEVEL ADJUSTMENT (A13R54, A6R5, A7R1, A12R1, A8R16, A21R24)

a. Set 4270A controls as shown in Figure d.

b. Connect DVM between PIN XA13-8R and chassis ground. Adjust A13R54 for a minimun reading between ±10mV.

c. Connect DVM between center conductor and outer conductor of "HIGH UNKNOWN". Adjust A6R5 for a minimum reading between ±100mV.

d. Connect DVM between A7Q5 emitter and chassis ground. Adjust A7R1 for a minimum reading between ±0.1V dc.

e. Connect DVM between A12 T.P. "E3" and chassis ground. Adjust A12R1 for a minimum reading between ±10mV dc.

f. Connect DVM between A8Q5 emitter and chassis ground. Adjust A8R16 for a minimum reading between ±10mV.

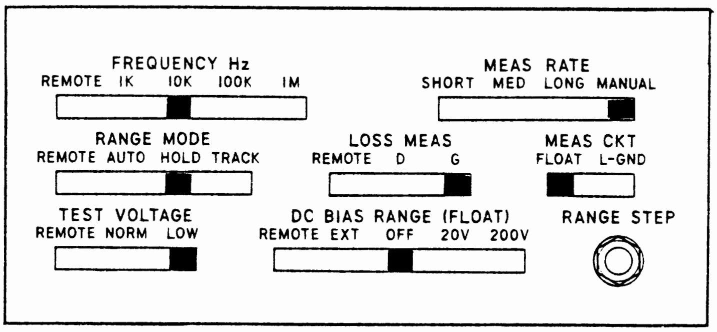


Figure d. Control Settings.

g. Connect DVM between A21TP1 and chassis ground. Adjust A21R24 for +6.0V ±0.1V display on DVM.

5-30. OSCILLATOR A13

5-31. FREQUENCY ADJUSTMENT (A13C1, A13C9, A13R9*)

a. Set controls as shown in Figure d.

Except: TEST VOLTAGE .... NORM

b. Connect counter to "HIGH UNKNOWN".

c. Display should read between 9.90kHz and 10.10 kHz. If not, adjust A13C1 for 10kHz.

d. Set FREQUENCY control to 1MHz. Counter should display between 990kHz and 1910kHz. If not, adjust A13C9 for 1MHz.

e. Set FREQUENCY control to 1kHz. Counter should display between 990Hz and 1010Hz. If reading is high, adjust R9 by connecting a 22MΩ resistor or 18MΩ in parallel with it.

f. Set FREQUENCY control to 100kHz. Display should read between 99.0kHz and 101.0kHz. If not, repeat steps c. through e.

5-32. TEST VOLTAGE (A13R30)

a. Connect AC Voltmeter to "HIGH UNKNOWN".

b. Set 4270A controls as shown in Figure d.

except: FREQUENCY.......... 1kHz
(Select 1000pF RANGE)
TEST VOLTAGE....... NORM

c. Adjust A13R30 for 1.0 volt rms.

d. Check the (rms) readings at 10kHz, 100kHz and 1MHz. All readings should be within the values in Table 5-18. If not, readjust A13R30.

Table 5-18. Test Voltage Adjustment

	AC VOLTMETER Reading
1 kHz	0.9 - 1.1 volt rms
10 kHz	0.45 - 0.55 volt rms
100 kHz	0.45 - 0.55 volt rms
1 MHz	0.45 - 0.55 volt rms

5-33. DISTORTION (A13R24)

a. Connect Distortion analyzer to "HIGH UNKNOWN".

b. Set 4270A controls as shown in Figure d,

except: FREQUENCY.......... 1kHz
(Select 1000pF RANGE)
TEST VOLTAGE....... NORM

c. Adjust A13R24 so that minimum distortion is indicated (which should be less than -54dB).

d. Check the distortion at 10kHz, 100kHz, as it should also be -54dB or less.

5-34. CURRENT DETECTOR ADJUSTMENT (A11R11, A11R24)

a. Connect the equipment as shown in Figure 5-4.

b. Set 4270A controls as shown in Figure e. "UNKNOWN" (no connection)

c. Set 3300A controls as follows.

FREQUENCY DIAL........ 1
RANGE.................. x1
CHANNEL A and B .... SQUARE
AMPLITUDE .... 12 O'CLOCK

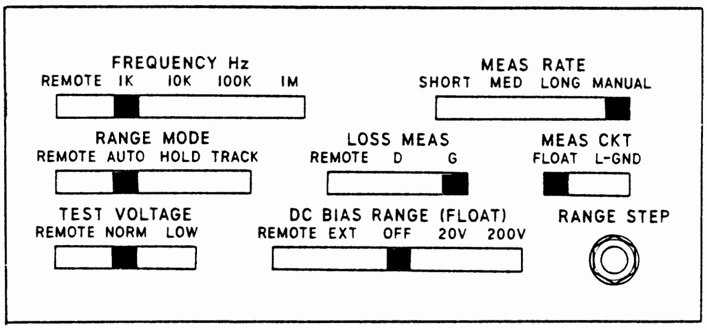


Figure e. Control Settings

d. Set 180A controls as follows.

1801A (VERTICAL)

DISPLAY................ A
SENSITIVITY .... .02 V/DIV
POLARITY .... +up
AC/DC .... DC

1820B (HORIZONTAL)

TIME/DIV................. 10m SEC
SWEEP MODE..............NORM
SYNC SOURCE............. EXT÷10 (AC)
SLOPE.................... + -

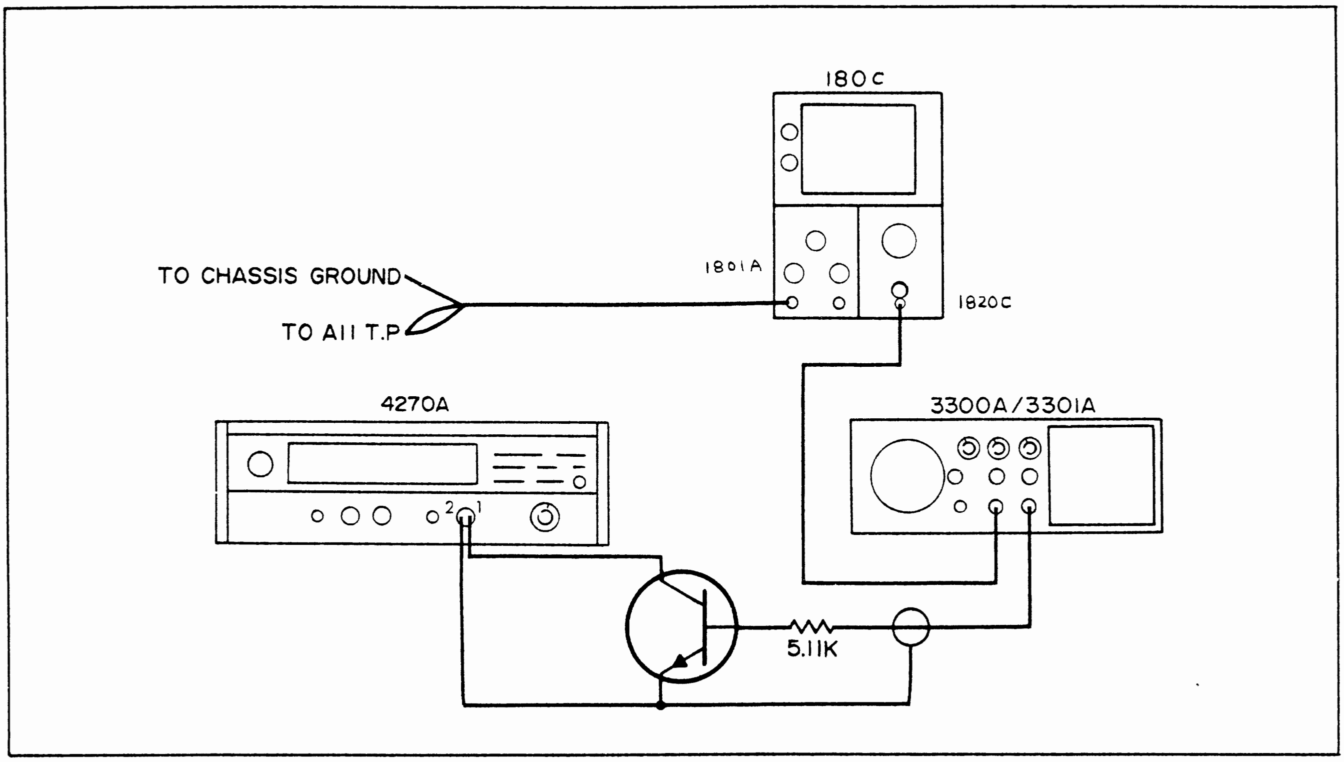


Figure 5-4. Current Detector Adjustment.

e. Adjust trigger level and center oscilloscope trace on graticule.

f. Adjust A11R11 for correct waveform as shown in Figure 5-5.

g. Disconnect Function Generator and REMOTE RESET. Connect the Decade Capacitor (4440B) to "UNKNOWN".

h. Connect oscilloscope with 10:1 probe between PIN XA11A 1L and chassis ground.

i. Set oscilloscope controls as follows:

1801A (VERTICAL)

DISPLAY................ A
SENSITIVITY............ .05 V/DIV
POLARITY.............. +up
AC/DC.................. AC

1820A (HORIZONTAL)

TIME/DIV............... .5m SEC
180A HORIZONTAL
MAGNIFIER..... x 1
SWEEP MODE........... AUTO
SYNC SOURCE .... INT (AC)
SLOPE.................. +

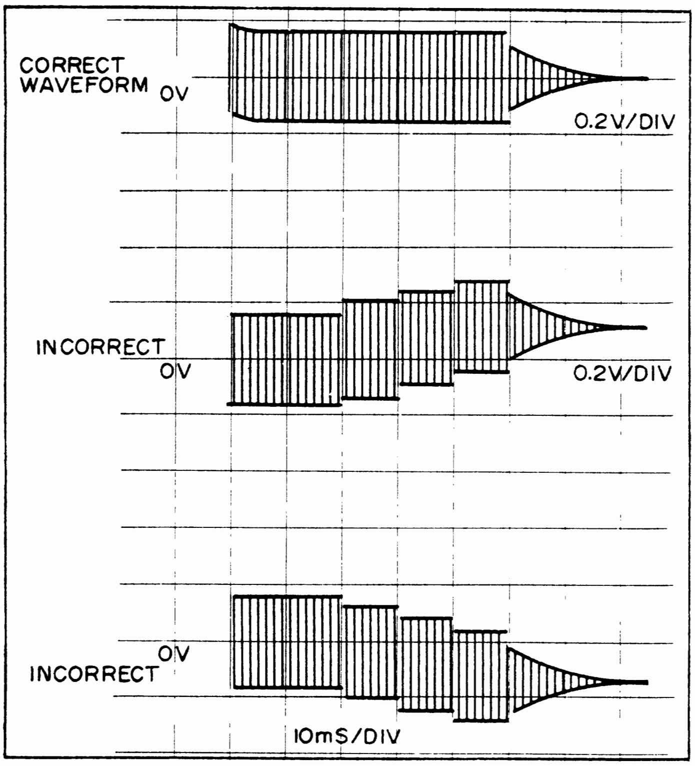


Figure 5-5. Current Detector A11R11 Adjustment

j. Set Decade Capacitor box to 100pF.

k. Depress RESET button and check 4270A display.

l. Set Decade Capacitor box to 102pF.

m. Center oscilloscope trace on graticule.

n. Adjust A11R24 for symmetrical waveform as shown in Figure 5-6.

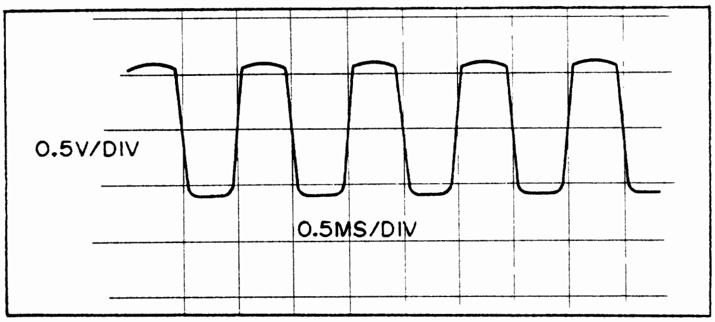


Figure 5-6. Current Detector A11R24 Adjustment.

5-35. OFF SET BIAS ADJUSTMENT (A19R5, A19R28, A10R27, A10R52).

a. Connect the equipment as shown in Figure 5-4. Set 4270A controls as shown in Figure f.

b. Connect XA19 pin 5-L and XA19 pin 10-L to circuit common by using short alligator clips.

c. Connect oscilloscope with 10:1 probes between TEST POINT 1 and chassis ground, and between TEST POINT 2 and chassis ground.

d. Set the oscilloscope SENS. to .05V/DIV.

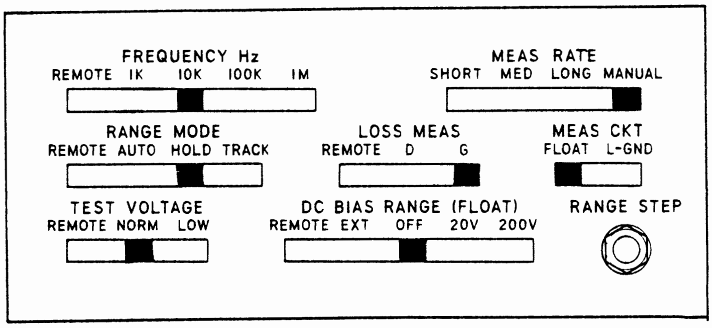


Figure f. Control Settings.

e. Adjust A19R5 for minimum output deflection at TEST POINT 1.

f. Adjust A19R28 for minimum output deflection at TEST POINT 2.

g. Remove the short clips from XA19 pin 5-L and XA19 pin 10-L. Disconnect oscilloscope from TEST POINT 1 and TEST POINT 2. Disconnect REMOTE RESET input and set MEAS RATE to SHORT.

h. Connect 1000pF Standard Capacitor and 2MΩ Resistor as shown in Figure 5-2.

i. 1000pF RANGE should be selected by depressing RANGE STEP button and set LOSS MEAS to D.

j. Note readings of C and D.

k. Set TEST VOLTAGE control to LOW and note readings of C and D.

l. Adjust A10R52 for C reading in step k to within ±5 counts tolerance with the C reading in step j.

m. Adjust A10R27 for D reading in step k. to within ±5 counts tolerance with the D reading in step j.

n. Disconnect the 2MΩ Resistor and connect 2kΩ Resistor to "UNKNOWN".

o. Set FREQUENCY control to 1MHz and TEST VOLTAGE control to NORM. Depress RESET and note C and D readings. If the 4270A does not balance, proceed to paragraph 5-46.

p. Set TEST VOLTAGE control to LOW and note C and D readings.

q. Adjust A10C31 for C reading in step p of within ±5 counts error with C reading in step o.

r. Adjust A10C10 for D reading in step p of within ±5 counts error with D reading in step o.

5-36. CAPACITANCE ACCURACY

5-37. 100nF RANGE ADJUSTMENT (A7R14)

a. Connect 100nF Standard Capacitor to "UNKNOWN".

b. Set controls as shown in Figure g.

c. Adjust A7R14 for the calibrated capacitance value of Standard.

5-38. 1μF RANGE ADJUSTMENT (A6R1)

a. Connect 1μF STD Capacitor to "UNKNOWN".

b. Set controls as shown in Figure g.

c. Adjust A6R1 for the calibrated capacitance value of standard.

5-39. 10nF RANGE ADJUSTMENT (C4)

a. Connect 10nF STD Capacitor to "UNKNOWN".

b. Set controls as shown in Figure g.

c. Adjust C4 in parallel with C3 for the calibrated value of the STD.

5-40. 1000pF RANGE ADJUSTMENT (C6)

a. Connect 1000pF STD Capacitor to "UNKNOWN".

b. Set controls as shown in Figure g.

c. Adjust C6 in parallel with C5 for the calibrated capacitance value of STD.

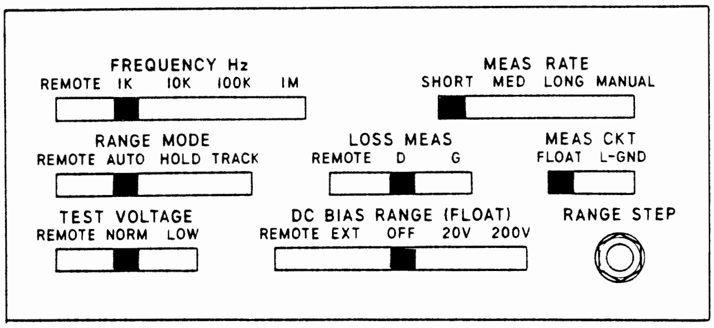


Figure g. Control Settings

5-41. 100pF and 10pF RANGE ADJUSTMENT (C8, C9)

NOTE

For the following procedure, the bottom ground cover for standard capacitors must be installed.

a. Connect 100pF STD capacitor to "UNKNOWN". Replace bottom guard cover.

b. Set controls as shown in Figure g.

c. Adjust C8 for the calibrated value of 100pF STD Capacitor.

d. Disconnect 100pF STD Capacitor and connect 10pF STD capacitor.

e. Set FREQUENCY control to 10KHz.

f. Adjust C9 for the calibrated value of the 10pF STD capacitor.

5-42. LOSS ACCURACY

5-43. 1m℧ RANGE ADJUSTMENT (A12R18)

a. Connect 2kΩ Resistor to "UNKNOWN".

b. Set controls as shown in Figure h.

c. Select 10nF RANGE by depressing RANGE STEP button.

d. Adjust A12R18 for 500.0μ℧ display on G reading.

5-44. 10m℧ RANGE ADJUSTMENT (A12R47*)

a. Connect 200Ω Resistor to "UNKNOWN".

b. Set controls as shown in Figure h.

c. Select 100nF RANGE by depressing RANGE STEP button.

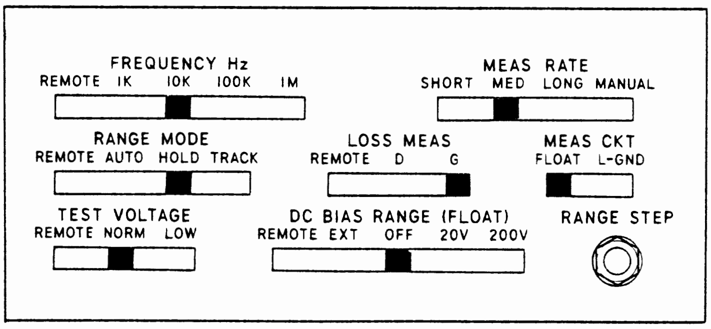


Figure h. Control Settings

d. Note the G reading on the 4270A which should be between 4.940m℧ and 5.060m℧. If the G reading is low, increase A12R47* and if the G reading is high, decrease A12R47*

5-45. D AMPLIFIER A8 ADJUSTMENT (A8R3)

a. Remove bottom guard cover for standard capacitor.

b. Connect 100nF STD Capacitor and 2kΩ Resistor as shown in Figure 6.

c. Set controls as shown in Figure h:

Except: FREQUENCY 1kHz
LOSS MEAS .... D

d. Select 100nF RANGE by depressing the RANGE STEP button.

e. Adjust A8R3 for D reading of .7957 ±10 counts.

5-46. 1MHz PHASE ADJUSTMENT

5-47. PHASE DETECTOR A10 ADJUSTMENT (A10C3*, A10C25*)

a. Connect 1000pF Standard Capacitor and 20kΩ Resistor as shown in Figure 5-2.

b. Set 4270A controls as shown in Figure i.

c. The 4270A should balance. If not, change A10C3* value in either direction for balance.

d. Replace the 20kΩ with a 333Ω (0698-5941) resistor.

e. The 4270A should balance. If not, change A10C25* value in either direction for balance.

f. Replace the 333Ω with 2kΩ. The 4270A should balance and note readings of C and D.

g. Set TEST VOLTAGE control to LOW. The 4270A should balance and note readings of C and D.

h. Adjust A10C31 so that C reading in step g is within ±5 counts of C reading in step f.

i. Adjust A10C10 so that D reading step g is within ±5 counts of D reading in step f.

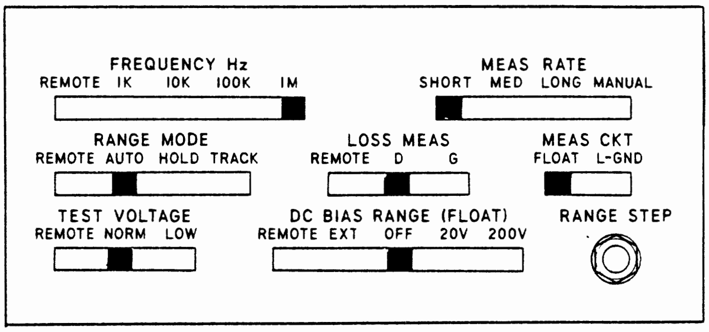


Figure i. Control Settings

5-48. Cs ATTENUATOR A14 ADJUSTMENT (C ADJ 1, C ADJ 2, C ADJ 3)

a. Connect the Decade Capacitor (hp Model 4440B) output in parallel with a 200kΩ Resistor to "UNKNOWN".

b. Set controls as shown in Figure i:

Except: RANGE MODE ...... HOLD

c. Select 1000 pF Range by depressing RANGE STEP button.

d. Set the Decade Capacitor for a reading between 99.6pF and 99.9pF on the 4270A and note the D reading (about .0080).

e. Set the Decade Capacitor for a reading between 100.0pF and 100.3pF on the 4270A and note the D reading.

f. The D reading in step e. should be within ±5 counts. with the reading in step d. Also check the D difference between the value obtained at setting C1 and C2 as shown in Table 5-19. If the D difference is within ±5 counts, proceed to paragraph 5-48. If the D difference is more than ±5 counts, proceed as follows:

g. Turn 4270A LINE off. Disconnect the cable from A14J1 and the cable from A16J14.

h. Pull out A14, install the Extender (HP Part No. 04270-7760) and insert A14 into the extender. Connect the cables to A14J1 and A16J14.

i. Turn 4270A LINE on. Set RANGE MODE control to TRACK.

Table 5-19. Cs ATT Adjustment

C1	C2	Dc1 - Dc2
09.99pF	10.00pF	±5 counts
19.99	20.00	"
39.99	40.00	"
79.99	80.00	"
99.99	100.00	"

j. Set the Decade Capacitor for a display between 400. 0pF and 400. 3pF on the 4270A, and note the dissipation factor reading.

k. Set the Decade Capacitor for a reading between 399. 6pF and 399. 9pF, and note the dissipation factor reading.

l. Adjust C ADJ 1 for same dissipation factor reading as in step j. If C ADJ 1 is out of range, adjust C ADJ 2 and C ADJ 3.

m. Set the Decade Capacitor for a display between 200. 0pF and 200. 3pF on the 4270A and note the dissipation factor reading.

n. Set the Decade Capacitor for a display between 199. 6pF and 199. 9pF on the 4270A and note the dissipation factor reading.

o. The dissipation factor reading in step n. should be same as the reading in step m. If not, calculate the average value of the dissipation factor given by the following:

$$\frac{D200.0 + D199.9}{2}$$

Adjust C ADJ 2 for the average dissipation factor display.

p. Set the Decade Capacitor for a reading between 200. 0pF and 200. 3pF on the 4270A and adjust C ADJ 1 for the average D display.

q. Repeat step o. and p. until the D readings are similar.

r. Set the Decade Capacitor for a readings between 100. 0pF and 100. 3pF on the 4270A and repeat step m. through q. Adjust C ADJ 2 for the D reading of 100. 0pF and C ADJ 3 for the D reading of 99. 9pF.

s. Repeat step j. through r. to ensure that C ADJ 1, C ADJ 2 and C ADJ 3 are properly adjusted.

t. Set the Decade Capacitor for a reading between 799. 6pF and 799. 9pF on the 4270A and note the D reading.

u. Set the Decade Capacitor for a reading between 800. 0pF and 800. 3pF on the 4270A and note the D reading which should be same as the D reading in step t. If not, adjust the stray capacitance of resistor A14R16 as follows:

1) Turn the 4270A LINE SWITCH off.
2) Remove the shield cover on A14 by taking out five screws.
3) Check for A14R16 location.
4) When the D reading in step u. is less than the reading in step t. paint A14R16 with silver paint increasing the area already painted. When the D reading in step u. is larger than the reading in step t, cut off the silver paint on the A14R16 decreasing the area.
5) Replace the shield cover on A14 and tighten the five screws.
6) Turn the 4270A LINE switch on.
7) Set RANGE MODE control to AUTO and after balance to TRACK.
8) Set Precision Variable Capacitor for 800. 0pF display on the 4270A and note the D reading which should be same as the reading in step t. If not, repeat step 1) through 7).

v. Set the Decade Capacitor for a display between 999. 6pF and 999. 9pF on the 4270A and note the D reading.

w. Set the Decade Capacitor for a display between 1000. 0pF and 1000. 3pF on the 4270A and note the D reading which should be the same as the reading in step v. If not, adjust the stray capacitance of Resistor A14R8 as described in step u.

x. Check that the D difference between the values obtained at setting C1 and C2 which should be within ±5 counts as shown in Table 5-19. If not, repeat step j. through w.

y. Replace A14 assembly.

5-49. Cs AMPLIFIER A7 PHASE ADJUSTMENT (A7C3)

a. Connect the 1000pF STD capacitor and 20 kΩ Resistor to "UNKNOWN" as shown in Figure 5-2.

b. Set controls as shown in Figure i.

c. Adjust A7C3 for D reading of . 0080.

5-50. 100pF Cs LOSS ADJUSTMENT (A7R20*)

a. Connect 100pF STD capacitor and 200kΩ Resistor to "UNKNOWN" as shown in Figure 5-2.

b. Set controls as shown in Figure i.

c. The D reading should be . 0080 ±11 counts. If not, adjust A7R20. If D reading is low, decrease A7R20; if reading is high, increase A7R20. (A change of ±1 count corresponds to a change of ±0. 16Ω).

5-51. 10pF Cs LOSS ADJUSTMENT (A7R21*)

a. Connect 10pF STD capacitor and 2MΩ Resistor to "UNKNOWN" as shown in Figure 5-2.

b. Set controls as shown in Figure i.

c. The D reading should be . 0080 ±11 counts. If not, adjust A7R21. If D reading is low, decrease A7R21; if reading is high, increase A7R21. (A change of ±1 count corresponds to a change of ±1. 6Ω).

5-52. D/G AMPLIFIER PHASE ADJUSTMENT (A12C6, A8C1)

a. Connect 1000pF STD capacitor and 200Ω Resistor.

b. Set controls as shown in Figure i:

Except:
RANGE MODE........ HOLD
LOSS MEAS.......... G

c. Select 1000pF RANGE by depressing RANGE STEP button.

d. The C reading should be within ±200 counts from the calibrated value of the STD Capacitor. If not, adjust A12C6.

e. Set LOSS MEAS control to D and check the difference between C value obtained in step d. and e., as it should be within ±20 counts. If not, adjust A8C1.

5-53. DC BIAS VOLTAGE ADJUSTMENT (A26R28, A26R14, A26R30)

a. Connect Digital Voltmeter to rear of BIAS OUTPUT connector and Decade Resistor to REMOTE PROGRAM terminals.

b. Set controls as shown in Figure j. and set BIAS VERNIER to REMOTE (full ccw in detent).

c. Set the Decade Resistor to 5kΩ.

d. Adjust A26R28 (200V ADJ) for -19.8V ±0.1 Volt display on the Digital Voltmeter. A DVM with a high input impedance is recommended (at least 10MΩ.)

e. Set the Decade Resistor to 0Ω.

f. Adjust A26R14 (Zero Adj) for +75 mV display on the Digital Voltmeter.

g. Repeat step c. through f.

h. Set DC BIAS RANGE control to 200V and set the Decade Resistor to 5kΩ.

i. Check the display on the Digital Voltmeter as it should be -198V ±2V.

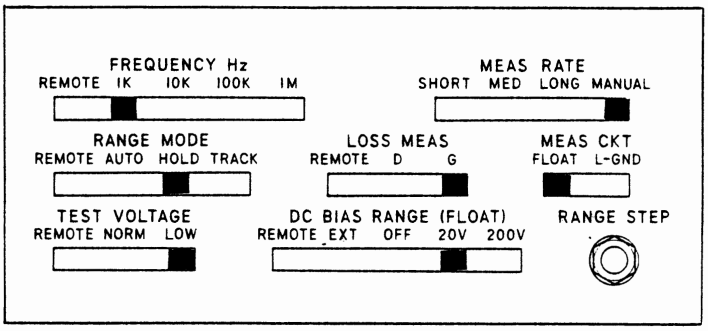


Figure j. Control Settings

j. Disconnect Decade Resistor from REMOTE PROGRAM terminals and connect the shorting bar between the terminals.

k. Set DC BIAS RANGE control to 20V and set BIAS VERNIER to "20".

l. Adjust A26R30 for -19.8V ±0.1V display on the digital voltmeter.

5-54. ASSEMBLY DESIGNATION

5-55. Table 5-20 lists the designation, name and Hewlett-Packard part number of assembly used in this instrument.

5-56. REMOVAL OF PRINTED CIRCUIT BOARDS

5-57. Boards assemblies A10 through A13 and A18 through A28 are equipped with integral plastic levers which assist in board removal. To remove board, lift up on inside edge of release levers. This will jack the board out of its socket. Lift up board to remove.

5-58. Numerical Display Assembly and Unit Display Assembly (A1, A2) Removal.

a. Remove two screws holding the mask of the front panel to the front panel.

b. Remove the nut securing RANGE STEP button to the mask of the front panel.

c. Remove the mask from front panel.

d. Remove the window by removing three screws that secure window to front panel.

e. To remove Numerical Display Assembly (A1) and Unit Display Assembly (A2) pull on inside edge of release levers. This will jack the board out of its socket.

5-59. Switch Control Assembly (A3) Removal.

a. Remove the mask of the front panel as described in paragraph 4-2.

b. Remove the cable connector from the Switch Control Assembly (A3).

Ass'y	Name	HP Part No.	Note
A1	Numerical Display	**04270-7721**	
A2	Unit ETC Display	**04270-7722**	
	Unit ETC Display	04270-7756	For Option 004, only
A3	Function Switch	**04270-7723**	
	Function Switch	04270-7757	For Option 004, only
A4	Cs Buffer Storage	**04270-7724**	The circuit change has been done. The old circuit for the 4270A with Serial Prefix 1019J/1020J and below is shown in Section VII BACK DATING. The new and old assemblies are interchangeable with each other.
A5	D/G Buffer Storage	**04270-7725**	
A6	Cx Amp	**04270-7726**	
A7	Cs Amp	**04270-7727**	
A8	D Amp	**04270-7728**	The circuit change has been done. The old circuit for the 4270A with Serial Number 1019J/1020J00195 and below is shown in Section VII BACK DATING. The new and old assemblies are interchangeable with each other.
	Cc Amp	04270-7753	For Option 004, only
A9	Not Assigned		
A10	Phase Detector	**04270-7758**	
	Phase Detector	04270-7730	For 4270A with Serial Prefix 1019J/1020J and below. Interchangeable with 04270-7758.
A11	Current Detector	**04270-7766**	
	Current Detector	04270-7730	For 4270A with Serial Prefix 1019J/1020J and below. Not interchangeable with 04270-7766 and 04270-7759.
	Current Detector	04270-7759	For 4270A with Serial Prefix 1031J/1032J and 1107J/1108J, only. Not interchangeable with 04270-7730 and 04270-7766.
A12	D/G Amp & Gs	**04270-7732**	
A13	OSC & Buffer Amp	**04270-7733**	
	OSC & Buffer Amp	04270-7751	For Option 002, only
	OSC & Buffer Amp	04270-7752	For Option 003, only
	OSC & Buffer Amp	04270-7754	For Option 005, only
A14	Cs Attenuator	**04270-7734**	
A15	D/G Attenuator	**04270-7735**	

Table 5-20. Assembly Designation

Ass'y	Name	HP Part No.	Note
A16	Cs Reversible Counter	**04270-7736**	
A17	Not Assigned		
A18	D/G Reversible Counter	**04270-7738**	
A19	Gate (1)	**04270-7739**	
A20	Gate (2)	**04270-7740**	
A21	Timing Circuit	**04270-7741**	
A22	Range Selector	**04270-7742**	
A23	Display Control	**04270-7743**	
A24	Reset & DC Bias Control	**04270-7744**	
	Reset & DC Bias Control	04270-7768	For Option 004 with Serial Prefix 1127J/ 1128J and above. Not interchangeable with 04270-7744.
A25	Switching Control	**04270-7745**	
A26	DC Bias Supply	**04270-7746**	
A27	Power Supply (1)	**04270-7747**	
A28	Power Supply (2)	**04270-7748**	
A29	Not Assigned		
A30	Diode Ass'y	**04270-7750**	
A31	Over Compensation Detector	04270-7755	For Option 004, only

Table 5-20. Assembly Designation (Cont'd)

c. Remove four screws which secure A3 to the front panel.

d. Remove A3 from inside of 4270A.

5-60. Cs Buffer Storage Assembly (A4) and D/G Buffer Storage Assembly (A5) Removal.

a. Remove the cable connector from the top of A4 (A5).

b. Lift up on inside edge of release levers. This will jack the board out of its socket.

5-61. Cx Amplifier Assembly (A6) Removal.

a. Remove shield cover by removing two screws.

b. Disconnect six wires from pins on the A6 Assembly.

c. Unsolder the wire from "HIGH" UNKNOWN connector.

d. Remove three screws which secure A6 assembly to chassis.

e. Remove A6 assembly by lifting it up.

5-62. Cs Amplifier Assembly (A7) Removal.

a. Remove shield cover by removing two screws.

b. Unsolder leads of relays from C standards.

c. To remove, grasp top of board and pull up.

5-63. D Amplifier Assembly (A8) Removal.

a. Remove shield cover by removing two screws.

b. To remove, grasp top of board and pull up.

5-64. Cs Attenuator Assembly (A14) Removal.

a. Remove top shield cover by removing four screws.

b. Disconnect the cable from A14J1.

c. Cut the cable strap which ties cable to J14.

d. Disconnect the cable from J14.

e. To remove A14 assembly, pull up on edge of the assembly.

f. Disconnect the cables from J15 and J16.

5-65. D/G Attenuator (A15).

a. Remove top shield cover by removing four screws.

b. Disconnect the cable from A15J1.

c. Disconnect the cable from J17.

d. To remove A15 assembly, pull up on edge of the assembly.

5-66. TROUBLESHOOTING

5-67. GENERAL. The following paragraphs, steps and "Troubleshooting Tree" aid in locating problems. Use this section to isolate trouble to an assembly; then go to that assembly schematic in Section VIII to further locate the defective components.

5-68. The following troubleshooting procedures which are designed to assist in isolating a malfunction(s) to an assembly include two steps; one is "Isolation of Trouble Area in Cabinet "which should be conducted before circuit troubleshooting to ensure that the trouble is not a result of conditions external to the Model 4270A and to obtain all possible information from the controls and indicators. The other is "Isolation of Trouble Area using Special Extenders "which simplify troubleshooting by their uses. After isolating a malfunction(s) to an assembly, go to that assembly schematic and troubleshooting in Section VIII to locate the defective components.

5-69. Isolation of Trouble Area in Cabinet.

a. Verify that the trouble is not a result of conditions external to the 4270A by disconnecting all cables to it (both front and rear) and check the function controls.

b. Obtains as much information as possible concerning the malfunction from the front panel of the instrument.

c. Refer to Table 2 to isolate the problem to a particular functional area(s).

5-70. Power Supply Check.

5-71. Power supplies are checked and adjusted to the values given in Table 5-21. The "MEAS CKT" control should be in "FLOAT".

5-72. ISOLATION OF TROUBLE AREA USING SPECIAL EXTENDER.

5-73. TROUBLESHOOTING OF FEEDBACK CIRCUIT. Model 4270A has two main feedback paths, one of which is the Cs Attenuator control signal and the other is the D/G Attenuator control signal. It is possible to modify the feedback path in order to obtain a linear signal flow. This modification is accomplished by grounding XA19 PIN 5L and XA19 PIN 10L or installing the special Extender I (HP Part No. 04270-7762) to XA19 and inserting A19 into the extender.

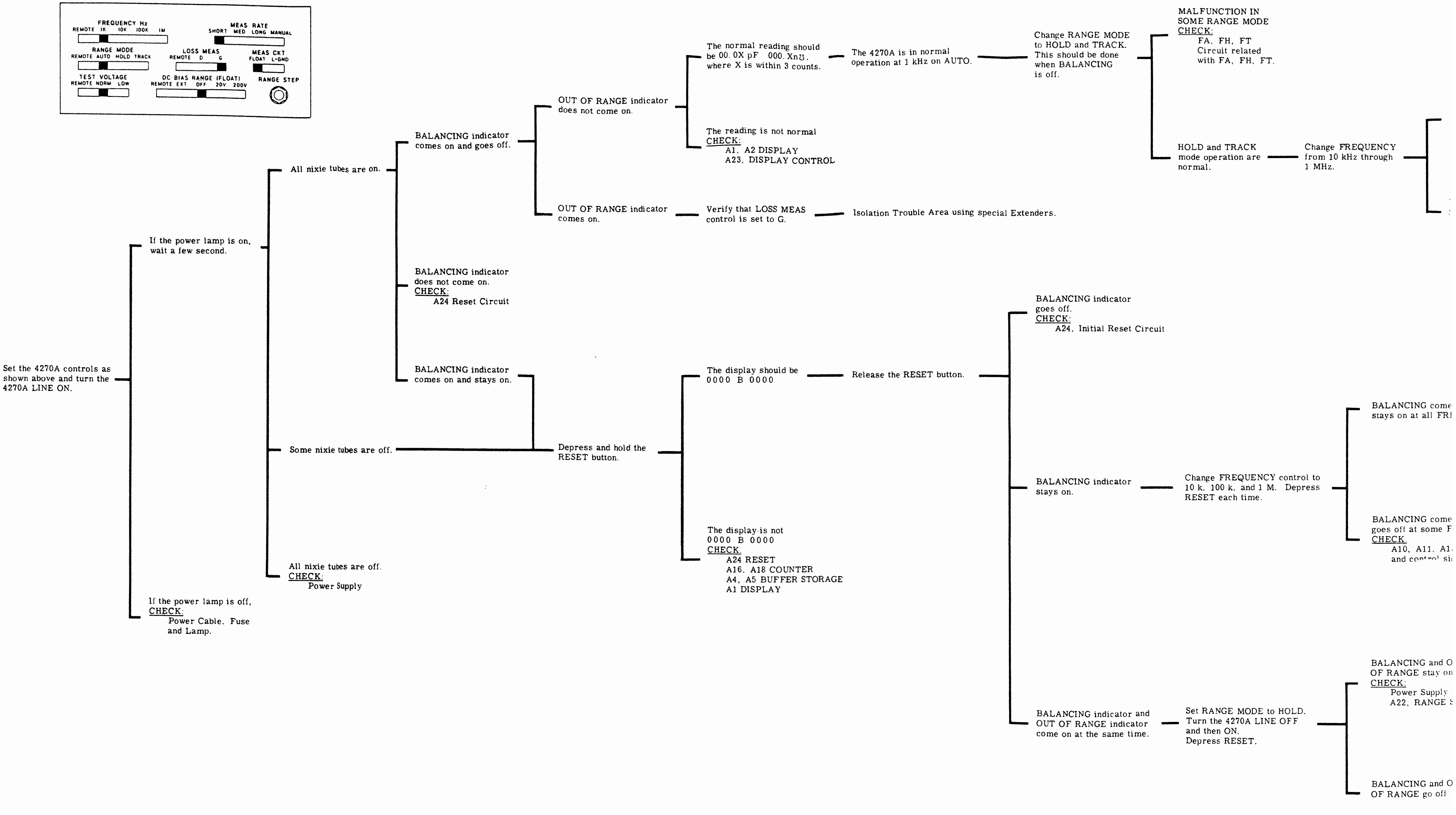


Figure 5-7. Troubleshooting Tree.

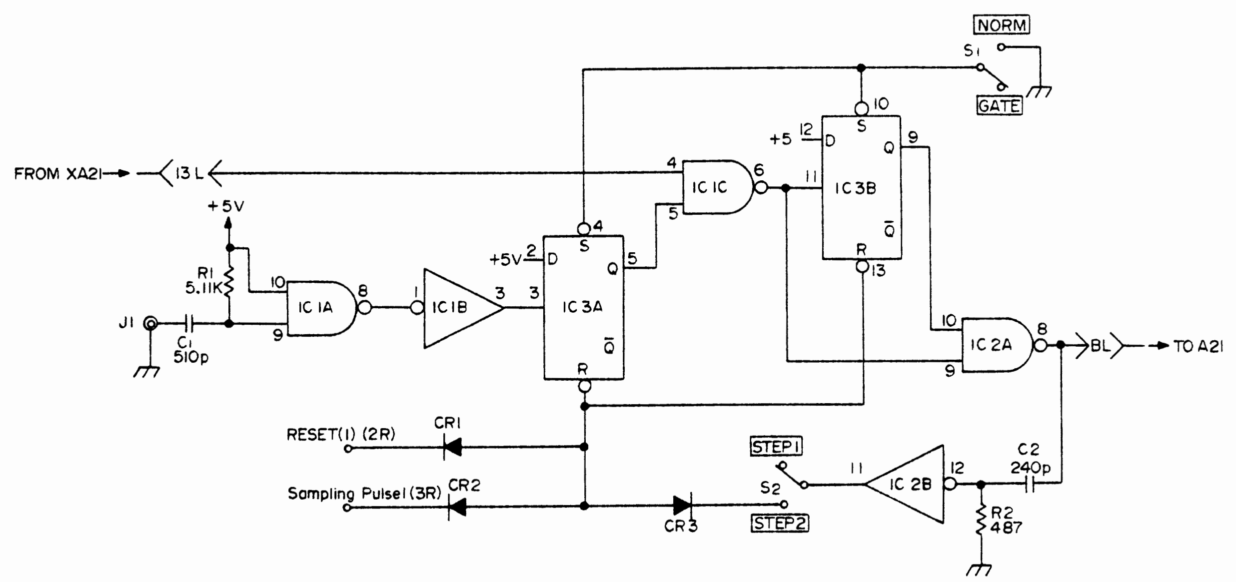
- MALFUNCTION IN SOME RANGE MODE
  CHECK:
  FA, FH, FT
  Circuit related with FA, FH, FT.

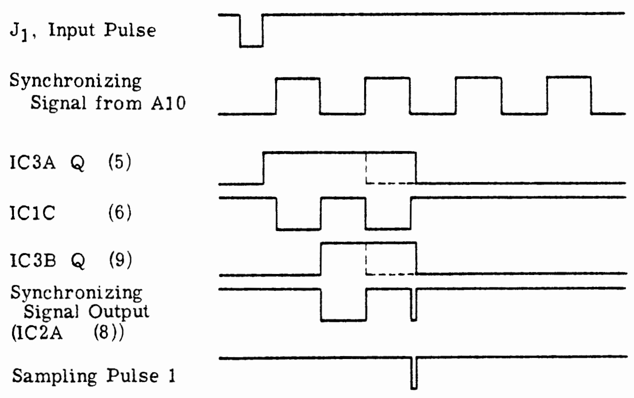
- HOLD and TRACK mode operation are normal.
  - Change FREQUENCY from 10 kHz through 1 MHz.
    - Operation is OK at all FREQUENCY.
    - MALFUNCTION in SOME FREQUENCY
      CHECK:
      Frequency Control signal and relays.

uit

- Change FREQUENCY control to 10 k, 100 k, and 1 M. Depress RESET each time.
  - BALANCING comes on and stays on at all FREQUENCY.
    - Set FREQUENCY to 1 kHz and RANGE MODE to HOLD. Turn the 4270A LINE OFF and then ON. Depress RESET.
      - BALANCING stays on.
        - Isolation Trouble Area using special Extenders.
      - BALANCING goes off. The reading should be 000. XpF 0.00XμƱ, where X is within 3 counts.
        - Depress RANGE STEP and check the range step operation.
          - RANGE STEP operation is good.
            CHECK:
            RESET (2)
            INITIAL SET PULSE
            FA, FH
            (00600)
            Cs counter
          - RANGE STEP operation is not good.
            CHECK:
            A22, RANGE SELECTOR
  - BALANCING comes on and goes off at some FREQUENCY.
    CHECK:
    A10, A11, A13 relays and control signals.

- Set RANGE MODE to HOLD. Turn the 4270A LINE OFF and then ON. Depress RESET.
  - BALANCING and OUT OF RANGE stay on.
    CHECK:
    Power Supply
    A22, RANGE SELECTOR
  - BALANCING and OUT OF RANGE go off.
    - Depress RANGE STEP and check the range step operation.
      - Range Step operation is normal.
        CHECK:
        RESET (2)
        Initial set pulse.
      - Range Step operation is not correct.
        CHECK:
        A22, RANGE SELECTOR





Operation of Special Extender II

1. Introduction.

   This extender has been designed for easy servicing of Model 4270A, manually balancing the bridge instead of automatically balancing. The operating procedure is quite simple and is described as follows.

2. Operation

   (1) Remove Top cover and shield cover of the 4270A.

   (2) Remove the Timing Circuit Assembly A21.

   (3) Install this special Extender II into XA21.

   (4) Insert A21 to this Extender II.

   (5) When NORM/GATE control is set to NORM, Sampling Pulses are automatically produced. When it is set to GATE, Sampling Pulses can be externally triggered.

   (6) When STEP I/STEP II control is set to STEP I, one Sampling Pulse is produced for every external pulse, and when it is set to STEP II, Sampling Pulse is produced for every other external pulse.

   (7) Connect Pulse Generator to J1.

Figure 5-8. Special Extender II(04270-7764).

5-74. LINEAR SIGNAL FLOW. After the modification above, the signal flow is shown in Figure 5-9. The 4270A can be broken down into three major blocks, the logic, the counter and the bridge. A major block actually consists of many other blocks such as the Logic, but proceeding to the following paragraphs, trouble can be isolated to any one of the blocks. Once the malfunction has been isolated to a block, refer to the schematic diagram in the manual for circuit troubleshooting.

5-75. TIMING CIRCUIT MODIFICATION. The special extender II (HP Part No. 04270-7764) shown in Figure 5-8, is helpful for troubleshooting of the 4270A. Set the 4270A LINE to off and replace the Timing Circuit Assembly A21. Insert A21 into the extender. With this arrangement, the balancing of the 4270A can be done step by step by using the external pulse.

Table 5-21. Power Supply Check

VOLTAGE	TEST POINT	PIN NO	DC VOLTAGE MIN - MAX	RIPPLE	ADJUSTMENT
+15	+15V	(XA27 3L to GND)	+14.90 - +15.10	3mVp-p	A27R6
+12	+12V	(XA27 5R to GND)	+11.90 - +12.10	"	A27R12
+10	+10V	(XA27 6L to GND)	+9.90 - +10.10	"	A27R19
-6	-6V	(XA27 7L to GND)	-5.90 - -6.10	"	A27R26
+5	+5V	(XA27 11L to GND)	+5.01 - +5.03	"	A27R33
+170		(XA28 DL to GND)	+165.0 - +180.0	3Vp-p	NO

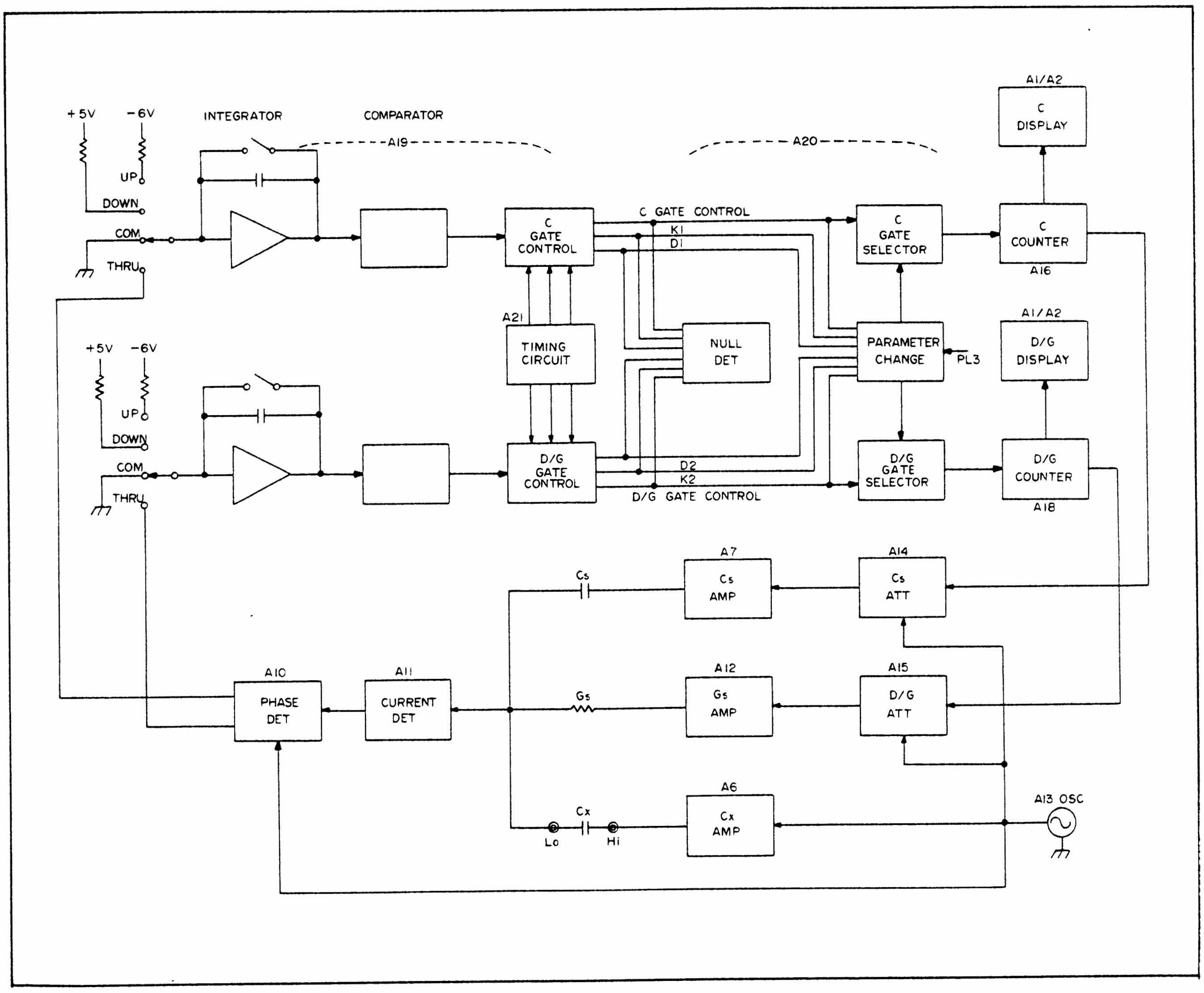


Figure 5-9. Block Diagram with Linear Single Flow

5-76. TEST SET UP.

a. Turn the 4270A LINE off.

b. Pull out A19 and A21, and install the Special Extender I (HP Part No. 04270-7762) into XA19 and the Special Extender II (HP Part No. 04270-7764) into XA21.

c. Insert A19 into the Special Extender I and A21 into the Special Extender II.

d. Connect equipment as shown in Figure 6.

e. Set the 4270A controls as shown in Figure 5-10 and STORAGE ON/OFF switch on A25 board to OFF. Select 1000pF RANGE.

f. Set the 222A controls as follows:

REP RATE .... MAN
PULSE DELAY .... .1 (μs)
VERNIER .... CCW
PULSE WIDTH .... .5 - 5 (μs)
VERNIER .... CW
PULSE AMPLITUDE.... 2 (volt)
VERNIER .... CW
PULSE POLARITY ..... -

g. Set the 180A controls as follows:
1801A (Vertical)

DISPLAY .... CHOP (A)
SENSITIVITY .... 0.5V/DIV (Both channels)
POLARITY ...... + up (")
AC/DC .... DC (")

1820A (Horizontal)

TIME/DIV .... 5 MSEC
180A HORIZONTAL MAGNIFIER... x 1
SWEEP MODE ... TRIGGER
SYNC SOURCE ... EXT (AC)
SLOPE .... +

h. Set the Special Extender I controls as follows:

C .... COM
D/G .... COM

i. Set the Special Extender II controls as follows:

NORM/GATE .... GATE
STEP I/STEP II ...... STEP I

j. Turn the 4270A and the 222A LINE on.

NOTE

The following checks should be done with the same settings as above, unless otherwise instructed.

5-77. LOGIC CIRCUIT CHECK

a. Set the Special Extender II NORM/GATE control to NORM and RANGE MODE of 4270A to AUTO.

b. Depress RESET button. The 4270A should balance and the display should be .1600μF 0.000m℧.

c. When both integrator inputs are connected to the

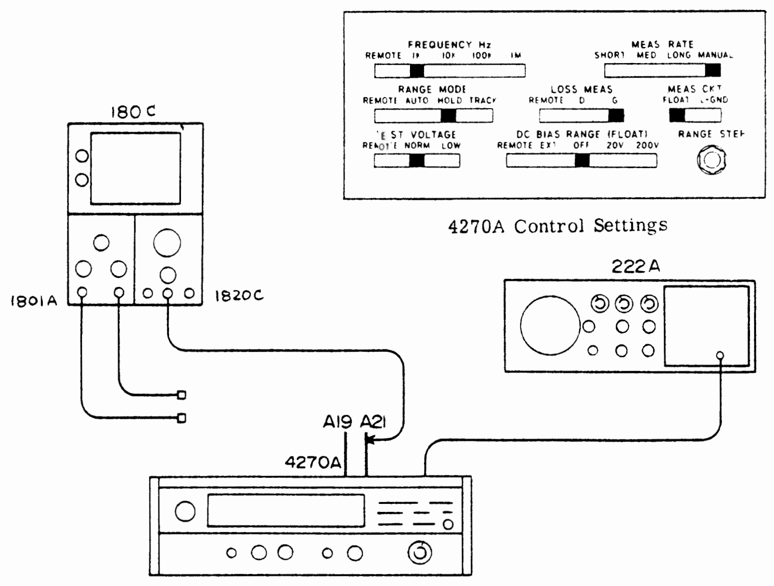


Figure 5-10. Test Set-up

circuit common, integrator outputs are zero and four comparator outputs are LOW. K1 and K2 K2 pulse are simultaneously produced with the first timing pulse PL2. Null Detector receives the K1 and K2 pulses and produces PN pulse which closes Main GATE. The 4270A should balance and the display should be .1600μF 0.000m℧.

d. If the 4270A balances but the display is 00.00pF 000.0n℧, the BALANCING lamp goes on or OUT OF RANGE lamp comes on, check K1 and K2 pulses as follows:

   1) Set the 4270A MEAS RATE control to SHORT.

   2) Connect oscilloscope A channel input to XA 19 PIN 8R and B channel input to XA19 PIN 7R using 10:1 probe.

   3) Connect oscilloscope EXT TRIG input to XA 21 PIN 2R using 10:1 probe.

   4) Adjust trigger level and center oscilloscope traces on graticule.

   5) The K1 and K2 pulses displayed should appear about 10 ms after starting of the sweep as shown in Figure 5-11.

      Note: Verify that the trigger is taken from the positive slope of RESET(1) pulse.

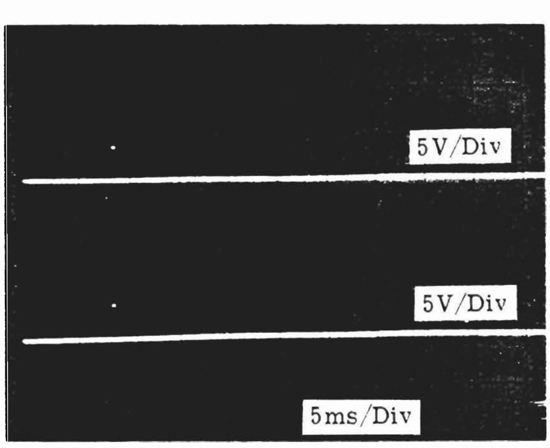


Figure 5-11. K1 and K2 Pulse

   6) If the pulse displayed does not appear at 10ms, adjust A19R5 for K1 and A19R28 for K2 so that the pulse is about 10ms.

   7) If the pulses do not appear, check Timing Circuit(A21), Comparator(A19), and Sampling Gate(A19).

   8) If K1 and K2 pulses appear, check Null Detector (A20).

e. Set MEAS RATE to MANUAL and RANGE MODE to HOLD. Select 1000pF Range by depressing RANGE STEP button.

f. Set C and D/G controls on the Extender I to DOWN position.

g. Depress RESET button.

h. When both integrator inputs are connected to the positive voltage (DOWN), integrator outputs go down and D1 and D2 pulses are produced. The Null Detector receives D1 pulse, D2 pulses Cs(00000) signal and Gs(00000), simultaneously produces PN. With the generation of the first PL2 Timing pulse, the 4270A should balance and the display should be 000.0pF 0.000μ℧.

i. If the BALANCING indicator stays on or OUT OF RANGE indicator comes on, check D1 and D2 pulses as follows:

   1) Set the 4270A MEAS RATE control to SHORT.

   2) Connect oscilloscope A channel input to XA 19 PIN CR and B channel input to XA19 PIN DR using 10:1 probes.

   3) Connect oscilloscope EXT TRIG input to XA 21 PIN 2R using 10:1 probes.

   4) Adjust trigger level and center oscilloscope traces on graticule.

   5) If the D1 or D2 pulse does not appear, check Comparator (A19) and Sampling Gate (A19).

   6) If the D1 and D2 pulses appear as shown in Figure 5-12, check Cs(00000), Gs(00000) signal and Null Detector.

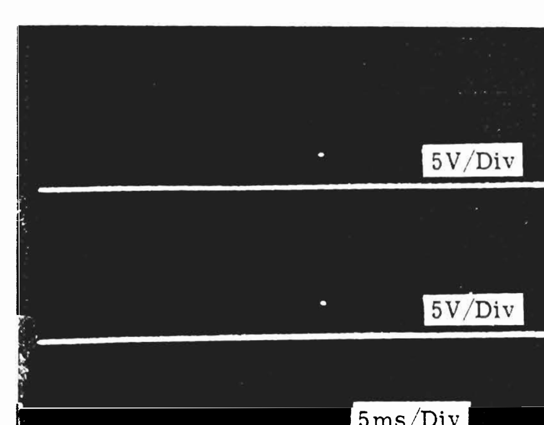


Figure 5-12. D1 and D2 Pulse

j. Set MEAS RATE to MANUAL.

k. Set NORM/GATE control on the Extender II to GATE. This makes the balancing of the 4270A proceed with the external pulse.

l. Depress RESET button. The BALANCING indicator should come on and the display should be 000.0pF 0.000μ℧. (RANGE MODE in HOLD and 1000pF RANGE)

m. Set C control on the Extender I to UP and set D/G control to COM.

n. Depress MANUAL button of the 222A once. The display of the 4270A should be 100.0pF 0.000μ℧.

o. If not, check UP 1, GATE SELECTOR, PARAMETER CONTROL and TIMING PULSE PL3.

p. Set C and D/G controls on the Extender I in Table 4 and depress MANUAL button of the 222A once for each setting of the Extender I.

q. Observe the 4270A display after depressing MANUAL button. The display should be as shown in Table 5-22.

5-78. COUNTER and DISPLAY CHECK (A16, A18 A4, A5, A1, A2).

a. Connect the equipment as shown in Figure 5-10 and set all of the controls as described in paragraph 5-76.

b. Depress RESET button. The BALANCING lamp should come on and the display should be 000.0pF 0.000μ℧.

c. Set RANGE MODE control to TRACK and depress RESET button. The BALANCING indicator should stay on and the display should be 000.0pF 0.000μ℧.

d. Set C control on the Extender I to UP and D/G control to UP.

e. Set REP. RATE of the 222A to 10 - 100 Hz and VERNIER control to ccw.

f. The D/G counter should start counting at the least significant digit and count up to 9999. If the counter does not start counting at the least significant digit or if no count is indicated, check A20 or A21. If the counter starts counting at the least significant digit but the count is not normal, check A18, A5, A1 and A2.

g. Set D/G control on the Extender I to DOWN.

h. The Cs counter should start counting at the least significant digit and count up to 10000. If the Cs counter does not start counting at the least significant digit, check A20. If the counter starts counting at the least significant digit but the count is not normal, check A16, A4, A1 and A2.

i. Set C control on the Extender I to DOWN.

j. The D/G counter should start counting down from the previous reading until the BALANCING indicator goes off. (the counting stops).

Table 5-22. LOGIC CHECK

Step	Setting of Extender I Cont.		4270A Display		Check
	C	D/G	C	G	
1	UP	COM	100.0pF	0.000μ℧	UP1, C Gate Selector, Parameter Control, Timing Pulse Pls.
2	DOWN	COM	090.0	0.000	Down 1, C Gate Control Pulse, C Gate Selector
3	UP	UP	090.0	1.000	UP 2, D/G Gate Selector, Parameter Control, C Gate Control Pulse
4	UP	DOWN	090.0	0.900	Down 2, D/G Gate Selector, D/G Gate Control Pulse
5	UP	UP	091.0	0.900	D/G Gate Control Pulse, C Gate Selector
6	DOWN	UP	091.0	0.910	D/G Gate Selector
7	DOWN	DOWN	091.0	0.909	D/G Gate Selector
8	UP	UP	091.1	0.909	C Gate Selector
9	DOWN	DOWN	091.1	0.908	
10	DOWN	UP	091.0	0.908	
11	UP	UP	091.0	0.909	
12	UP	COM	091.0	* 0.909	Null Detector

* Balancing Indicator should go off.

k. Depress RESET button.

l. The Cs counter should start counting down from the previous reading until the BALANCING indicator goes off.

5-79. BRIDGE CIRCUIT CHECK.

a. Connect equipment as shown in Figure 5-10 and set all of the controls as described in paragraph 5-76.

b. Set C control on the Extender I to UP and D/G control to DOWN.

c. Depress RESET button, set RANGE MODE control to TRACK and depress RESET again.

d. Depress pulse generator MANUAL button twice. The counter reading should be 000. 1pF 0.000$\mu\mho$.

e. Each time the MANUAL button is depressed, the Cs counter should count up one digit. Continue depressing the MANUAL button until Cs counter counts up to 50 digits (005. 0pF 0. 000$\mu\mho$).

f. Connect oscilloscope channel A vertical input to "HIGH UNKNOWN" and channel B vertical input to XA11 PIN 1L and chassis ground with the 10:1 probes. Oscilloscope B channel pattern should be 1kHz sine wave, 0. 8 volt peak-to-peak and phase relation between A and B channel should be 45° out of phase (refer to Figure 5-13). Internal trigger (channel A) should be used.

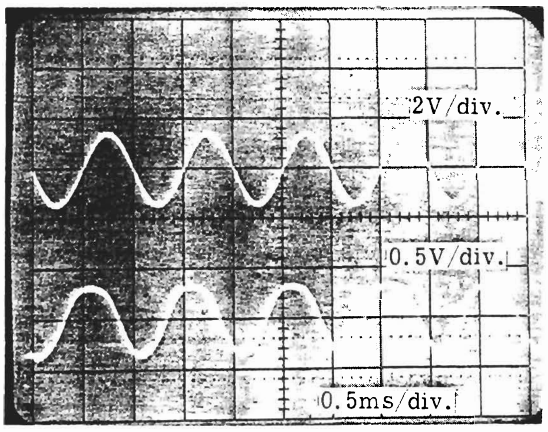


Figure 5-13. Waveforms at "HI" and XA11 PIN 1L

g. If there are no outputs or noisy outputs at "HIGH UNKNOWN" and XA11 PIN 1L, check A13. If there is no output or noisy output only at XA11 PIN 1L, proceed to step h.

h. Set RANGE MODE control to HOLD and change the capacitance range from 1000pF to 10nF one by one, by depressing RANGE STEP button. The amplitude of B channel display should be between 0. 6 V (p-p) and 0. 8 V (p-p) except 10pF Range. The phase relation between A channel and B channel should be 45° out of phase.

i. If there is no output or noisy output at XA11 PIN 1L on some range, check Cs and A7 relay identified with the range. If there is no output or noisy on all RANGE (10pF RANGE should be checked at 10kHz), proceed to step j.

j. Set the capacitance range to 1000pF and depress RESET button. The 4270A display should be all zero. Connect 5pF (HP Part No. 0160-2250) to "UNKNOWN".

k. The oscilloscope display should be as same as shown in Figure 10 except B channel display should be 180° out of phase.

l. If there is no output or noisy output at XA11 PIN 1L, check A11. If there is a good output, at XA11 PIN 1L the current detector (A11) may normally operate, and check the Cs Amp (A7) and Cs Att (A14).

m. Remove the 5pF capacitance from "UNKNOWN".

n. Set RANGE MODE to TRACK, depress RESET button and set C control on the Special Extender I to UP and D/G control to UP.

o. Depress MANUAL button of the 222A. The D/G counter should count 1 digit.

p. Continue depressing MANUAL button until the D/G counter counts 50 digits.

q. Oscilloscope pattern should be as shown in Figure 5-14. The amplitude is about 1. 0V p-p and the phase relation between A channel and B channel is 45° out of phase.

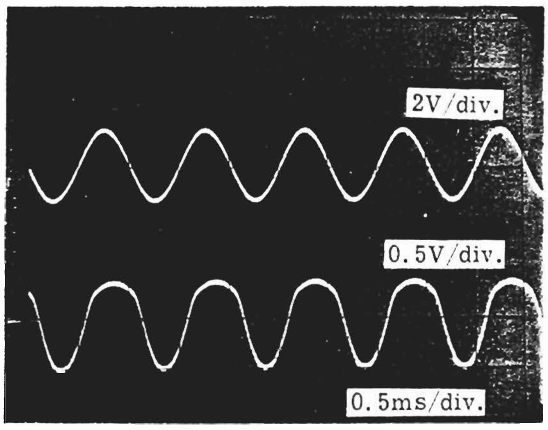


Figure 5-14. Bridge Circuit Check A

r. Set RANGE MODE control to HOLD and change the conductance range from 10$\mu\mho$ to 100$\mu\mho$, one by one, by depressing RANGE STEP button. Only the amplitude of B channel display should vary between 1. 0V (p-p) and 0. 8V (p-p). The phase relation between A channel and B channel should be 45° out of phase.

s. If the oscilloscope pattern of the B channel does not appear or is noisy on some ranges, check Gs and the relay identified with the range in Gs Amp (A12). If the display of the B channel is not good on all ranges, check the Gs Amp (A12) and D/G Attenuator (A15).

t. If there is a good output at XA11 PIN 1L on all ranges, the bridge circuit may be normal except the phase detector A10.

u. The phase detector A10 may be checked as follows:

(1) Connect oscilloscope A channel input to "HIGH" unknown and B channel input to A10 Test Point and chassis ground.

(2) The oscilloscope patterns should be as shown in Figure 5-15.

(3) Connect the oscilloscope B channel input to XA10 3R instead of A10 Test Point.

(4) The oscilloscope B channel pattern should be as shown in Figure 5-16.

(5) If the both output at A10 Test Point and at XA10 3R are not normal, check the input signal to XA10 5L. If one of them is not normal, check the circuits identified with the output.

(6) When both output are normal, set Cs counter to 0050 as described in step b. through e.

(7) Connect the oscilloscope A channel input to A10Q9 emitter and B channel input to A10Q18 emitter. The pattern should be as shown in Figure 5-17.

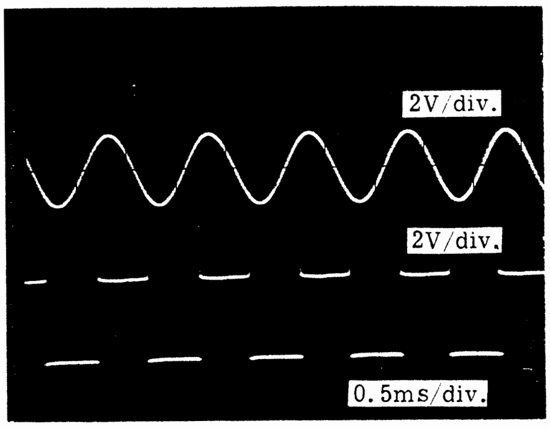


Figure 5-15. Bridge Circuit Check B

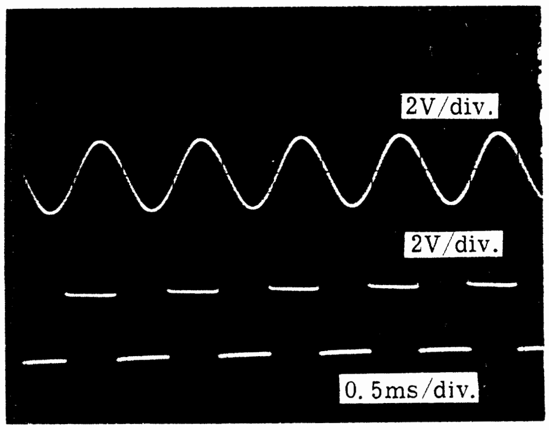


Figure 5-16. Bridge Circuit Check C

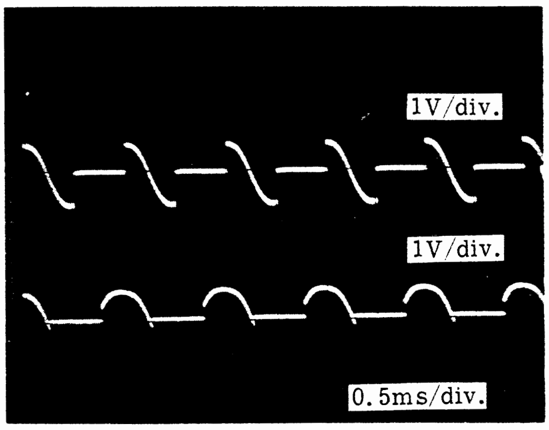


Figure 5-17. PHASE Detector Check

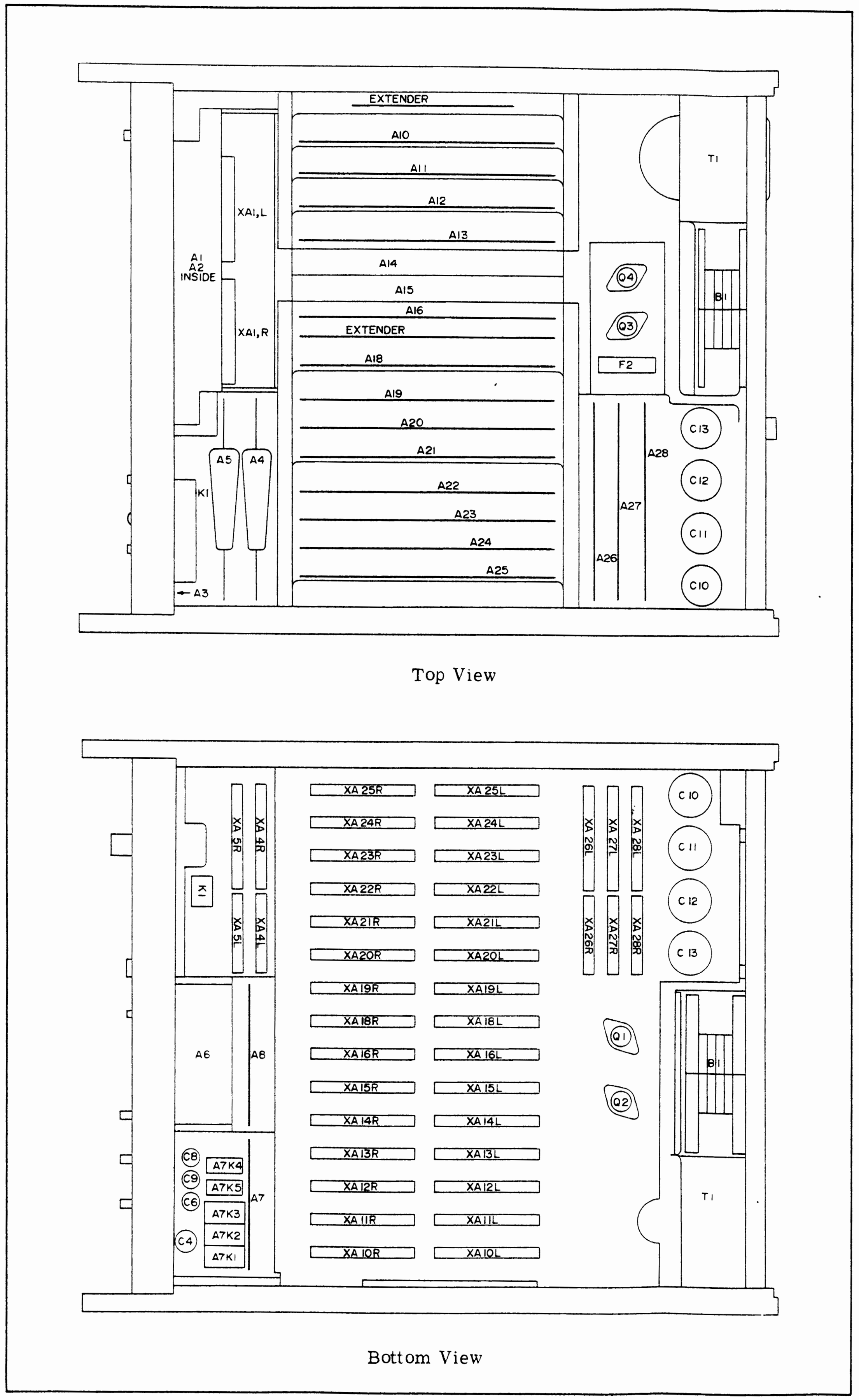


Figure 5-18. Assembly Location.

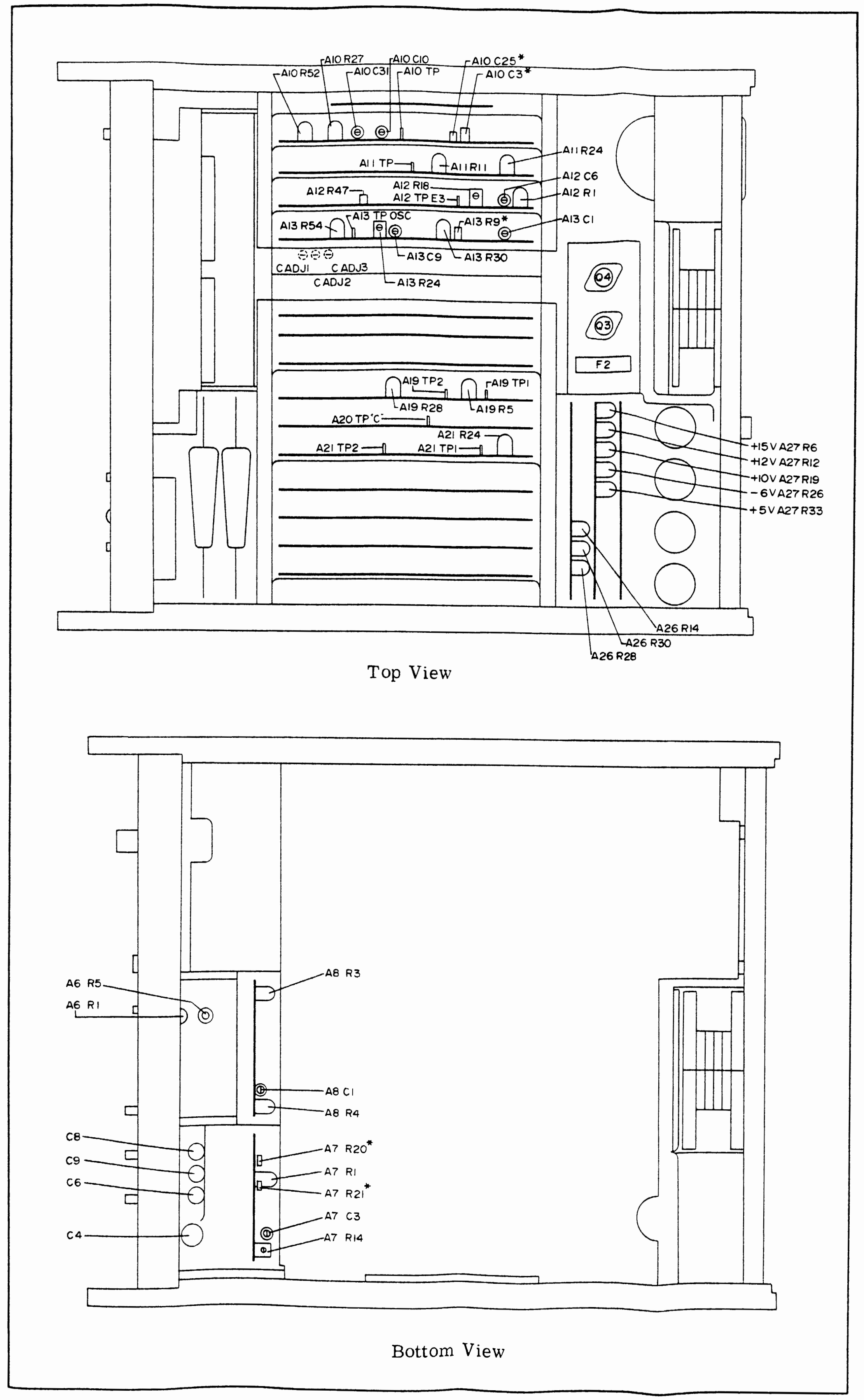


Figure 5-19. Adjustment Location.

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 4270A
Automatic Capacitance Bridge
Serial No.

Test Performed by ______________

Date ______________

5-7. ACCURACY CHECK

	1 kHz	10 kHz	100 kHz	1 MHz
10pF		Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±21 (A)-(E) ______ ±36 (F) ______ (B)-(F) ______ ±10 +S. C.	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±41 (A)-(E) ______ ±56 (F) ______ (B)-(F) ______ ±20 +S. C.	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±111 (A)-(E) ______ ±126 (F) ______ (B)-(F) ______ ±110 +S. C.
100pF	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±12 (A)-(E) ______ ±27 (F) ______ (B)-(F) ______ ±10 +S. C.	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±12 (A)-(E) ______ ±27 (F) ______ (B)-(F) ______ ±10 +S. C.	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±32 (A)-(E) ______ ±47 (F) ______ (B)-(F) ______ ±20 +S. C.	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±101 (A)-(E) ______ ±117 (F) ______ (B)-(F) ______ ±101 +S. C.
1000pF	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±11 (A)-(E) ______ ±26 (F) ______ (B)-(F) ______ ±10	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±11 (A)-(E) ______ ±26 (F) ______ (B)-(F) ______ ±10	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±31 (A)-(E) ______ ±46 (F) ______ (B)-(F) ______ ±20	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±101 (A)-(E) ______ ±116 (F) ______ (B)-(F) ______ ±100
10nF	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±11 (A)-(E) ______ ±26 (F) ______ (B)-(F) ______ ±10	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±11 (A)-(E) ______ ±26 (F) ______ (B)-(F) ______ ±10	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±31 (A)-(E) ______ ±46 (F) ______ (B)-(F) ______ ±20	

PERFORMANCE CHECK TEST CARD (Cont'd)

100nF	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±11 (A)-(E) ______ M26 (F) ______ (B)-(F) ______ ±10	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±11 (A)-(E) ______ ±26 (F) ______ (B)-(F) ______ ±10
1µF	Limit Counts (A) ______ (B) ______ (E) ______ (A)-(B) ______ ±11 (A)-(E) ______ ±26 (F) ______ (B)-(F) ______ ±10	

(A) Calibrated value of STD capacitance.

(B) Capacitance reading at NORM test voltage.

(E) Capacitance at LOW test voltage.

(F) Capacitance reading when 0.1 D 1.

5-10. D/G ACCURACY CHECK

STD	D/G			
	1 kHz	10 kHz	100 kHz	1 MHz
10 pF		G ______ D ______	G ______ D ______	G ______ D ______
100 pF	G ______ D ______	G ______ D ______	G ______ D ______	G ______ D ______
1000 pF	G ______ D ______	G ______ D ______	G ______ D ______	G ______ D ______
10 nF	G ______ D ______	G ______ D ______	G ______ D ______	
100 nF	G ______ D ______	G ______ D ______		
1 µF	G ______ D ______			

PERFORMANCE CHECK TEST CARD (Cont'd)

5-11. CAPACITANCE AND D/G ACCURACY CHECK

	Readings		
	Capacitance	D	G
in step d.	________	________	________
in step c.	________	________	________
(d)-(e)	-9. 0nF≤ ≤-11. 0nF	0. 050≤ ≤0. 077	16μ℧≤ ≤24μ℧

5-12. RANGE MODE

		CHECK
AUTOMATIC RANGING	(AUTO)	________
RANGE STEPPING	(HOLD)	________
OUT OF RANGE	(TRACK)	________

5-16. INTERNAL OSCILLATOR

FREQUENCY	1 kHz	990 Hz≤	________	≤1010 Hz
	10 kHz	9. 90 kHz≤	________	≤10. 10 kHz
	100 kHz	99. 0 kHz≤	________	≤101. 0 kHz
	1 MHz	990 kHz≤	________	≤1010. kHz
TEST VOLTAGE; NORM				
	1 kHz	0. 90 V≤	________	≤1. 10 V
	1 kHz on 1μF RANGE	90 mV≤	________	≤ 110 mV
	10 kHz	450 mV≤	________	≤ 550 mV
	100 kHz	450 mV≤	________	≤ 550 mV
	1 MHz	450 mV≤	________	≤ 550 mV
TEST VOLTAGE; LOW				
	1 kHz	180 mV≤	________	≤ 220 mV
	1 kHz on 1μF RANGE	18 mV≤	________	≤ 22 mV
	10 kHz	90 mV≤	________	≤ 110 mV
	100 kHz	90 mV≤	________	≤ 110 mV
	1 MHz	90 mV≤	________	≤ 110 mV

5-17. DC BIAS

20 V RANGE (LOCAL)	________
200 V RANGE (LOCAL)	________
20 V RANGE (REMOTE)	________
200 V RANGE (REMOTE)	________

5-18. REMOTE OPERATION

REMOTE FREQUENCY	____________
REMOTE TEST VOLTAGE	____________
REMOTE LOSS MEAS	____________
REMOTE RANGE MODE	____________
REMOTE DC BIAS RANGE	____________

5-19. RECORDER OUTPUT ____________

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION

6-2. This section contains information for ordering replacement parts. Table 6-2 lists parts in alphanumerical order of their reference designators and indicates the description (see Table 6-1 for abbreviations used) and -hp- stock number of each parts, together with any applicable notes.

6-3. Miscellaneous parts associated with each assembly are listed at the end of each assembly listing. Others are listed at the end of Table 6-2.

6-4. ORDERING INFORMATION

6-5. To obtain replacement parts, address order or inquiry to your local Hewlett-Packard Field Office (see lists at rear of this manual for addresses). Identify parts by their Hewlett-Packard stock numbers.

6-6. To obtain a part that is not listed, include:

a. Instrument model number.

b. Instrument serial number.

c. Description of the part.

d. Function and location of the part.

REFERENCE DESIGNATORS

A	= assembly	E	= misc electronic part	P	= plug	V	= vacuum, tube, neon bulb, photocell, etc.
B	= motor	F	= fuse	Q	= transistor		
BT	= battery	FL	= filter	R	= resistor	VR	= voltage regulator
C	= capacitor	J	= jack	RT	= thermistor	W	= cable
CP	= coupler	K	= relay	S	= switch	X	= socket
CR	= diode	L	= inductor	T	= transformer	Y	= crystal
DL	= delay line	M	= meter	TB	= terminal board		
DS	= device signaling (lamp)	MP	= mechanical part	TP	= test point		

ABBREVIATIONS

A	= amperes	H	= henries	NPN	= negative-positive-negative	RMS	= root-mean square
A.F.C.	= automatic frequency control	HEX	= hexagonal	NRFR	= not recommended for field replacement	RWV	= reverse working voltage
AMPL	= amplifier	HG	= mercury	NSR	= not separately replaceable	S-B	= slow-blow
B.F.O.	= beat frequency oscillator	HR	= hour(s)	OBD	= order by description	SCR	= screw
BE CU	= beryllium copper	IF	= intermediate freq	OH	= oval head	SE	= selenium
BH	= binder head	IMPG	= impregnated	OX	= oxide	SECT	= section(s)
BP	= bandpass	INCD	= incandescent	P	= peak	SEMICON	= semiconductor
BRS	= brass	INCL	= include(s)	PC	= printed circuit	SI	= silicon
BWO	= backward wave oscillator	INS	= insulation(ed)	PF	= picofarads = 10 farads	SIL	= silver
CCW	= counter-clockwise	INT	= internal	PH BRZ	= phosphor bronze	SL	= slide
CER	= ceramic	K	= kilo = 1000	PHL	= Phillips	SPG	= spring
CMO	= cabinet mount only	LH	= left hand	PIV	= peak inverse voltage	SPL	= special
COEF	= coefficient	LIN	= linear taper	PNP	= positive-negative-positive	SST	= stainless steel
COM	= common	LK WASH	= lock washer	P/O	= part of	SR	= split ring
COMP	= composition	LOG	= logarithmic taper	POLY	= polystyrene	STL	= steel
COMPL	= complete	LPF	= low pass filter	PORC	= porcelain	TA	= tantalum
CONN	= connector	M	= milli = 10^{-3}	POS	= position(s)	TD	= time delay
CP	= cadmium plate	MEG	= meg = 10^{6}	POT	= potentiometer	TGL	= toggle
CRT	= cathode-ray tube	MET FLM	= metal film	PP	= peak-to-peak	THD	= thread
CW	= clockwise	MET OX	= metallic oxide	PT	= point	TI	= titanium
DEPC	= deposited carbon	MFR	= manufacturer	PWV	= peak working voltage	TOL	= tolerance
DR	= drive	MINAT	= miniature	RECT	= rectifier	TRIM	= trimmer
ELECT	= electrolytic	MOM	= momentary	RF	= radio frequency	TWT	= traveling wave tube
ENCAP	= encapsulated	MTG	= mounting	RH	= round head or right hand	U	= micro = 10^{-6}
EXT	= external	MY	= "mylar"	RMO	= rack mount only	VAR	= variable
F	= farads	N	= nano (10^{-9})			VDCW	= dc working volts
FH	= flat head	N/C	= normally closed			W/	= with
FIL H	= fillister head	NE	= neon			W	= watts
FXD	= fixed	NI PL	= nickel plate			WIV	= working inverse voltage
GE	= germanium	N/O	= normally open			WW	= wirewound
GL	= glass	NPO	= negative positive zero (zero temperature coefficient)			W/O	= without
GRD	= ground(ed)						

Table 6-1. List of Reference Designators and Abbreviations

Table 6-2, Reference Designation Index

Reference Designation	Stock No.	Description	Note
A1	04270-7721	NUMERICAL DISPLAY ASS'Y	
	04270-8721	BOARD:BLANK P.C.	
A1CR1	1901-0025	DIODE:SILICON	
A1DS1	1970-0025	ELECTRON TUBE	
A1DS2	1970-0025	ELECTRON TUBE	
A1DS3	1970-0025	ELECTRON TUBE	
A1DS4	1970-0025	ELECTRON TUBE	
A1DS5	1970-0025	ELECTRON TUBE	
A1DS6	1970-0025	ELECTRON TUBE	
A1DS7	1970-0025	ELECTRON TUBE	
A1DS8	1970-0025	ELECTRON TUBE	
A1DS9	1970-0025	ELECTRON TUBE	
A1IC1	1820-0092	IC:NIXIE DRIVER	
A1IC2	1820-0092	IC:NIXIE DRIVER	
A1IC3	1820-0092	IC:NIXIE DRIVER	
A1IC4	1820-0092	IC:NIXIE DRIVER	
A1IC5	1820-0092	IC:NIXIE DRIVER	
A1IC6	1820-0092	IC:NIXIE DRIVER	
A1IC7	1820-0092	IC:NIXIE DRIVER	
A1IC8	1820-0092	IC:NIXIE DRIVER	
A1Q1	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A1R1	0698-3498	R:FXD MET FLM 8660 OHM 1% 1/8W	
A1R2	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A1R3	0698-3157	R:FXD MET FLM 19.6k OHM 1% 1/8W	
A1R4	0698-3157	R:FXD MET FLM 19.6k OHM 1% 1/8W	
A1R5	0698-3157	R:FXD MET FLM 19.6k OHM 1% 1/8W	
A1R6	0698-3157	R:FXD MET FLM 19.6k OHM 1% 1/8W	
A1R7	0698-3157	R:FXD MET FLM 19.6k OHM 1% 1/8W	
A1R8	0698-3157	R:FXD MET FLM 19.6k OHM 1% 1/8W	
A1R9	0698-3157	R:FXD MET FLM 19.6k OHM 1% 1/8W	
A1R10	0698-3157	R:FXD MET FLM 19.6k OHM 1% 1/8W	
A1R11	0698-3157	R:FXD MET FLM 19.6k OHM 1% 1/8W	
A1X2L	1251-0472	CONNECTOR:PRINTED CIRCUIT 12 CONTACTS	
A1X2R	1251-0472	CONNECTOR:PRINTED CIRCUIT 12 CONTACTS	
		MISCELLANEOUS	
	5040-5111	EXTRACTOR:BLACK	
	5040-5112	EXTRACTOR:BROWN	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A2	04270-7722	UNIT ETC DISPLAY ASS'Y	
	04270-8722	BOARD:BLANK P.C.	
A2DS1	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS2	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS3	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS4	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS5	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS6	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS7	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS8	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS9	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS10	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS11	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS12	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS13	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS14	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS15	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS16	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS17	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS18	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS19	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2DS20	2140-0028	LAMP:NEON FROSTED T-2 BULB 115V AC/DC	
A2R1	0757-0467	R:FXD MET FLM 121k OHM 1% 1/8W	
A2R2	0757-0467	R:FXD MET FLM 121k OHM 1% 1/8W	
A2R3	0698-4502	R:FXD MET FLM 64.9k OHM 1% 1/8W	
A2R4	0698-4502	R:FXD MET FLM 64.9k OHM 1% 1/8W	
A2R5	0698-4502	R:FXD MET FLM 64.9k OHM 1% 1/8W	
A2R6	0698-4502	R:FXD MET FLM 64.9k OHM 1% 1/8W	
A2R7	0698-4502	R:FXD MET FLM 64.9k OHM 1% 1/8W	
A2R8	0757-0467	R:FXD MET FLM 121k OHM 1% 1/8W	
A2R9	0757-0467	R:FXD MET FLM 121k OHM 1% 1/8W	
		MISCELLANEOUS	
	04270-5023	LAMP HOLDER:CAPACITANCE UNIT	
	04270-5024	LAMP HOLDER:CONDUCTANCE UNIT	
	04270-5025	LAMP HOLDER:DECIMAL POINT, 2 REQ'D	
	04270-8521	FILM:CAPACITANCE UNIT	
	04270-8522	FILM:CONDUCTANCE UNIT	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A3	04270-7723	FUNCTION SWITCH	
	04270-8723	BOARD:BLANK P.C.	
A3C1	0160-1557	C:FXD MYLAR .001μF 100VDCW	
A3R1	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	
A3R2	0757-0458	R:FXD MET FLM 51.1k OHM 1% 1/8W	
A3R3	0698-3452	R:FXD MET FLM 147k OHM 1% 1/8W	
A3R4	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	
A3R5	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	
A3R6	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	
A3R7	0698-4125	R:FXD MET FLM 953 OHM 1% 1/8W	
A3S1	04270-7032	SWITCH:SLIDE	
	5020-3440	SPRING:DETENT	
A3S2	04270-7032	SWITCH:SLIDE	
	5020-3440	SPRING:DETENT	
A3S3	04270-7032	SWITCH:SLIDE	
	5020-3440	SPRING:DETENT	
A3S4	04270-7032	SWITCH:SLIDE	
	5020-3440	SPRING:DETENT	
A3S5	04270-7032	SWITCH:SLIDE	
	5020-3440	SPRING:DETENT	
A3S6	04270-7032	SWITCH:SLIDE	
	5020-3440	SPRING:DETENT	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A3S7	04270-7032	SWITCH:SLIDE	
	5020-3440	SPRING:DETENT	
A3S8	3101-0063	SWITCH:PUSH BUTTON SPST 100mA 115VAC	
A3X1	1251-1388	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
		MISCELLANEOUS	
	04270-3036	GUIDE:SLIDE SWITCH	
	04270-3037	GUIDE:SLIDE SWITCH 2 REQ'D	
	04270-3038	GUIDE:SLIDE SWITCH	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A4	04270-7724	Cs BUFFER STORAGE ASS'Y	
	04270-8724	BOARD:BLANK P.C.	
A4CR1	1901-0025	DIODE:SILICON	
A4CR2	1901-0025	DIODE:SILICON	
A4 IC1	1820-0054	IC:QUAD 2-INPUT NAND GATE	
A4 IC2	1820-0116	IC:4 BIT STORAGE UNIT	
A4 IC3	1820-0116	IC:4 BIT STORAGE UNIT	
A4 IC4	1820-0116	IC:4 BIT STORAGE UNIT	
A4 IC5	1820-0116	IC:4 BIT STORAGE UNIT	
A4Q1	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A4Q2	1850-0158	TRANSISTOR:PNP GERM EIA 2N2635	
A4Q3	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A4R1	0698-4471	R:FXD MET FLM 7150 OHM 1% 1/8W	
A4R2	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A4R3	0698-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A4R4	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A4R5	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A4R6	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A4R7	0757-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A4R8		NOT ASSIGED	
A4R11		NOT ASSIGNED	
A4R12		NOT ASSIGNED	
A4R13		NOT ASSIGNED	
A4R14		NOT ASSIGNED	
A4R15		NOT ASSIGNED	
A4R16		NOT ASSIGNED	
A4R17		NOT ASSIGNED	
A4R18		NOT ASSIGNED	
A4R19		NOT ASSIGNED	
A4R20		NOT ASSIGNED	
A4R21		NOT ASSIGNED	
A4R22		NOT ASSIGNED	
A4R23		NOT ASSIGNED	
A4R24		NOT ASSIGNED	
A4R25		NOT ASSIGNED	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
		MISCELLANEOUS	
	5040-5115	EXTRACTOR:YELLOW	
	5040-5111	EXTRACTOR:BLACK	
A5	04270-7725	D/G BUFFER STORAGE ASS'Y	
	04270-8725	BOARD:BLANK P.C.	
A5IC1	1820-0116	IC:4 BIT STORAGE UNIT	
A5IC2	1820-0116	IC:4 BIT STORAGE UNIT	
A5IC3	1820-0116	IC:4 BIT STORAGE UNIT	
A5IC4	1820-0116	IC:4 BIT STORAGE UNIT	
A5R1		NOT ASSIGNED	
A5R2		NOT ASSIGNED	
A5R3		NOT ASSIGNED	
A5R4		NOT ASSIGNED	
A5R5		NOT ASSIGNED	
A5R6		NOT ASSIGNED	
A5R7		NOT ASSIGNED	
A5R8		NOT ASSIGNED	
A5R9		NOT ASSIGNED	
A5R10		NOT ASSIGNED	
A5R11		NOT ASSIGNED	
A5R12		NOT ASSIGNED	
A5R13		NOT ASSIGNED	
A5R14		NOT ASSIGNED	
A5R15		NOT ASSIGNED	
A5R16		NOT ASSIGNED	
		MISCELLANEOUS	
	5040-5111	EXTRACTOR:BLACK	
	5040-5116	EXTRACTOR:GREEN	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A6	04270-7726	Cx AMP ASS'Y	
	04270-8726	BOARD:BLANK P.C.	
A6C1*	0160-0356	C:FXD MICA 18pF 5% 300VDCW	
A6C2	0160-2201	C:FXD MICA 51pF 5% 300VDCW	
A6C3	0160-2262	C:FXD CER 16pF 5% 500VDCW	
A6C4	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A6C5	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A6C6	0160-0127	C:FXD CER 1.0μF 25VDCW	
A6C7	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A6C8	0160-2202	C:FXD MICA 75pF 5% 300VDCW	
A6CR1	1902-3110	DIODE:SILICON 5.90V 2% 400mW	
A6CR2	1902-3082	DIODE:SILICON 4.64V ±5% 400mW	
A6CR3	1902-3082	DIODE:SILICON 4.64V ±5% 400mW	
A6CR4	1901-0025	DIODE:SILICON	
A6K1	0490-0213	RELAY REED:SPST SRF-13A	
A6Q1	1853-0075	TRANSISTOR:PNP SILICON DUAL	
A6Q2	1854-0073	TRANSISTOR:NPN SILICON	
A6Q3	1853-0015	TRANSISTOR:PNP SILICON 2N3640	
A6Q4	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A6Q5	1853-0012	TRANSISTOR:PNP SILICON 2N2904A	
A6R1	2100-1772	R:VAR WW LIN 500 OHM 10% 1/2W	
A6R2	0698-2034	R:FXD MET FLM 18.3k OHM 0.1% 1/8W	
A6R3	0698-1493	R:FXD MET FLM 1600 OHM 0.1% 1/8W	
A6R4	0698-1491	R:FXD MET FLM 460 OHM 0.1% 1/8W	
A6R5	2100-1774	R:VAR WW LIN 2k OHM 5% 1W	
A6R6	0757-0290	R:FXD MET FLM 6.19k OHM 1% 1/8W	
A6R7	0757-0398	R:FXD MET FLM 75.0 OHM 1% 1/8W	
A6R8	0757-0398	R:FXD MET FLM 75.0 OHM 1% 1/8W	
A6R9	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A6R10	0698-1491	R:FXD MET FLM 460 OHM 0.1% 1/8W	
A6R11*	0757-0443	R:FXD MET FLM 11k OHM 1% 1/8W	
A6R12	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A6R13	0683-0365	R:FXD COMP 3.60 OHM 5% 1/4W	
A6R14	0757-0402	R:FXD MET FLM 110 OHM 1% 1/8W	
A6R15	0757-0317	R:FXD MET FLM 1.33k OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A6R16	0698-0083	R:FXD MET FLM 1.96k OHM 1% 1/8W	
A6R17	0757-0394	R:FXD MET FLM 51.1 OHM 1% 1/8W	
A6R18	0698-1493	R:FXD MET FLM 1600 OHM 0.1% 1/8W	
A6R19	0698-0090	R:FXD MET FLM 464 OHM 1% 1/2W	
A6R20	0757-0424	R:FXD MET FLM 1100 OHM 1% 1/8W	
A6R21	0698-3433	R:FXD MET FLM 28.7 OHM 1% 1/8W	
A6R22	0683-0565	R:FXD COMP 5.6 OHM 5% 1/4W	
A6R23	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A7	04270-7727	Cs AMP ASS'Y	
	04270-8727	BOARD:BLANK P.C.	
A7C1	0160-2201	C:FXD MICA 51pF 5% 300VDCW	
A7C2	0160-2262	C:FXD CER 16pF 5% 500VDCW	
A7C3	0121-0422	C:VAR:GLASS:0.8 - 4.5pF	
A7C4	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A7C5	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A7C6	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A7C7	0160-0127	C:FXD CER 1.0μF 20% 25VDCW	
A7C8	0160-0127	C:FXD CER 1.0μF 20% 25VDCW	
A7C9	0160-0127	C:FXD CER 1.0μF 20% 25VDCW	
A7CR1	1902-3110	DIODE:SILICON 5.90V 2% 400mW	
A7CR2	1902-3110	DIODE:SILICON 5.90V 2% 400mW	
A7CR3	1902-3110	DIODE:SILICON 5.90V 2% 400mW	
A7CR4	1901-0025	DIODE:SILICON	
A7CR5	1901-0025	DIODE:SILICON	
A7CR6	1901-0025	DIODE:SILICON	
A7CR7	1901-0025	DIODE:SILICON	
A7CR8	1901-0025	DIODE:SILICON	
A7K1	0490-0214	RELAY REED:SRG-13A	
A7K2	0490-0214	RELAY REED:SRG-13A	
A7K3	0490-0216	RELAY REED:SRG-13H	
A7K4	0490-0213	RELAY REED:SPST SRF-13A	
A7K5	0490-0213	RELAY REED:SPST SRF-13A	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A7Q1	1853-0075	TRANSISTOR:PNP SILICON DUAL	
A7Q2	1854-0073	TRANSISTOR:NPN SILICON	
A7Q3	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	
A7Q4	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A7Q5	1853-0012	TRANSISTOR:PNP SILICON 2N2904A	
A7R1	2100-1759	R:VAR WW LIN 2k OHM 5% 1W	
A7R2	0757-0290	R:FXD MET FLM 6.19k OHM 1% 1/8W	
A7R3	0757-0398	R:FXD MET FLM 75.0 OHM 1% 1/8W	
A7R4	0757-0398	R:FXD MET FLM 75.0 OHM 1% 1/8W	
A7R5	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A7R6	0757-0412	R:FXD MET FLM 365 OHM 1% 1/8W	
A7R7	0757-0317	R:FXD MET FLM 1330 OHM 1% 1/8W	
A7R8	0698-0083	R:FXD MET FLM 1.96k OHM 1% 1/8W	
A7R9	0698-3155	R:FXD MET FLM 4.46k OHM 1% 1/8W	
A7R10	0683-0365	R:FXD COMP 3.6 OHM 5% 1/4W	
A7R11	0757-0402	R:FXD MET FLM 110 OHM 1% 1/8W	
A7R12	0757-0394	R:FXD MET FLM 51.1 OHM 1% 1/8W	
A7R13	0698-1495	R:FXD MET FLM 1.6k OHM 0.1% 1/8W	
A7R14	2100-2520	R:VAR CERMET FLM LIN 50 OHM 30% 1/2W	
A7R15	0698-0090	R:FXD MET FLM 464 OHM 1% 1/2W	
A7R16	0757-0419	R:FXD MET FLM 681 OHM 1% 1/8W	
A7R17	0698-3433	R:FXD MET FLM 28.7 OHM 1% 1/8W	
A7R18	0683-0565	R:FXD COMP 5.6 OHM 5% 1/4W	
A7R19	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A7R20*	0811-2466	R:FXD WW 1.2 OHM 5% 1/2W	
A7R21*	0757-0379	R:FXD MET FLM 12.1 OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A8	04270-7728	D AMP ASS'Y	
	04270-8728	BOARD:BLANK P.C.	
A8C1	0121-0422	C:VAR GLASS 0.8-4.5pF	
A8C2	0160-2201	C:FXD MICA 51pF 5% 300VDCW	
A8C3	0160-2262	C:FXD CER 16pF 5% 500VDCW	
A8C4	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A8C5	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A8C6	0160-0127	C:FXD CER 1μF 20% 25VDCW	
A8C7	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A8C8	0150-0059	C:FXD CER 3.3pF +0.25pF 500VDCW	
A8CR1	1902-3110	DIODE:SILICON 5.90V 2% 400mW	
A8CR2	1901-0025	DIODE:SILICON	
A8CR3	1901-0025	DIODE:SILICON	
A8K1	0490-0213	RELAY REED:SRF-13A	
A8K2	0490-0213	RELAY REED:SRF-13A	
A8Q1	1853-0075	TRANSISTOR:PNP SILICON DUAL	
A8Q2	1853-0015	TRANSISTOR:PNP SILICON 2N3640	
A8Q3	1854-0073	TRANSISTOR:NPN SILICON	
A8Q4	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A8Q5	1853-0012	TRANSISTOR:PNP SILICON 2N2904A	
A8R1	0757-0290	R:FXD MET FLM 6.19k OHM 1% 1/8W	
A8R2	0698-3153	R:FXD MET FLM 3.83k OHM 1% 1/8W	
A8R3	2100-1756	R:VAR WW LIN 200 OHM 10% 1/2W	
A8R4	2100-0806	R:VAR WW LIN 5k OHM 10% 1/2W	
A8R5	0757-0290	R:FXD MET FLM 6.19k OHM 1% 1/8W	
A8R6	0757-0398	R:FXD MET FLM 75 OHM 1% 1/8W	
A8R7	0757-0398	R:FXD MET FLM 75 OHM 1% 1/8W	
A8R8	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A8R9	0757-1094	R:FXD MET FLM 1.47k OHM 1% 1/8W	
A8R10	0757-0317	R:FXD MET FLM 1330 OHM 1% 1/8W	
A8R11	0698-0083	R:FXD MET FLM 1.96k OHM 1% 1/8W	
A8R12	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A8R13	0683-0365	R:FXD COMP 3.6 OHM 5% 1/4W	
A8R14	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	
A8R15	0757-0394	R:FXD MET FLM 51.1 OHM 1% 1/8W	
A8R16	0757-0424	R:FXD MET FLM 1.1k OHM 1% 1/8W	
A8R17	0698-0090	R:FXD MET FLM 464 OHM 1% 1/2W	
A8R18	0698-3433	R:FXD MET FLM 28.7 OHM 1% 1/8W	
A8R19	0683-0565	R:FXD COMP 5.6 OHM 5% 1/4W	
A8R20	0683-0565	R:FXD COMP 5.6 OHM 5% 1/4W	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A9		NOT ASSIGNED	
A10	04270-7758	PHASE DETECTOR ASS'Y	
	04270-8758	BOARD:BLANK P.C.	
A10C1	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A10C2	0160-2203	C:FXD MICA 91pF 5% 300VDCW	
A10C3*	0140-0145	C:FXD MICA 22pF 5% 300VDCW	
A10C4	0180-0229	C:FXD TANT 33μF 10% 10VDCW	
A10C5	0180-0197	C:FXD TANT 2.2μF 10% 20VDCW	
A10C6	0180-0229	C:FXD TANT 33μF 10% 10VDCW	
A10C7	0160-0127	C:FXD CER 1.0μF 20% 25VDCW	
A10C8	0180-0229	C:FXD TANT 33μF 10% 10VDCW	
A10C9	0180-0228	C:FXD TANT 22μF 10% 15VDCW	
A10C10	0121-0059	C:VAR CER DISK 2-8pF 300VDCW NPO	
A10C11	0150-0059	C:FXD CER 3.3pF ±0.25pF 500VDCW	
A10C12	0160-1271	C:FXD POLYE 0.01μF 5% 100VDCW	
A10C13		NOT ASSIGNED	
A10C14	0180-0228	C:FXD TANT 22μF 10% 15VDCW	
A10C15		NOT ASSIGNED	
A10C16	0160-1271	C:FXD POLYE 0.01μF 5% 100VDCW	
A10C17	0160-0291	C:FXD TANT 1.0μF 10% 35VDCW	
A10C18	0160-1586	C:FXD MET POLYE 0.1μF 5% 100VDCW	
A10C19	0140-0196	C:FXD MICA 150pF 5% 300VDCW	
A10C20	0160-2968	C:FXD MICA 1350pF 5% 500VDCW	
A10C21	0160-1550	C:FXD POLYE 0.015μF 5% 100VDCW	
A10C22	0160-1546	C:FXD MET POLYE 0.15μF 100VDCW	
A10C23	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A10C24	0160-2203	C:FXD MICA 91pF 5% 300VDCW	
A10C25*	0140-0191	C:FXD MICA 56pF 5% 300VDCW	
A10C26	0180-0229	C:FXD TANT 33μF 10% 10VDCW	
A10C27	0180-0197	C:FXD TANT 2.2μF 10% 20VDCW	
A10C28	0180-0229	C:FXD TANT 33μF 10% 10VDCW	
A10C29	0160-0127	C:FXD CER 1.0μF 20% 25VDCW	
A10C30	0180-0228	C:FXD TANT 22μF 10% 15VDCW	
A10C31	0121-0059	C:VAR CER DISK 2 - 8pF 300VDCW NPO	
A10C32	0150-0059	C:FXD CER 3.3pF ±0.25pF 500VDC	
A10C33	0160-1271	C:FXD POLYE 0.01μF 5% 100VDCW	
A10C34	0160-1271	C:FXD POLYE 0.01μF 5% 100VDCW	
A10C35	0180-0228	C:FXD TANT 22μF 10% 15VDCW	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A10C36		NOT ASSIGNED	
A10C37	0160-1271	C:FXD POLYE 0.01μF 5% 100VDCW	
A10C38	0160-0291	C:FXD TANT 1.0μF 10% 35VDCW	
A10C39	0160-0291	C:FXD CER 1.0μF 20% 25VDCW	
A10C40	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A10C41	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A10CR1	1902-0049	DIODE:SILICON BREAKDOWN 6.19V 400mW	
A10CR2	1901-0040	DIODE:SILICON	
A10CR3	1902-0049	DIODE:SILICON BREAKDOWN 6.19V 400mW	
A10CR4	1901-0040	DIODE:SILICON	
A10IC1	1820-0321	IC:DIFF COMPARATOR	
A10IC2	1820-0051	IC:AMP DC HI GAIN	
A10IC3	1820-0321	IC:DIFF COMPARATOR	
A10IC4	1820-0051	IC:AMP DC HI GAIN	
A10K1	0490-0213	RELAY REED:SPST SRF-13A	
A10K2	0490-0213	RELAY REED:SPST SRF-13A	
A10K3	0490-0213	RELAY REED:SPST SRF-13A	
A10Q1	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A10Q2	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A10Q3	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A10Q4	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A10Q5	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A10Q6	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A10Q7	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	
A10Q8	1854-0092	TRANSISTOR:NPN SILICON 2N3563	
A10Q9	1854-0092	TRANSISTOR:NPN SILICON 2N3563	
A10Q10	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	
A10Q11	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A10Q12	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A10Q13	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A10Q14	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A10Q15	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A10Q16	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	
A10Q17	1854-0092	TRANSISTOR:NPN SILICON 2N3563	
A10Q18	1854-0092	TRANSISTOR:NPN SILICON 2N3563	
A10Q19	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A10R1	0698-0085	R:FXD MET FLM 2.61k OHM 1% 1/8W	
A10R2	0698-0085	R:FXD MET FLM 2.61k OHM 1% 1/8W	
A10R3	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A10R4	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A10R5	0698-0085	R:FXD MET FLM 2.61k OHM 1% 1/8W	
A10R6	0757-0290	R:FXD MET FLM 6.19k OHM 1% 1/8W	
A10R7	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R8		NOT ASSIGNED	
A10R9	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A10R10	0698-3154	R:FXD MET FLM 4.22k OHM 1% 1/8W	
A10R11	0757-0279	R:FXD MET FLM 3.16k OHM 1% 1/8W	
A10R12	0757-0279	R:FXD MET FLM 3.16k OHM 1% 1/8W	
A10R13	0757-0419	R:FXD MET FLM 681 OHM 1% 1/8W	
A10R14	0757-0428	R:FXD MET FLM 1.62k OHM 1% 1/8W	
A10R15	0698-0085	R:FXD MET FLM 2.61k OHM 1% 1/8W	
A10R16	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R17	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R18	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R19	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R20	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	
A10R21	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A10R22	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A10R23	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A10R24	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A10R25	0757-0279	R:FXD MET FLM 3.16k OHM 1% 1/8W	
A10R26	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	
A10R27	2100-1754	R:VAR WW LIN 50 OHM 10% 1/2W	
A10R28	0757-0279	R:FXD MET FLM 3.16k OHM 1% 1/8W	
A10R29	0757-0378	R:FXD MET FLM 11.0 OHM 1% 1/8W	
A10R30	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A10R31	0698-0085	R:FXD MET FLM 2.61k OHM 1% 1/8W	
A10R32	0757-0290	R:FXD MET FLM 6.19k OHM 1% 1/8W	
A10R33	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R34	0757-0395	R:FXD MET FLM 56.2 OHM 1% 1/8W	
A10R35	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A10R36	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A10R37	0757-0279	R:FXD MET FLM 3.16k OHM 1% 1/8W	
A10R38	0757-0279	R:FXD MET FLM 3.16k OHM 1% 1/8W	
A10R39	0757-0419	R:FXD MET FLM 681 OHM 1% 1/8W	
A10R40	0698-0085	R:FXD MET FLM 2.61k OHM 1% 1/8W	
A10R41	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R42	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R43	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R44	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R45	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A10R46	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A20R47	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A10R48	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A10R49	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A10R50	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R51	0698-0082	R:FXD MET FLM 464 OHM 1% 1/8W	
A10R52	2100-1754	R:VAR WW LIN 50 OHM 10% 1/2W	
A10R53	0698-3155	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A10R54	0757-0378	R:FXD MET FLM 11.0 OHM 1% 1/8W	
A10R55	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5111	EXTRACTOR:BLACK	
	5040-5112	EXTRACTOR:BROWN	
A11	04270-7766	CURRENT DETECTOR ASS'Y	
	04270-8731	BOARD:BLANK P.C.	
A11C1	0160-1309	C:FXD MP 0.5μF 10% 250VDCW	
A11C2	0160-1309	C:FXD MP 0.5μF 10% 250VDCW	
A11C3	0160-2203	C:FXD MICA 91pF 5% 300VDCW	
A11C4	0160-2218	C:FXD MICA 1000pF 5% 300VDCW	
A11C5	0160-1271	C:FXD POLYE 0.01μF 5% 100VDCW	
A11C6	0160-1586	C:FXD MET POLYE 0.1μF 5% 100VDCW	
A11C7	0160-2257	C:FXD CER 10pF ±0.25pF 500VDCW	
A11C8	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A11C9*	0160-2199	C:FXD MICA 30pF 5% 300VDCW	
A11C10	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A11C11	0160-0127	C:FXD CER 1.0μF 20% 25VDCW	
A11C12	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A11C13	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A11C14		NOT ASSIGNED	
A11C15	0180-0228	C:FXD TANT 22μF 10% 15VDCW	
A11C16	0160-0127	C:FXD CER 1.0MF 20% 25VDCW	
A11C17	0150-0121	C:FXD CER 0.1μF -20+80% 50VDCW	
A11C18	0150-0121	C:FXD CER 0.1μF -20+80% 50VDCW	
A11C19	0150-0121	C:FXD CER 0.1μF -20+80% 50VDCW	
A11C20	0150-0121	C:FXD CER 0.1μF -20+80% 50VDCW	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A11R6	0698-3438	R:FXD MET FLM 147 OHM 1% 1/8W	
A11R7	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A11R8	0698-3154	R:FXD MET FLM 4.22k OHM 1% 1/8W	
A11R9	0698-3154	R:FXD MET FLM 4.22k OHM 1% 1/8W	
A11R10	0757-0419	R:FXD MET FLM 681 OHM 1% 1/8W	
A11R11	2100-1757	R:VAR WW LIN 500 OHM 10% 1/2W	
A11R12	0757-1094	R:FXD MET FLM 1.47k OHM 1% 1/8W	
A11R13	0757-0294	R:FXD MET FLM 17.8 OHM 1% 1/8W	
A11R14	0757-0294	R:FXD MET FLM 17.8 OHM 1% 1/8W	
A11R15	0698-3150	R:FXD MET FLM 2.37k OHM 1% 1/8W	
A11R16	0698-0085	R:FXD MET FLM 2.61k OHM 1% 1/8W	
A11R17	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A11R18	0757-0280	R:FXD MET FLM 1.0k OHM 1% 1/8W	
A11R19	0757-0443	R:FXD MET FLM 11k OHM 1% 1/8W	
A11R20	0757-0443	R:RXS MET FLM 11k OHM 1% 1/8W	
A11R21	0698-0085	R:FXD MET FLM 2.61k OHM 1% 1/8W	
A11R22	0698-0085	R:FXD MET FLM 2.61k OHM 1% 1/8W	
A11R23	0757-0200	R:FXD MET FLM 5.62k OHM 1% 1/8W	
A11R24	2100-1759	R:VAR WW LIN 2k OHM 10% 1/2W	
A11R25	0757-0424	R:FXD MET FLM 1100 OHM 1% 1/8W	
A11R26	0757-0400	R:FXD MET FLM 90.9 OHM 1% 1/8W	
A11R27	0757-0400	R:FXD MET FLM 90.9 OHM 1% 1/8W	
A11R28		NOT ASSIGNED	
A11R29	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A11R30	0757-0280	R:FXD MET FLM 1.0k OHM 1% 1/8W	
A11R31	0757-0280	R:FXD MET FLM 1.0k OHM 1% 1/8W	
A11R32	0757-0278	R:FXD MET FLM 1.78k OHM 1% 1/8W	
A11R33	0698-3150	R:FXD MET FLM 2.37k OHM 1% 1/8W	
A11R34	0757-0424	R:FXD MET FLM 1100 OHM 1% 1/8W	
A11R35	0698-3156	R:FXD MET FLM 14.7k OHM 1% 1/8W	
A11R36	0698-3156	R:FXD MET FLM 14.7k OHM 1% 1/8W	
A11R37	0698-3430	R:FXD MET FLM 21.5 OHM 1% 1/8W	
A11R38	0698-3430	R:FXD MET FLM 21.5 OHM 1% 1/8W	
A11R39	0698-3152	R:FXD MET FLM 4.64k OHM 1% 1/8W	
A11R40	0757-0443	R:FXD MET FLM 11k OHM 1% 1/8W	
A11R41	0757-0443	R:FXD MET FLM 11k OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5112	EXTRACTOR:BROWN 2 REQ'D	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A11C21	0150-0121	C:FXD CER 0.1μF -20+80% 50VDCW	
A11C22	0150-0121	C:FXD CER 0.1μF -20+80% 50VDCW	
A11C23	0150-0121	C:FXD CER 0.1μF -20+80% 50VDCW	
A11C24	0150-0121	C:FXD CER 0.1μF -20+80% 50VDCW	
A11C25	0160-0127	C:FXD CER 1.0μF 20% 25VDCW	
A11C26	0150-0121	C:FXD CER 0.1μF -20 +80% 50VDCW	
A11C27	0150-0121	C:FXD CER 0.1μF -20 +80% 50VDCW	
A11CR1	1901-0025	DIODE:SILICON	
A11CR2	1901-0025	DIODE:SILICON	
A11CR3	1902-3082	DIODE:SILICON BREAKDOWN 4.64V 400mW	
A11CR4	1901-0040	DIODE:SILICON	
A11CR5	1901-0040	DIODE:SILICON	
A11CR6	1901-0040	DIODE:SILICON	
A11CR7	1901-0040	DIODE:SILICON	
A11CR8	1901-0040	DIODE:SILICON	
A11CR9	1901-0040	DIODE:SILICON	
A11CR10	1901-0025	DIODE:SILICON	
A11CR11	1901-0025	DIODE:SILICON	
A11K1	0490-0213	RELAY REED:SPST SRF-13A	
A11K2	0490-0213	RELAY REED:SPST SRF-13A	
A11K3	0490-0213	RELAY REED:SPST SRF-13A	
A11K4	0490-0213	RELAY REED:SPST SRF-13A	
A11K5	0490-0213	RELAY REED:SPST SRF-13A	
A11K6	0490-0213	RELAY REED:SPST SRF-13A	
A11K7	0490-0213	RELAY REED:SPST SRF-13A	
A11K8	0490-0213	RELAY REED:SPST SRF-13A	
A11Q1	1855-0049	TRANSISTOR:FET DUAL	
A11Q2	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A11Q3	1853-0075	TRANSISTOR:PNP SILICON DUAL	
A11Q4	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A11Q5	1854-0221	TRANSISTOR:NPN SILICON DUAL	
A11Q6	1854-0221	TRANSISTOR:NPN SILICON DUAL	
A11Q7	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	
A11Q8	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	
A11Q9	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A11Q10	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A11Q11	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A11Q12	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A11R1	0757-0470	R:FXD MET FLM 162k OHM 1% 1/8W	
A11R2	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A11R3	0757-0428	R:FXD MET FLM 1.62k OHM 1% 1/8W	
A11R4	0757-0405	R:FXD MET FLM 162 OHM 1% 1/8W	
A11R5	0683-1655	R:FXD COMP 1.6M OHM 5% 1/4W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A12Q11	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A12Q12	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12Q13	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12Q14	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A12Q15	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A12Q16	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12Q17	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12Q18	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A12Q19	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A12Q20	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12Q21	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12Q22	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A12Q23	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A12Q24	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12Q25	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12R1	2100-1759	R:VAR WW LIN 2000 OHM 10% 1/2W	
A12R2	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A12R3	0757-0398	R:FXD MET FLM 75.0 OHM 1% 1/8W	
A12R4	0757-0398	R:FXD MET FLM 75.0 OHM 1% 1/8W	
A12R5	0757-0412	R:FXD MET FLM 365 OHM 1% 1/8W	
A12R6	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A12R7	0757-0422	R:FXD MET FLM 909 OHM 1% 1/8W	
A12R8	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A12R9	0698-4421	R:FXD MET FLM 249 OHM 1% 1/8W	
A12R10	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A12R11	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A12R12	0698-4037	R:FXD MET FLM 46.4 OHM 1% 1/8W	
A12R13		NOT ASSIGNED	
A12R14	0757-0424	R:FXD MET FLM 1100 OHM 1% 1/8W	
A12R15	0698-0090	R:FXD MET FLM 464 OHM 1% 1/2W	
A12R16	0683-0365	R:FXD COMP 3.6 OHM 5% 1/4W	
A12R17	0698-1495	R:FXD MET FLM 1.6k OHM 0.1%	
A12R18	2100-2520	R:VAR CERMET FLM LIN 50 OHM 30% 1/2W	
A12R19	0698-3160	R:FXD MET FLM 31.6k OHM 5% 1/8W	
A12R20	0757-0462	R:FXD MET FLM 75k OHM 1% 1/8W	
A12R21	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A12R22	0757-0443	R:FXD MET FLM 11.0k OHM 1% 1/8W	
A12R23	0757-0443	R:FXD MET FLM 11.0k OHM 1% 1/8W	
A12R24	0698-2036	R:FXD MET FLM 1M OHM 0.1% 1/4W	
A12R25	0698-3160	R:FXD MET FLM 31.6k OHM 5% 1/8W	
A12R26	0757-0462	R:FXD MET FLM 75k OHM 1% 1/8W	
A12R27	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A12R28	0757-0443	R:FXD MET FLM 11.0k OHM 1% 1/8W	
A12R29	0757-0443	R:FXD MET FLM 11.0k OHM 1% 1/8W	
A12R30	0698-2039	R:FXD MET FLM 99.9k OHM 0.1% 1/4W	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A12	04270-7732	D/G AMP & Gs ASS'Y	
	04270-8732	BOARD:BLANK P.C.	
A12C1	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A12C2	0160-2201	C:FXD MICA 51pF 5% 300VDCW	
A12C3		NOT ASSIGNED	
A12C4	0160-0127	C:FXD CER 1.0μF 20% 25VDCW	
A12C5	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A12C6	0121-0422	C:VAR GLASS 0.8 - 4.5pF	
A12C7	0160-1309	C:FXD MP 0.5μF 10% 250VDCW	
A12CR1	1902-3110	DIODE:SILICON 5.90V 2% 400mW	
A12CR2	1902-3110	DIODE:SILICON 5.90V 2% 400mW	
A12CR3	1901-0025	DIODE:SILICON	
A12CR4	1901-0025	DIODE:SILICON	
A12CR5	1901-0025	DIODE:SILICON	
A12CR6	1901-0025	DIODE:SILICON	
A12CR7	1901-0025	DIODE:SILICON	
A12CR8	1901-0025	DIODE:SILICON	
A12CR9	1901-0025	DIODE:SILICON	
A12CR10	1901-0025	DIODE:SILICON	
A12CR11	1901-0025	DIODE:SILICON	
A12K1	0490-0213	RELAY REED:SPST SRF-13A	
A12K2	0490-0213	RELAY REED:SPST SRF-13A	
A12K3	0490-0213	RELAY REED:SPST SRF-13A	
A12K4	0490-0213	RELAY REED:SPST SRF-13A	
A12K5	0490-0215	RELAY REED:SPST SRF-13H	
A12K6	0490-0215	RELAY REED:SPST SRF-13H	
A12K7	0490-0215	RELAY REED:SPST SRF-13H	
A12Q1	1853-0075	TRANSISTOR:PNP SILICON DUAL	
A12Q2	1854-0073	TRANSISTOR:NPN SILICON	
A12Q3	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	
A12Q4	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12Q5	1853-0012	TRANSISTOR:PNP SILICON 2N2904A	
A12Q6	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A12Q7	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A12Q8	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12Q9	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A12Q10	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A13C11	0180-0116	C:FXD TANT 6.8μF 10% 35VDCW	
A13C12	0180-0228	C:FXD TANT 22μF 10% 15VDCW	
A13C13	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A13C14	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A13C15	0180-0229	C:FXD TANT 33μF 10% 10VDCW	
A13C16	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A13C17	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A13C18	0160-2208	C:FXD MICA 330pF 5% 300VDCW	
A13C19	0180-0228	C:FXD TANT 22μF 10% 15VDCW	
A13C20	0160-0127	C:FXD CER 1.0μF 20% 25VDCW	
A13CR1	1902-3110	DIODE:SILICON BREAKDOWN 5.90V 2% 400mW	
A13CR2	1902-0049	DIODE:SILICON BREAKDOWN 6.19V 400mW	
A13CR3	1902-3149	DIODE:SILICON BREAKDOWN 9.09V 5% 400mW	
A13CR4	1901-0025	DIODE:SILICON	
A13CR5	1901-0025	DIODE:SILICON	
A13CR6	1902-0041	DIODE:SILICON	
A13CR7	1901-0025	DIODE SILICON	
A13CR8	1901-0025	DIODE:SILICON	
A13CR9	1901-0025	DIODE:SILICON	
A13CR10	1901-0025	DIODE:SILICON	
A13K1	0490-0214	RELAY REED:SRG-13A	
A13K2	0490-0214	RELAY REED:SRG-13A	
A13K3	0490-0214	RELAY REED:SRG-13A	
A13K4	0490-0214	RELAY REED:SRG-13A	
A13K5	0490-0213	RELAY REED:SPST SRF-13A	
A13K6	0490-0213	RELAY REED:SPST SRF-13A	
A13Q1	1854-0221	TRANSISTOR:NPN SILICON DUAL	
A13Q2	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	
A13Q3	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A13Q4	1853-0012	TRANSISTOR:PNP SILICON 2N2904A	
A13Q5	1855-0107	TRANSISTOR:FET N CHANNEL 2SK-13	
A13Q6	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A13Q7	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A13Q8	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A13Q9	1854-0221	TRANSISTOR:NPN SILICON DUAL	
A13Q10	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A13Q11	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	
A13Q12	1853-0015	TRANSISTOR:PNP SILICON JEDEC 2N3640	
A13Q13	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A13Q14	1853-0012	TRANSISTOR:PNP SILICON 2N2904A	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A12R31	0698-3160	R:FXD MET FLM 31.6k OHM 5% 1/8W	
A12R32	0757-0462	R:FXD MET FLM 75k OHM 1% 1/8W	
A12R33	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A12R34	0757-0443	R:FXD MET FLM 11.0k OHM 1% 1/8W	
A12R35	0757-0443	R:FXD MET FLM 11.0k OHM 1% 1/8W	
A12R36	0698-3028	R:FXD MET FLM 9.9k OHM 0.1% 1/4W	
A12R37	0698-3160	R:FXD MET FLM 31.6k OHM 5% 1/8W	
A12R38	0757-0462	R:FXD MET FLM 75k OHM 1% 1/8W	
A12R39	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A12R40	0757-0443	R:FXD MET FLM 11.0k OHM 1% 1/8W	
A12R41	0757-0279	R:FXD MET FLM 3.16k OHM 1% 1/8W	
A12R42	0698-2037	R:FXD MET FLM 900 OHM 0.1% 1/4W	
A12R43	0698-3160	R:FXD MET FLM 31.6k OHM 5% 1/8W	
A12R44	0757-0462	R:FXD MET FLM 75k OHM 1% 1/8W	
A12R45	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A12R46	0757-0443	R:FXD MET FLM 11.0k OHM 1% 1/8W	
A12R47*	0698-0083	R:FXD MET FLM 1.96k OHM 1% 1/8W	
A12R48	0698-1486	R:FXD MET FLM 98 OHM 0.1% 1/4W	
A12R49	0698-1486	R:FXD MET FLM 98 OHM 0.1% 1/4W	
		MISCELLANEOUS	
	5040-5112	EXTRACTOR:BROWN	
	5040-5113	EXTRACTOR:RED	
A13	04270-7733	OSC & BUFFER AMP ASS'Y	
	04270-8733	BOARD:BLANK P.C.	
A13C1	0121-0105	C:VAR CER 9-35pF N650	
A13C2	0160-0978	C:FXD MICA 1500pF 1% 500VDCW	
A13C3	0140-0192	C:FXD MICA 68pF 5% 300VDCW	
A13C4	0160-0978	C:FXD MICA 1500pF 1% 500VDCW	
A13C5*	0160-2307	C:FXD MICA 47pF 5% 300VDCW	
A13C6	0160-2229	C:FXD MICA 3000pF 5% 300VDCW	
A13C7	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A13C8	0140-0190	C:FXD MICA 39pF 5% 300VDCW	
A13C9	0121-0105	C:VAR CER 9-35pF N650	
A13C10	0180-0106	C:FXD TANT 60μF 20% 6VDCW	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A13R1	0698-2035	R:FXD MET FLM 100k OHM 0.1% 1/4W	
A13R2	0698-2031	R:FXD MET FLM 10k OHM 0.1% 1/4W	
A13R3	0698-1492	R:FXD MET FLM 1k OHM 0.1% 1/4W	
A13R4	0698-1487	R:FXD MET FLM 100 OHM 0.1% 1/4W	
A13R5	0698-2035	R:FXD MET FLM 100k OHM 0.1% 1/4W	
A13R6	0698-2031	R:FXD MET FLM 10k OHM 0.1% 1/4W	
A13R7	0698-1492	R:FXD MET FLM 1k OHM 0.1% 1/4W	
A13R8	0698-1487	R:FXD MET FLM 100 OHM 0.1% 1/4W	
A13R9	0698-8255	R:FXD COMP 8.2M OHM 5% 1/4W	
A13R10	0757-0346	R:FXD MET FLM 10 OHM 1% 1/8W	
A13R11	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
A13R12	R:F -3447	R:FXD MET FLM 422 OHM 1% 1/8W	
A13R13	0698-3447	R:FXD MET FLM 422 OHM 1% 1/8W	
A13R14	0698-0085	R:FXD MET FLM 2610 OHM 1% 1/8W	
A13R15	0698-3437	R:FXD MET FLM 138 OHM 1% 1/8W	
A13R16	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A13R17	0757-0279	R:FXD MET FLM 3160 OHM 1% 1/8W	
A13R18	0757-0416	R:FXD MET FLM 511 OHM 1% 1/8W	
A13R19	0757-0814	R:FXD MET FLM 511 OHM 1% 1/2W	
A13R20	0757-0418	R:FXD MET FLM 619 OHM 1% 1/8W	
A13R21	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A13R22	0698-4467	R:FXD MET FLM 1050 OHM 1% 1/8W	
A13R23	0698-3440	R:FXD MET FLM 196 OHM 1% 1/8W	
A13R24	2100-2515	R:VAR CER LIN 200k OHM 30% 0.5W	
A13R25	0757-0199	R:FXD MET FLM 21.5k OHM 1% 1/8W	
A13R26	0757-0459	R:FXD MET FLM 56.2k OHM 1% 1/8W	
A13R27	0757-0279	R:FXD MET FLM 3160 OHM 1% 1/8W	
A13R28	0698-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A13R29	0698-3150	R:FXD MET FLM 2370 OHM 1% 1/8W	
A13R30	2100-1759	R:FXD MET FLM 2000 OHM 10% 1/2W	
A13R31	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A13R32	0698-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A13R33	0757-0290	R:FXD MET FLM 6190 OHM 1% 1/8W	
A13R34	0698-3154	R:FXD MET FLM 4220 OHM 1% 1/8W	
A13R35	0698-3428	R:FXD MET FLM 14.7 OHM 1% 1/8W	
A13R36	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A13R37	0757-0416	R:FXD MET FLM 511 OHM 1% 1/8W	
A13R38	0757-0290	R:FXD MET FLM 6190 OHM 1% 1/8W	
A13R39	0698-3154	R:FXD MET FLM 422 OHM 1% 1/8W	
A13R40	0698-3442	R:FXD MET FLM 237 OHM 1% 1/8W	
A13R41	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A13R42	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A13R43	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A13R44	0757-0397	R:FXD MET FLM 68.1 OHM 1% 1/8W	
A13R45	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A13R46	0757-0317	R:FXD MET FLM 1330 OHM 1% 1/8W	
A13R47	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A13R48	0698-0090	R:FXD MET FLM 464 OHM 1% 1/2W	
A13R49	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A13R50	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A13R51	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A13R52	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
A13R53	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A13R54	2100-1758	R:VAR WW LIN 1000 OHM 10% 1/2W	
A13R55	0698-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A13R56	0757-0416	R:FXD MET FLM 511 OHM 1% 1/8W	
A13R57	0683-0335	R:FXD COMP 3.3 OHM 5% 1/4W	
A13R58	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A13R59	0698-3450	R:FXD MET FLM 42.2k OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5112	EXTRACTOR:BROWN	
	5040-5114	EXTRACTOR:ORANGE	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A14	04270-7734	Cs ATTENUATOR ASS'Y	
	04270-8734	BOARD:BLANK P.C.	
A14C1	0160-2238	C:FXD CER 1.5pF ±0.25pF 500VDCW	
A14C2	0121-0138	C:VAR AIR 1.2/4.2pF	
A14C3	0160-2236	C:FXD CER 1.0pF ±0.25pF 500VDCW	
A14C4	0160-2236	C:FXD CER 1.0pF ±0.25pF 500VDCW	
A14C5		C:VAR NSR PART OF 04270-7734 INDICATED AS C ADJ 1	
A14C6		C:VAR NSR PART OF 04270-7734 INDICATED AS C ADJ 2	
A14CR1	1902-3002	DIODE:SILICON BREAKDOWN 2.37V±5% 400mW	
A14J1	1250-0110	CONNECTOR:RECEPTACLE BULK HEAD	
A14P1-A14P13		NOT ASSIGNED	
A14P14	1250-0311	CONNECTOR:MTS-P-1.5-171 Au	
A14P15	1250-0311	CONNECTOR:MTS-P-1.5-171 Au	
A14P16	1250-0311	CONNECTOR:MTS-P-1.5-171 Au	
A14Q1	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q2	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q3	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q4	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q5	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q6	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q7	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q8	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q9	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q10	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q11	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q12	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q13	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q14	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q15	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q16	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q17	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q18	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q19	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q20	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q21	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q22	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q23	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q24	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q25	1854-0120	TRANSISTOR:NPN SILICON 2SC979	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A14Q26	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q27	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q28	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q29	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q30	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q31	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q32	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q33	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q34	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q35	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q36	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q37	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q38	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q39	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q40	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q41	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q42	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q43	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q44	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q45	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q46	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q47	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q48	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q49	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q50	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q51	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q52	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q53	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q54	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q55	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q56	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q57	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q58	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q59	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q60	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q61	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q62	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q63	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q64	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q65	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q66	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q67	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q68	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q69	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q70	1854-0120	TRANSISTOR:NPN SILICON 2SC979	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A14R31*	0698-3540	R:FXD MET FLM 15.4k OHM 1% 1/8W	
A14R32	0698-1500	R:FXD MET FLM 8008 OHM 0.05% 1/4W	
A14R33	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R34	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R35	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R36	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R37*	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A14R38	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R39*	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A14R40	0698-2032	R:FXD MET FLM 16.018k OHM 0.05% 1/4W	
A14R41	0698-1496	R:FXD MET FLM 2000 OHM 0.05% 1/4W	
A14R42	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R43	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R44	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R45	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R46*	0757-0440	R:FXD MET FLM 7.50k OHM 1% 1/8W	
A14R47	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R48*	0757-0440	R:FXD MET FLM 7.50k OHM 1% 1/8W	
A14R49	0698-1496	R:FXD MET FLM 2000 OHM 0.05% 1/4W	
A14R50	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R51	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R52	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R53	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R54*	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A14R55	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R56*	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A14R57	0698-1498	R:FXD MET FLM 4003 OHM 0.05% 1/4W	
A14R58	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R59	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R60	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R61	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R62*	0698-3540	R:FXD MET FLM 15.4k OHM 1% 1/8W	
A14R63	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R64*	0698-3540	R:FXD MET FLM 15.4k OHM 1% 1/8W	
A14R65	0698-1500	R:FXD MET FLM 8008 OHM 0.05% 1/4W	
A14R66	0757-0123	R:FXD MET FLM 34.3k OHM 1% 1/8W	
A14R67	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R68	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R69	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R70*	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A14R71	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R72*	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A14R73	0698-2032	R:FXD MET FLM 16.018k OHM 0.05% 1/4W	
A14R74	0698-1490	R:FXD MET FLM 321.5 OHM 0.05% 1/4W	
A14R75	0698-3460	R:FXD MET FLM 422k OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A14Q71	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q72	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q73	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q74	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q75	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q76	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q77	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q78	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q79	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q80	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q81	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q82	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A14Q83	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A14Q84	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14Q85	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A14R1	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R2	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R3	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R4	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R5*	0757-0200	R:FXD MET FLM 5.62k OHM 1% 1/8W	
A14R6	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R7*	0757-0200	R:FXD MET FLM 5.62k OHM 1% 1/8W	
A14R8	0698-1494	R:FXD MET FLM 1600 OHM 0.05% 1/4W	
A14R9	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R10	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R11	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R12	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R13*	0757-0440	R:FXD MET FLM 7.50k OHM 1% 1/8W	
A14R14	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R15*	0757-0440	R:FXD MET FLM 7.50k OHM 1% 1/8W	
A14R16	0698-1496	R:FXD MET FLM 2000 OHM 0.05% 1/4W	
A14R17	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R18	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R19	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R20	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R21*	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A14R22	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R23*	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A14R24	0698-1498	R:FXD MET FLM 4003 OHM 0.05% 1/4W	
A14R25	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R26	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R27	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R28	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R29*	0698-3540	R:FXD MET FLM 15.4k OHM 1% 1/8W	
A14R30	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A14R76	0698-1496	R:FXD MET FLM 2000 OHM 0.05% 1/4W	
A14R77	0757-0123	R:FXD MET FLM 34.8kOHM 1% 1/8W	
A14R78	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R79	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R80	0698-3162	R:FXD MET FLM 46.4kOHM 1% 1/8W	
A14R81	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A14R82	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R83	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A14R84	0698-1497	R:FXD MET FLM 2000 OHM 0.1% 1/4W	
A14R85	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R86	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R87	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R88	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R89	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A14R90	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R91	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A14R92	0698-1499	R:FXD MET FLM 4003 OHM 0.1% 1/4W	
A14R93	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R94	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R95	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R96	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R97	0698-3156	R:FXD MET FLM 14.7k OHM 1% 1/8W	
A14R98	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R99	0698-3156	R:FXD MET FLM 147k OHM 1% 1/8W	
A14R100	0698-2030	R:FXD MET FLM 8008 OHM 0.1% 1/4W	
A14R101	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R102	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R103	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R104	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R105	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A14R106	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R107	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A14R108	0698-2033	R:FXD MET FLM 16.018k OHM 0.1% 1/4W	
A14R109	0698-1489	R:FXD MET FLM 321.1 OHM 0.05% 1/4W	
A14R110	0698-1497	R:FXD MET FLM 2000 OHM 0.1% 1/4W	
A14R111	0698-1488	R:FXD MET FLM 280.6 OHM 0.1% 1/4W	
A14R112	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R113	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R114	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R115	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R116	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A14R117	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R118	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A14R119	0698-1497	R:FXD MET FLM 2000 OHM 0.1% 1/4W	
A14R120	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No	Description	Note
A14R121	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R122	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R123	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R124	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A14R125	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R126	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A14R127	0698-1499	R:FXD MET FLM 4003 OHM 0.1% 1/4W	
A14R128	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R129	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R130	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R131	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R132	0698-3156	R:FXD MET FLM 14.7k OHM 1% 1/8W	
A14R133	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R134	0698-3156	R:FXD MET FLM 14.7k OHM 1% 1/8W	
A14R135	0698-2030	R:FXD MET FLM 8008 OHM 0.1% 1/4W	
A14R136	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A14R137	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R138	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A14R139	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R140	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A14R141	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A14R142	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A14R143	0698-2033	R:FXD MET FLM 16.018k OHM 0.1% 1/4W	
		MISCELLANEOUS	
	04270-1048	DECK	
	04270-3022	BLOCK	
	04270-5021	SHIELD, 5 REQ'D	
	04270-5028	SPRING	
	04270-7023	SHIELD BOX	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A15	04270-7735	G/D ATTENUATOR ASS'Y	
	04270-8734	BOARD:BLANK P.C.	
A15C1	0160-2236	C:FXD CER 1.0pF ±0.25pF 500VDCW	
A15C2	0160-2236	C:FXD CER 1.0pF ±0.25pF 500VDCW	
A15C3	0160-2236	C:FXD CER 1.0pF ±0.25pF 500VDCW	
A15CR1	1902-3002	DIODE:SILICON BREAKDOWN 2.37V ±5% 400mW	
A15J1		NOT ASSIGNED	
A15J2	1250-0110	CONNECTOR:RECEPTACLE BULK HEAD	
A15P1-A15P16		NOT ASSIGNED	
A15P17	1250-0311	CONNECTOR:MTS-P-1.5-171Au	
A15Q1	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q2	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q3	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q4	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q5	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q6	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q7	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q8	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q9	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q10	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q11	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q12	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q13	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q14	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q15	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q16	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q17	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q18	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q19	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q20	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q21	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q22	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q23	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q24	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q25	1854-0120	TRANSISTOR:NPN SILICON 2SC979	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A15Q26	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q27	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q28	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q29	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q30	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q31	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q32	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q33	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q34	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q35	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q36	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q37	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q38	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q39	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q40	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q41	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q42	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q43	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q44	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q45	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q46	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q47	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q48	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q49	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q50	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q51	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q52	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q53	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q54	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q55	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q56	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q57	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q58	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q59	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q60	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q61	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q62	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q63	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q64	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q65	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q66	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q67	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q68	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q69	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q70	1854-0120	TRANSISTOR:NPN SILICON 2SC979	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A15R31*	0698-3540	R:FXD MET FLM 15.4k OHM 1% 1/8W	
A15R32	0698-1500	R:FXD MET FLM 8008 OHM 0.05% 1/4W	
A15R33	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R34	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R35	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R36	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R37*	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A15R38	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R39*	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A15R40	0698-2032	R:FXD MET FLM 16.018k OHM 0.05% 1/4W	
A15R41	0698-1496	R:FXD MET FLM 2000 OHM 0.05% 1/4W	
A15R42	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R43	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R44	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R45	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R46*	0757-0440	R:FXD MET FLM 7.50k OHM 1% 1/8W	
A15R47	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R48*	0757-0440	R:FXD MET FLM 7.50k OHM 1% 1/8W	
A15R49	0698-1496	R:FXD MET FLM 2000 OHM 0.05% 1/4W	
A15R50	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R51	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R52	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R53	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R54*	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A15R55	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R56*	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A15R57	0698-1498	R:FXD MET FLM 4003 OHM 0.05% 1/4W	
A15R58	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R59	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R60	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R61	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R62	0698-3540	R:FXD MET FLM 15.4k OHM 1% 1/8W	
A15R63	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R64*	0698-3540	R:FXD MET FLM 15.4k OHM 1% 1/8W	
A15R65	0698-1500	R:FXD MET FLM 8008 OHM 0.05% 1/4W	
A15R66	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R67	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R68	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R69	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R70*	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A15R71	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R72	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A15R73	0698-2032	R:FXD MET FLM 16.018k OHM 0.05% 1/4W	
A15R74	0698-1490	R:FXD MET FLM 321.5 OHM 0.05% 1/4W	
A15R75	0698-3460	R:FXD MET FLM 422k OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A15Q71	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q72	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q73	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q74	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q75	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q76	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q77	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q78	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q79	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q80	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q81	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q82	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A15Q83	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A15Q84	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15Q85	1854-0120	TRANSISTOR:NPN SILICON 2SC979	
A15R1	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R2	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R3	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R4	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R5*	0757-0200	R:FXD MET FLM 5.62k OHM 1% 1/8W	
A15R6	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R7*	0757-0200	R:FXD MET FLM 5.62k OHM 1% 1/8W	
A15R8	0698-1494	R:FXD MET FLM 1600 OHM 0.05% 1/4W	
A15R9	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R10	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R11	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R12	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R13*	0757-0440	R:FXD MET FLM 7.50k OHM 1% 1/8W	
A15R14	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R15*	0757-0440	R:FXD MET FLM 7.50k OHM 1% 1/8W	
A15R16	0698-1496	R:FXD MET FLM 2000 OHM 0.05% 1/4W	
A15R17	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R18	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R19	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R20	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R21*	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A15R22	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R23*	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A15R24	0698-1498	R:FXD MET FLM 4003 OHM 0.05% 1/4W	
A15R25	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R26	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R27	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R28	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R29	0698-3540	R:FXD MET FLM 15.4k OHM 1% 1/8W	
A15R30	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A15R76	0698-1496	R:FXD MET FLM 2000 OHM 0.05% 1/4W	
A15R77	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R78	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R79	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R80	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R81	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A15R82	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R83	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A15R84	0698-1497	R:FXD MET FLM 2000 OHM 0.1% 1/4W	
A15R85	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R86	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R87	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R88	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R89	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A15R90	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R91	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A15R92	0698-1499	R:FXD MET FLM 4003 OHM 0.1% 1/4W	
A15R93	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R94	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R95	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R96	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R97	0698-3156	R:FXD MET FLM 14.7k OHM 1% 1/8W	
A15R98	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R99	0698-3156	R:FXD MET FLM 14.7k OHM 1% 1/8W	
A15R100	0698-2030	R:FXD MET FLM 8008 OHM 0.1% 1/4W	
A15R101	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R102	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R103	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R104	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R105	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A15R106	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R107	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A15R108	0698-2033	R:FXD MET FLM 16.018k OHM 0.1% 1/4W	
A15R109	0698-1489	R:FXD MET FLM 321.1 OHM 0.05% 1/4W	
A15R110	0698-1497	R:FXD MET FLM 2000 OHM 0.1% 1/4W	
A15R111	0698-1488	R:FXD MET FLM 280.6 OHM 0.1% 1/4W	
A15R112	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R113	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R114	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R115	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R116	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A15R117	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R118	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A15R119	0698-1497	R:FXD MET FLM 2000 OHM 0.1% 1/4W	
A15R120	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A15R121	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R122	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R123	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R124	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A15R125	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R126	0698-3498	R:FXD MET FLM 8.66k OHM 1% 1/8W	
A15R127	0698-1499	R:FXD MET FLM 4003 OHM 0.1% 1/4W	
A15R128	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R129	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R130	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R131	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R132	0698-3156	R:FXD MET FLM 14.7k OHM 1% 1/8W	
A15R133	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R134	0698-3156	R:FXD MET FLM 14.7k OHM 1% 1/8W	
A15R135	0698-2030	R:FXD MET FLM 8008 OHM 0.1% 1/4W	
A15R136	0757-0123	R:FXD MET FLM 34.8k OHM 1% 1/8W	
A15R137	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R138	0698-3449	R:FXD MET FLM 28.7k OHM 1% 1/8W	
A15R139	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R140	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A15R141	0698-3162	R:FXD MET FLM 46.4k OHM 1% 1/8W	
A15R142	0698-3158	R:FXD MET FLM 23.7k OHM 1% 1/8W	
A15R143	0698-2033	R:FXD MET FLM 16.018k OHM 0.1% 1/4W	
		MISCELLANEOUS	
	04270-1049	DECK	
	04270-5021	SHIELD 5 REQ'D	
	04270-7031	SHIELD BOX	
	04470-7215	WIRE ASS'Y	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A16Q1	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A16Q2	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A16R1	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A16R2	0757-0440	R:FXD MET FLM 7500 OHM 1% 1/8W	
A16R3	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A16R4	0757-0440	R:FXD MET FLM 7500 OHM 1% 1/8W	
A16R5	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A16R6	0757-0440	R:FXD MET FLM 7500 OHM 1% 1/8W	
A16R7	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A16R8	0757-0440	R:FXD MET FLM 7500 OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5112	EXTRACTOR:BROWN	
	5040-5117	EXTRACTOR:BLUE	
A17		NOT ASSIGNED	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A16	04270-7736	Cs REVERSIBLE COUNTER & DRIVER ASS'Y	
	04270-8736	BOARD:BLANK P.C	
A16CR1	1910-0016	DIODE:GERM	
A16CR2	1910-0016	DIODE:GERM	
A16CR3	1910-0016	DIODE:GERM	
A16CR4	1910-0016	DIODE:GERM	
A16CR5	1910-0016	DIODE:GERM	
A16CR6	1910-0016	DIODE:GERM	
A16CR7	1910-0016	DIODE:GERM	
A16CR8	1910-0016	DIODE:GERM	
A16CR9	1910-0016	DIODE:GERM	
A16CR10	1910-0016	DIODE:GERM	
A16CR11	1910-0016	DIODE:GERM	
A16IC1	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A16IC2	1820-0076	IC:TTL DUAL M/S FF W/PRESET/CLEAR	
A16IC3	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A16IC4	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A16IC5	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A16IC6	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A16IC7	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A16IC8	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A16IC9	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A16IC10	1820-0076	IC:TTL DUAL M/S FF W/PRESET/CLEAR	
A16IC11	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A16IC12	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A16IC13	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A16IC14	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A16IC15	1820-0076	IC:TTL DUAL M/S FF W/PRESET/CLEAR	
A16IC16	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A16IC17	1820-0075	IC:TTL DUAL MASTER SLAVE FF	
A16IC18	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A16IC19	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A16IC20	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A16IC21	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A16IC22	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A16IC23	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A16IC24	1820-0075	IC:TTL DUAL MASTER SLAVE FF	
A16IC25	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A16IC26	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A16IC27	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A16IC28	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A16IC29	1820-0075	IC:TTL DUAL MASTER SLAVE FF	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A18	04270-7738	D/G REVERSIBLE COUNTER & DRIVER ASS'Y	
	04270-8738	BOARD:BLANK P. C.	
A18CR1	1910-0016	DIODE:GERM	
A18CR2	1910-0016	DIODE:GERM	
A18CR3	1910-0016	DIODE:GERM	
A18CR4	1910-0016	DIODE:GERM	
A18CR5	1910-0016	DIODE:GERM	
A18IC1	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A18IC2	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A18IC3	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A18IC4	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A18IC5	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A18IC6	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A18IC7	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A18IC8	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A18IC9	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A18IC10	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A18IC11	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A18IC12	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A18IC13	1820-0054	IC:TTL QUAD 2-INPUT NOR GATE	
A18IC14	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A18IC15	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A18IC16	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A18IC17	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A18IC18	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A18IC19	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A18IC20	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A18IC21	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A18IC22	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A18IC23	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A18IC24	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A18IC25	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A18IC26	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A18IC27	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A18IC28	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A18IC29	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A18Q1	1854-0119	TRANSISTOR:NPN SILICON 2SC979	

See list of abbreviations in introduction to this section.

Reference Designation	Stock No.	Description	Note
A18R1	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A18R2	0757-0440	R:FXD MET FLM 7500 OHM 1% 1/8W	
A18R3	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A18R4	0757-0440	R:FXD MET FLM 7500 OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5112	EXTRACTOR:BROWN	
	5040-4529	EXTRACTOR:GRAY	
A19	04270-7739	GATE (1) ASS'Y	
	04270-8739	BOARD:BLANK P. C.	
A19C1	0160-1598	C:POLYSTYRENE 1000pF 1% 50VDCW	
A19C2	0160-2307	C:FXD MICA 47pF 5% 300VDCW	
A19C3	0160-1271	C:FXD MYLAR 0.01μF 5% 50VDCW	
A19C4	0160-2204	C:FXD MICA 100pF 5% 300VDCW	
A19C5	0160-2204	C:FXD MICA 100pF 5% 300VDCW	
A19C6	0160-1598	C:POLYSTYRENE 1000pF 1% 50VDCW	
A19C7	0160-2307	C:FXD MICA 47pF 5% 300VDCW	
A19C8	0160-1271	C:FXD MYLAR 0.01μF 5% 50VDCW	
A19C9	0160-2204	C:FXD MICA 100pF 5% 300VDCW	
A19C10	0160-2204	C:FXD MICA 100pF 5% 300VDCW	
A19C11	0160-2307	C:FXD MICA 47pF 5% 300VDCW	
A19CR1	1901-0040	DIODE:SILICON	
A19CR2	1901-0040	DIODE:SILICON	
A19CR3	1901-0040	DIODE:SILICON	
A19CR4	1901-0040	DIODE:SILICON	
A19CR5	1901-0040	DIODE:SILICON	
A19CR6	1901-0040	DIODE:SILICON	
A19CR7	1901-0040	DIODE:SILICON	
A19CR8	1901-0040	DIODE:SILICON	
A19CR9	1901-0040	DIODE:SILICON	
A19CR10	1910-0016	DIODE:GERM	
A19CR11	1910-0016	DIODE:GERM	
A19CR12	1910-0016	DIODE:GERM	
A19CR13	1910-0016	DIODE:GERM	
A19CR14	1910-0016	DIODE:GERM	
A19CR15	1910-0016	DIODE:GERM	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A19Q6	1850-0158	TRANSISTOR:PNP GERM EIA 2635	
A19Q7	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A19Q8	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A19Q9	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A19R1	0757-0442	R:FXD MET FLM 10.0k OHM 1% 1/8W	
A19R2	0757-0416	R:FXD MET FLM 511 OHM 1% 1/8W	
A19R3	0757-0416	R:FXD MET FLM 511 OHM 1% 1/8W	
A19R4*	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
A19R5	2100-1760	R:VAR WW LIN 5000 OHM 10% 1/2W	
A19R6	0698-3429	R:FXD MET FLM 19.6 OHM 1% 1/8W	
A19R7	0698-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A19R8	0757-0434	R:FXD MET FLM 3650 OHM 1% 1/8W	
A19R9	0757-0288	R:FXD MET FLM 9.09k OHM 1% 1/8W	
A19R10	0757-0288	R:FXD MET FLM 9.09k OHM 1% 1/8W	
A19R11	0757-0405	R:FXD MET FLM 162 OHM 1% 1/8W	
A19R12	0757-0405	R:FXD MET FLM 162 OHM 1% 1/8W	
A19R13	0757-0278	R:FXD MET FLM 1.78 OHM 1% 1/8W	
A19R14	0757-0288	R:FXD MET FLM 9.09k OHM 1% 1/8W	
A19R15	0757-0288	R:FXD MET FLM 9.09k OHM 1% 1/8W	
A19R16	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A19R17	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A19R18	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A19R19	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A19R20	0698-3153	R:FXD MET FLM 3830 OHM 1% 1/8W	
A19R21	0698-3153	R:FXD MET FLM 3830 OHM 1% 1/8W	
A19R22	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A19R23	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A19R24	0757-0442	R:FXD MET FLM 10.0k OHM 1% 1/8W	
A19R25	0757-0416	R:FXD MET FLM 511 OHM 1% 1/8W	
A19R26	0757-0416	R:FXD MET FLM 511 OHM 1% 1/8W	
A19R27*	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
A19R28	2100-1760	R:VAR WW LIN 5000 OHM 10% 1/2W	
A19R29	0698-3429	R:FXD MET FLM 19.6 OHM 1% 1/8W	
A19R30	0698-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A19R31	0757-0434	R:FXD MET FLM 3650 OHM 1% 1/8W	
A19R32	0757-0288	R:FXD MET FLM 9.09k OHM 1% 1/8W	
A19R33	0757-0288	R:FXD MET FLM 9.09k OHM 1% 1/8W	
A19R34	0757-0405	R:FXD MET FLM 162 OHM 1% 1/8W	
A19R35	0757-0405	R:FXD MET FLM 162 OHM 1% 1/8W	
A19R36	0757-0278	R:FXD MET FLM 1.78k OHM 1% 1/8W	
A19R37	0757-0288	R:FXD MET FLM 9.09k OHM 1% 1/8W	
A19R38	0757-0288	R:FXD MET FLM 9.09k OHM 1% 1/8W	
A19R39	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A19R40	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A19CR16	1910-0016	DIODE:GERM	
A19CR17	1901-0040	DIODE:SILICON	
A19CR18	1901-0040	DIODE:SILICON	
A19CR19	1901-0040	DIODE:SILICON	
A19CR20	1901-0040	DIODE:SILICON	
A19CR21	1901-0040	DIODE:SILICON	
A19CR22	1901-0040	DIODE:SILICON	
A19CR23	1901-0040	DIODE:SILICON	
A19CR24	1901-0040	DIOCE:SILICON	
A19CR25	1901-0040	DIOCE:SILICON	
A19CR26	1910-0016	DIODE:GERM	
A19CR27	1910-0016	DIODE:GERM	
A19CR28	1910-0016	DIODE:GERM	
A19CR29	1910-0016	DIODE:GERM	
A19CR30	1910-0016	DIODE:GERM	
A19CR31	1910-0016	DIODE:GERM	
A19CR32	1910-0016	DIODE:GERM	
A19IC1	1820-0051	IC:OP AMP	
A19IC2	1820-0321	IC:DIFF COMPARATOR	
A19IC3	1820-0321	IC:DIFF COMPARATOR	
A19IC4	1820-0132	IC:TTL HEX INVERTER	
A19IC5	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A19IC6	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A19IC7	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A19IC8	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A19IC9	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A19IC10	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A19IC11	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A19IC12	1820-0051	IC:OP AMP	
A19IC13	1820-0321	IC:DIFF COMPARATOR	
A19IC14	1820-0321	IC:DIFF COMPARATOR	
A19IC15	1820-0077	IC:TTL DUAL DELAY FLOP FLOP	
A19IC16	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A19IC17	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A19Q1	1850-0158	TRANSISTOR:PNP GERM EIA 2635	
A19Q2	1850-0158	TRANSISTOR:PNP GERM EIA 2635	
A19Q3	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A19Q4	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A19Q5	1850-0158	TRANSISTOR:PNP GERM EIA 2635	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A19R41	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A19R42	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A19R43	0698-3153	R:FXD MET FLM 3830 OHM 1% 1/8W	
A19R44	0698-3153	R:FXD MET FLM 3830 OHM 1% 1/8W	
A19R45	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A19R46	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A19R47	0757-0442	R:FXD MET FLM 10.0k OHM 1% 1/8W	
A19R48	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5112	EXTRACTOR: BROWN	
	5040-5119	EXTRACTOR: WHITE	
A20	04270-7740	GATE (2) ASS'Y	
	04270-8740	BOARD:BLANK P.C.	
A20C1	0140-0199	C:FXD MICA 240pF 5% 300VDCW	
A20CR1	1910-0016	DIODE:GERM	
A20CR2	1910-0016	DIODE:GERM	
A20IC1	1820-0132	IC:TTL HEX INVERTER	
A20IC2	1820-0068	IC:TTL REIPLE 3-INPUT NAND GATE	
A20IC3	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A20IC4	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A20IC5	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A20IC6	1820-0327	IC:TTL QUAD 2-INPUT NAND GATE	
A20IC7	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A20IC8	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A20IC9	1820-0327	IC:TTL QUAD 2-INPUT NAND GATE	
A20IC10	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A20IC11	1820-0327	IC:TTL QUAD 2-INPUT NAND GATE	
A20IC12	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A20IC13	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A20IC14	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A20IC15	1820-0327	IC:TTL QUAD 2-INPUT NAND GATE	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A20IC16	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A20IC17	1820-0076	IC:TTL DUAL MASTER/SLAVE FF W/PRESET/CLEAR	
A20IC18	1820-0076	IC:TTL DUAL MASTER/SLAVE FF W/PRESET/CLEAR	
A20IC19	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A20IC20	1820-0076	IC:TTL DUAL MASTER/SLAVE FF W/PRESET/CLEAR	
A20IC21	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A20IC22	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A20IC23	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A20IC24	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A20IC25	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A20R1	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A20R2	0698-3150	R:FXD MET FLM 2370 OHM 1% 1/8W	
A20R3	0698-3151	R:FXD MET FLM 2870 OHM 1% 1/8W	
A20R4	0698-3153	R:FXD MET FLM 3.83k OHM 1% 1/8W	
A20R5	0757-0279	R:FXD MET FLM 3.16k OHM 1% 1/8W	
A20R6	0698-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A20R7	0698-3178	R:FXD MET FLM 4870 OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5113	EXTRACTOR: RED	
	5040-5111	EXTRACTOR: BLACK	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A21	04270-7741	TIMING CIRCUIT ASS'Y	
	04270-8741	BOARD:BLANK P.C.	
A21C1	0160-2204	C:FXD MICA 100pF 5% 300VDCW	
A21C2	0160-2221	C:FXD MICA 1300pF 5% 300VDCW	
A21C3	0160-2226	C:FXD MICA 2200pF 5% 300VDCW	
A21C4	0160-2307	C:FXD MICA 47pF 300VDCW	
A21C5	0140-0170	C:FXD MICA 5600pF 5% 300VDCW	
A21C6	0140-0196	C:FXD MICA 150pF 5% 300VDCW	
A21C7	0160-1557	C:FXD MYLAR 0.001μF 10% 100VDCW	
A21C8	0180-0374	C:FXD TANT 10μF 10% 20VDCW	
A21C9	0160-2202	C:FXD MICA 75pF 5% 300VDCW	
A21C10	0180-0229	C:FXD TANT 33μF 10% 10VDCW	
A21C11	0160-1545	C:FXD MYLAR 0.022μF 5% 100VDCW	
A21C12	0160-1545	C:FXD MYLAR 0.022μF 5% 100VDCW	
A21C13	0160-2307	C:FXD MICA 47pF 5% 300VDCW	
A21C14	0140-0199	C:FXD MICA 240pF 5% 300VDCW	
A21C15	0160-2210	C:FXD MICA 470pF 5% 300VDCW	
A21C16	0180-0374	C:FXD TANT 10μF 10% 30VDCW	
A21C17	0160-2940	C:FXD MICA 470pF 5% 300VDCW	
A21C18	0140-0199	C:FXD MICA 240pF 5% 300VDCW	
A21C19	0140-0170	C:FXD MICA 5600pF 5% 300VDCW	
A21C20		NOT ASSIGNED	
A21CR1	1910-0016	DIODE:GERM	
A21CR2	1910-0016	DIODE:GERM	
A21CR3	1910-0016	DIODE:GERM	
A21CR4	1910-0016	DIODE:GERM	
A21CR5	1902-3082	DIODE:BREAKDOWN 4.64V 5% 400mW	
A21CR6	1901-0025	DIODE:SILICON	
A21CR7	1901-0025	DIODE:SILICON	
A21CR8	1910-0016	DIODE:GERM	
A21CR9	1901-0025	DIODE:SILICON	
A21CR10	1901-0025	DIODE:SILICON	
A21CR11	1910-0016	DIODE:GERM	
A21CR12	1910-0016	DIODE:GERM	
A21CR13	1910-0016	DIODE:GERM	
A21CR14	1910-0016	DIODE:GERM	
A21CR15	1910-0016	DIODE:GERM	
A21CR16	1910-0016	DIODE:GERM	
A21CR17	1910-0016	DIODE:GERM	
A21CR18	1910-0016	DIODE:GERM	
A21CR19	1910-0025	DIODE:SILICON	
A21CR20	1910-0016	DIODE:GERM	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A21CR21	1910-0016	DIODE:GERM	
A21CR22	1910-0016	DIODE:GERM	
A21IC1	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A21IC2	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A21IC3	1820-0328	IC:TTL QUAD 2-INPUT NAND GATE	
A21IC4	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A21IC5	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A21IC6	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A21IC7	1820-0075	IC:TTL DUAL MASTER/SLAVE FF	
A21IC8	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A21IC9	1820-0077	IC:TTL DUAL DELAY FLIP DLOP	
A21IC10	1820-0068	IC:TTL TRIPLE 3-INPUT NAND GATE	
A21IC11	1820-0132	IC:TTL HEX INVERTER	
A21IC12	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A21IC13	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A21IC14	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A21IC15	1820-0412	IC:TIME BASE DECADE	
A21IC16	1820-0054	IC:QUAD 2-INPUT NAND GATE	
A21IC17	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A21L1	9140-0137	COIL:FXD RF 1000μH	
A21Q1	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A21Q2	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A21Q3	1853-0010	TRANSISTOR:PNP SILICON PD 360mW FT:250MC	
A21Q4	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A21Q5	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A21Q6	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A21Q7	1854-0039	TRANSISTOR:NPN SILICON EIA 2N3053	
A21Q8	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A21Q9	1853-0010	TRANSISTOR:PNP SILICON PD 360mW FT:250MC	
A21Q10	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A21Q11	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A21Q12	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A21Q13	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A21R1	0698-3153	R:FXD MET FLM 3830 OHM 1% 1/8W	
A21R2	0698-3153	R:FXD MET FLM 3830 OHM 1% 1/8W	
A21R3	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A21R4	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A21R5	0757-0279	R:FXD MET FLM 3.16k OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A22	04270-7742	RANGE SELECTOR ASS'Y	
	04270-8742	BOARD:BLANK P.C.	
A22CR1	1910-0016	DIODE:GERM	
A22CR2	1910-0016	DIODE:GERM	
A22CR3	1910-0016	DIODE:GERM	
A22CR4	1910-0016	DIODE:GERM	
A22CR5	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR6	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR7	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR8	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR9	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR10	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR11	1901-0025	DIODE:SILICON	
A22CR12	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR13	1901-0025	DIODE:SILICON	
A22CR14	1901-0025	DIODE:SILICON	
A22CR15	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR16	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR17	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR18	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR19	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR20	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR21	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR22	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR23	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR24	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR25	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR26	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR27	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR28	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR29	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR30	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR31	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR32	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR33	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR34	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR35	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR36	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR37	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR38	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR39	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR40	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A21R6	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A21R7	0698-3260	R:FXD MET FLM 464k OHM 1% 1/8W	
A21R8	0698-3136	R:FXD MET FLM 17.8k OHM 1% 1/8W	
A21R9	0757-0454	R:FXD MET FLM 33.2k OHM 1% 1/8W	
A21R10	0757-0454	R:FXD MET FLM 33.2k OHM 1% 1/8W	
A21R11	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A21R12	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A21R13	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A21R14	0757-0289	R:FXD MET FLM 13.3k OHM 1% 1/8W	
A21R15	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A21R16	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A21R17	0757-0459	R:FXD MET FLM 56.2k OHM 1% 1/8W	
A21R18	0698-3154	R:FXD MET FLM 4220 OHM 1% 1/8W	
A21R19	0757-0290	R:FXD MET FLM 6.19k OHM 1% 1/8W	
A21R20	0698-4705	R:FXD MET FLM 47k OHM 1% 1/8W	
A21R21	0698-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A21R22	0698-3438	R:FXD MET FLM 147 OHM 1% 1/8W	
A21R23	0698-3438	R:FXD MET FLM 147 OHM 1% 1/8W	
A21R24	2100-1757	R:VAR WW LIN 500 OHM 10% 1/2W	
A21R25	0698-3150	R:FXD MET FLM 2370 OHM 1% 1/8W	
A21R26	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A21R27	0757-0424	R:FXD MET FLM 1100 OHM 1% 1/8W	
A21R28	0757-0289	R:FXD MET FLM 13.3k OHM 1% 1/8W	
A21R29	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A21R30	0757-0424	R:FXD MET FLM 1100 OHM 1% 1/8W	
A21R31	0698-3161	R:FXD MET FLM 38.3k OHM 1% 1/8W	
A21R32	0757-0424	R:FXD MET FLM 1100 OHM 1% 1/8W	
A21R33	0757-0424	R:FXD MET FLM 1100 OHM 1% 1/8W	
A21R34	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A21R35	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A21R36	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A21R37	0757-0422	R:FXD MET FLM 909 OHM 1% 1/8W	
A21R38	0757-0984	R:FXD MET FLM 2150 OHM 1% 1/8W	
A21R39	0757-0439	R:FXD MET FLM 6.81k OHM 1% 1/8W	
A21R40	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A21R41	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A21R42	0698-3452	R:FXD MET FLM 147k OHM 1% 1/8W	
A21R43	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A21R44	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A21R45	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A21R46	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5113	EXTRACTOR: RED	
	5040-5112	EXTRACTOR: BROWN	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A22Q1	1850-0158	TRANSISTOR:PNP GERM EIA 2N2635	
A22Q2	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A22Q3	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q4	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q5	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q6	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q7	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q8	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q9	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q10	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q11	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q12	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q13	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q14	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q15	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q16	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q17	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q18	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q19	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q20	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q21	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q22	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q23	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q24	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q25	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q26	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q27	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q28	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A22Q29	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q30	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q31	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q32	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22Q33	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A22R1	0757-0447	R:FXD MET FLM 16.1k OHM 1% 1/8W	
A22R2	0757-0438	R:FXD MET FLM 5100 OHM 1% 1/8W	
A22R3	0698-3151	R:FXD MET FLM 2870 OHM 1% 1/8W	
A22R4	0757-0442	R:FXD MET FLM 10.0k OHM 1% 1/8W	
A22R5	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R6	0698-3161	R:FXD MET FLM 38.3k OHM 1% 1/8W	
A22R7	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A22R8	0698-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A22R9	0757-0288	R:FXD MET FLM 9.09k OHM 1% 1/8W	
A22R10	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A22CR41	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR42	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR43	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR44	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR45	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR46	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR47	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR48	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR49	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR50	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR51	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR52	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR53	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR54	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR55	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR56	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR57	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR58	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR59	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR60	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR61	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR62	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR63	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR64	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR65	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR66	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR67	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR68	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR69	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR70	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR71	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR72	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR73	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22CR74	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A22IC1	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A22IC2	1820-0076	IC:TTL DUAL M/S PRESET CLEAR	
A22IC3	1820-0076	IC:TTL DUAL M/S PRESET CLEAR	
A22IC4	1820-0075	IC:TTL DUAL MASTER SLAVE FF	
A22IC5	1820-0327	IC:TTL QUAD 2-INPUT NAND GATE	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A22R56	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A22R57	0757-0466	R:FXD MET FLM 1.10k OHM 1% 1/8W	
A22R58	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A22R59	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R60	0698-3495	R:FXD MET FLM 866 OHM 1% 1/8W	
A22R61	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R62	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R63	0698-3495	R:FXD MET FLM 866 OHM 1% 1/8W	
A22R64	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R65	0698-3495	R:FXD MET FLM 866 OHM 1% 1/8W	
A22R66	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R67	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A22R68	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R69	0698-3495	R:FXD MET FLM 866 OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5113	EXTRACTOR:RED 2-REQ'D	
A23	04270-7743	DISPLAY CONTROL ASS'Y	
	04270-8743	BOARD:BLANK P.C.	
A23C1	0160-0939	C:FXD MICA 430pF 5% 300VDCW	
A23C2	0160-2206	C:FXD MICA 160pF 5% 300VDCW	
A23C3	0180-0197	C:FXD TANT 2.2μF 10% 20VDCW	
A23CR1	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR2	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR3	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR4	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR5	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR6	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR7	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR8	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR9	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR10	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A22R11	0757-0428	R:FXD MET FLM 1620 OHM 1% 1/8W	
A22R12	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R13	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A22R14	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
A22R15	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A22R16	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A22R17	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R18	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R19	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A22R20	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A22R21	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R22	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R23	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A22R24	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A22R25	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R26	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R27	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A22R28	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A22R29	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R30	0757-0290	R:FXD MET FLM 6.19k OHM 1% 1/8W	
A22R31	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A22R32	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A22R33	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A22R34	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R35	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R36	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R37	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R38	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R39	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R40	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R41	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R42	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R43	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R44	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R45	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R46	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R47	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R48	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R49	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R50	0757-0439	R:FXD MET FLM 6810 OHM 1% 1/8W	
A22R51	0757-0455	R:FXD MET FLM 36.5k OHM 1% 1/8W	
A22R52	0757-0455	R:FXD MET FLM 36.5k OHM 1% 1/8W	
A22R53	0757-0455	R:FXD MET FLM 36.5k OHM 1% 1/8W	
A22R54	0757-0455	R:FXD MET FLM 36.5k OHM 1% 1/8W	
A22R55	0757-0455	R:FXD MET FLM 36.5k OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A23CR11	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR12	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR13	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR14	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR15	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR16	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR17	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR18	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR19	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR20	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR21	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR22	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR23	1901-0025	DIODE:SILICON	
A23CR24	1901-0025	DIODE:SILICON	
A23CR25	1901-0025	DIODE:SILICON	
A23CR26	1901-0025	DIODE:SILICON	
A23CR27	1901-0025	DIODE:SILICON	
A23CR28	1901-0025	DIODE:SILICON	
A23CR29	1910-0016	DIODE:GERM	
A23CR30	1910-0016	DIODE:GERM	
A23CR31	1910-0016	DIODE:GERM	
A23CR32	1910-0016	DIODE:GERM	
A23CR33	1901-0025	DIODE:SILICON	
A23CR34	1901-0025	DIODE:SILICON	
A23CR35	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR36	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR37	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR38	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR39	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR40	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR41	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR42	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR43	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR44	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR45	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR46	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR47	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR48	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR49	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR50	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A23CR51	1901-0081	DIODE:SILICON 50V WORKING 10NS 6pF	
A23CR52	1910-0016	DIODE:GERM	
A23CR53	1910-0016	DIODE:GERM	
A23CR54	1910-0016	DIODE:GERM	
A23CR55	1910-0016	DIODE:GERM	
A23CR56	1910-0016	DIODE:GERM	
A23CR57	1910-0016	DIODE:GERM	
A23CR58	1901-0025	DIODE:SILICON	
A23CR59	1901-0025	DIODE:SILICON	
A23CR60	1901-0025	DIODE:SILICON	
A23CR61	1901-0025	DIODE:SILICON	
A23CR62	1901-0025	DIODE:SILICON	
A23CR63	1901-0025	DIODE:SILICON	
A23Q1	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q2	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q3	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q4	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q5	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q6	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q7	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q8	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q9	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q10	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q11	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q12	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q13	1854-0003	TRANSISTOR:NPN SILICON SIMILAR TO 2N1711	
A23Q14	1854-0003	TRANSISTOR:NPN SILICON SIMILAR TO 2N1711	
A23Q15	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q16	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q17	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q18	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q19	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q20	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A23Q21	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q22	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q23	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q24	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q25	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A23Q26	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A23R1		NOT ASSIGNED	
A23R2	0698-4435	R:FXD MET FLM 2490 OHM 1% 1/8W	
A23R3	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R4	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A23R5		NOT ASSIGNED	
A23R6	0698-4435	R:FXD MET FLM 2490 OHM 1% 1/8W	
A23R7	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R8	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A23R9		NOT ASSIGNED	
A23R10	0698-4435	R:FXD MET FLM 2490 OHM 1% 1/8W	
A23R11	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R12	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A23R13		NOT ASSIGNED	
A23R14	0698-4435	R:FXD MET FLM 2490 OHM 1% 1/8W	
A23R15	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R16	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A23R17		NOT ASSIGNED	
A23R18		NOT ASSIGNED	
A23R19	0698-4435	R:FXD MET FLM 2490 OHM 1% 1/8W	
A23R20	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R21	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A23R22	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R23	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R24	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R25	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R26	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R27	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R28	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R29	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R30	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R31	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R32	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R33	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R34	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R35	0757-0289	R:FXD MET FLM 13.3k OHM 1% 1/8W	
A23R36	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R37	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A23R38	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
A23R39	0698-3136	R:FXD MET FLM 17.8k OHM 1% 1/8W	
A23R40	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A23R41	0757-0428	R:FXD MET FLM 1620 OHM 1% 1/8W	
A23R42	0757-0428	R:FXD MET FLM 1620 OHM 1% 1/8W	
A23R43	0698-4037	R:FXD MET FLM 46.4 OHM 1% 1/8W	
A23R44	0757-0452	R:FXD MET FLM 27.4k OHM 1% 1/8W	
A24R45	0757-0459	R:FXD MET FLM 56.2k OHM 1% 1/8W	
A23R46		NOT ASSIGNED	
A23R47	0698-4435	R:FXD MET FLM 2490 OHM 1% 1/8W	
A23R48	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R49	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A23R50		NOT ASSIGNED	
A23R51	0698-4435	R:FXD MET FLM 2490 OHM 1% 1/8W	
A23R52	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R53	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A23R54		NOT ASSIGNED	
A23R55	0698-4435	R:FXD MET FLM 2490 OHM 1% 1/8W	
A23R56	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R57	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A23R58		NOT ASSIGNED	
A23R59	0698-4435	R:FXD MET FLM 2490 OHM 1% 1/8W	
A23R60	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R61	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A23R62		NOT ASSIGNED	
A23R63	0698-4435	R:FXD MET FLM 2490 OHM 1% 1/8W	
A23R64	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A23R65	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A23R66	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R67	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R68	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R69	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R70	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R71	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R72	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R73	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R74	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R75	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R76	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R77	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R78	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	
A23R79	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A23R80	0698-3159	R:FXD MET FLM 26.1k OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A24CR16	1910-0016	DIODE:GERM	
A24CR17	1901-0025	DIODE:SILICON	
A24CR18	1910-0016	DIODE:GERM	
A24CR19	1910-0016	DIODE:GERM	
A24CR20	1910-0016	DIODE:GERM	
A24CR21	1910-0016	DIODE:GERM	
A24CR22	1910-0016	DIODE:GERM	
A24CR23	1910-0016	DIODE:GERM	
A24CR24	1910-0016	DIODE:GERM	
A24CR25	1910-0016	DIODE:GERM	
A24CR26	1910-0016	DIODE:GERM	
A24CR27	1910-0016	DIODE:GERM	
A24CR28	1910-0016	DIODE:GERM	
A24CR29	1910-0016	DIODE:GERM	
A24CR30	1910-0016	DIODE:GERM	
A24CR31	1910-0016	DIODE:GERM	
A24CR32	1910-0016	DIODE:GERM	
A24CR33	1901-0025	DIODE:SILICON	
A24CR34	1901-0025	DIODE:SILICON	
A24CR35	1910-0016	DIODE:GERM	
A24CR36	1910-0016	DIODE:GERM	
A24CR37	1910-0016	DIODE:GERM	
A24IC1	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A24IC2	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A24IC3	1820-0076	IC:TTL DUAL M/S FF W/PRESET/CLEAR	
A24IC4	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A24IC5	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A24IC6	1820-0327	IC:TTL QUAD 2-INPUT NAND GATE	
A24IC7	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A24IC8	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A24IC9	1820-0077	IC:TTL DUAL DELAY FLIP FLOP	
A24Q1	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q2	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q3	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q4	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q5	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A24Q6	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q7	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A24Q8	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q9	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q10	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A24Q11	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q12	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q13	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q14	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q15	1854-0119	TRANSISTOR:NPN SILICON 2SC979	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A23R81	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5113	EXTRACTOR RED	
	5040-5114	EXTRACTOR ORANGE	
A24	04270-7744	RESET & DC BIAS CONTROL ASS'Y	
	04270-8744	BOARD:BLANK P.C.	
A24C1	0160-2204	C:FXD MICA 100pF 5% 300VDCW	
A24C2	0180-0100	C:FXD TANT 4.7µF 10% 35VDCW	
A24C3	0140-0199	C:FXD MICA 240pF 5% 300VDCW	
A24C4	0180-1745	C:FXD TANT 1.5µF 10% 20VDCW	
A24C5	0160-2206	C:FXD MICA 160pF 5% 300VDCW	
A24C6	0160-2204	C:FXD MICA 100pF 5% 300VDCW	
A24C7	0180-0291	C:FXD TANT 1µF 10% 35VDCW	
A24C8	0180-0229	C:FXD TANT 33µF 10% 15VDCW	
A24C9	0140-0199	C:FXD MICA 240pF 5% 300VDCW	
A24C10	0160-2224	C:FXD MICA 1800pF 5% 300VDCW	
A24C11	0160-2204	C:FXD MICA 100pF 5% 300VDCW	
A24C12	0180-0197	C:FXD TANT 2.2µF 10% 20VDCW	
A24CR1	1910-0016	DIODE:GERM	
A24CR2	1910-0016	DIODE:GERM	
A24CR3	1910-0016	DIODE:GERM	
A24CR4	1910-0016	DIODE:GERM	
A24CR5	1901-0025	DIODE:SILICON	
A24CR6	1901-0025	DIODE:SILICON	
A24CR7	1901-0025	DIODE:SILICON	
A24CR8	1901-0025	DIODE:SILICON	
A24CR9	1910-0016	DIODE:GERM	
A24CR10	1910-0016	DIODE:GERM	
A24CR11	1910-0016	DIODE:GERM	
A24CR12	1910-0016	DIODE:GERM	
A24CR13	1910-0016	DIODE:GERM	
A24CR14	1901-0025	DIODE:SILICON	
A24CR15	1910-0016	DIODE:GERM	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A24R26	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A24R27	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A24R28	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A24R29	0757-0447	R:FXD MET FLM 16. 2k OHM 1% 1/8W	
A24R30	0757-0447	R:FXD MET FLM 16. 2k OHM 1% 1/8W	
A24R31	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A24R32	0757-0440	R:FXD MET FLM 7. 5k OHM 1% 1/8W	
A24R33	0757-0417	R:FXD MET FLM 562 OHM 1% 1/8W	
A24R34	0698-3159	R:FXD MET FLM 26. 1k OHM 1% 1/8W	
A24R35	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A24R36	0698-3152	R:FXD MET FLM 3480 OHM 1% 1/8W	
A24R37	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R38	0698-0083	R:FXD MET FLM 1960 OHM 1% 1/8W	
A24R39	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A24R40	0757-0279	R:FXD MET FLM 3160 OHM 1% 1/8W	
A24R41	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R42	0698-3152	R:FXD MET FLM 3480 OHM 1% 1/8W	
A24R43	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R44	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A24R45	0757-0417	R:FXD MET FLM 562 OHM 1% 1/8W	
A24R46	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R47	0757-0417	R:FXD MET FLM 562 OHM 1% 1/8W	
A24R48	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R49	0698-3157	R:FXD MET FLM 19. 6k OHM 1% 1/8W	
A24R50	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R51	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A24R52	0757-0288	R:FXD MET FLM 9. 09k OHM 1% 1/8W	
A24R53	0698-3540	R:FXD MET FLM 15. 4k OHM 1% 1/8W	
A24R54	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A24R55	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A24R56	0757-0422	R:FXD MET FLM 909 OHM 1% 1/8W	
A24R57	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A24R58	0698-3700	R:FXD MET FLM 715 OHM 1% 1/8W	
A24R59	0757-0447	R:FXD MET FLM 16. 2k OHM 1% 1/8W	
A24R60	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A24R61	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R62	0698-3449	R:FXD MET FLM 28. 7k OHM 1% 1/8W	
A24R63	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A24R64	0698-4014	R:FXD MET FLM 787 OHM 1% 1/8W	
A24R65	0698-3159	R:FXD MET FLM 26. 1k OHM 1% 1/8W	
A24R66	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A24R67	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R68	0698-3151	R:FXD MET FLM 1870 OHM 1% 1/8W	
A24R69	0757-0466	R:FXD MET FLM 110k OHM 1% 1/8W	
A24R70	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A24Q16	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A24Q17	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q18	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q19	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q20	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A24Q21	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A24Q22	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q23	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q24	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A24Q25	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A24Q26	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q27	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q28	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A24Q29	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24Q30	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A24R1	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R2	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R3	0698-3452	R:FXD MET FLM 147k OHM 1% 1/8W	
A24R4	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A24R5	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R6	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A24R7	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R8	0698-3159	R:FXD MET FLM 26. 1k OHM 1% 1/8W	
A24R9	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A24R10	0757-0424	R:FXD MET FLM 1100 OHM 1% 1/8W	
A24R11	0757-0419	R:FXD MET FLM 681 OHM 1% 1/8W	
A24R12	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A24R13	0698-3155	R:FXD MET FLM 4640 OHM 1% 1/8W	
A24R14	0757-0424	R:FXD MET FLM 1100 OHM 1% 1/8W	
A24R15	0757-0274	R:FXD MET FLM 1. 21k OHM 1% 1/8W	
A24R16	0757-0447	R:FXD MET FLM 16. 2k OHM 1% 1/8W	
A24R17	0757-0200	R:FXD MET FLM 5620 OHM 1% 1/8W	
A24R18	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R19	0757-0447	R:FXD MET FLM 16. 2k OHM 1% 1/8W	
A24R20	0757-0416	R:FXD MET FLM 511 OHM 1% 1/8W	
A24R21	0757-0440	R:FXD MET FLM 7. 5k OHM 1% 1/8W	
A24R22	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A24R23	0698-3151	R:FXD MET FLM 2870 OHM 1% 1/8W	
A24R24		NOT ASSIGNED	
A24R25	0757-1094	R:FXD MET FLM 1470 OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No	Description	Note
A25IC1	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A25IC2	1820-0132	IC:TTL HEX INVERTER	
A25IC3	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A25IC4	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A25IC5	1820-0328	IC:TTL QUAD 2-INPUT NOR GATE	
A25Q1	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A25Q2	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A25Q3	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A25Q4	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A25Q5	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A25Q6	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A25Q7	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A25Q8	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A25Q9	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A25Q10	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A25Q11	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A25Q12	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A25Q13	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A25Q14	1854-0119	TRANSISTOR:NPN SILICON 2SC979	
A25Q15	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A25Q16	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A25Q17	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A25Q18	1854-0118	TRANSISTOR:NPN SILICON 2SC728B	
A25Q19	1854-0053	TRANSISTOR:NPN SILICON JEDEC 2N2218	
A25S1	3101-0973	SWITCH-SLIDE 0.5A 125V ACDC	
A25R1	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A25R2	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A25R3	0698-0084	R:FXD MET FLM 2150 OHM 1% 1/8W	
A25R4	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A25R5	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A25R6	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A25R7	0757-0444	R:FXD MET FLM 12.1k OHM 1% 1/8W	
A25R8	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A25R9	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A25R10	0757-0443	R:FXD MET FLM 11.0k OHM 1% 1/8W	
A25R11	0757-0463	R:FXD MET FLM 82.5k OHM 1% 1/8W	
A25R12	0698-0083	R:FXD MET FLM 1960 OHM 1% 1/8W	
A25R13	0757-0290	R:FXD MET FLM 6190 OHM 1% 1/8W	
A25R14	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A25R15	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
		MISCELLANEOUS	
	5040-5113	EXTRACTOR:RED	
	5040-5115	EXTRACTOR:YELLOW	
A25	04270-7745	SWITCHING CONTROL ASS'Y	
	04270-8745	BOARD:BLANK P.C.	
A25C1	0160-1544	C:FXD MYLAR 4700pF 5% 50VDCW	
A25CR1	1910-0016	DIODE:GERM	
A25CR2	1910-0016	DIODE:GERM	
A25CR3	1910-0016	DIODE:GERM	
A25CR4	1910-0016	DIODE:GERM	
A25CR5	1910-0016	DIODE:GERM	
A25CR6	1910-0016	DIODE:GERM	
A25CR7	1910-0016	DIODE:GERM	
A25CR8	1910-0016	DIODE:GERM	
A25CR9	1910-0016	DIODE:GERM	
A25CR10	1910-0016	DIODE:GERM	
A25CR11	1910-0016	DIODE:GERM	
A25CR12	1910-0016	DIODE:GERM	
A25CR13	1910-0016	DIODE:GERM	
A25CR14	1910-0016	DIODE:GERM	
A25CR15	1910-0016	DIODE:GERM	
A25CR16	1910-0016	DIODE:GERM	
A25CR17	1910-0016	DIODE:GERM	
A25CR18	1910-0016	DIODE:GERM	
A25CR19	1910-0016	DIODE:GERM	
A25CR20	1910-0016	DIODE:GERM	
A25CR21	1910-0016	DIODE:GERM	
A25CR22	1910-0016	DIODE:GERM	
A25CR23	1910-0016	DIODE:GERM	
A25CR24	1910-0016	DIODE:GERM	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A26	04270-7746	DC BIAS SUPPLY ASS'Y	
	04270-8746	BOARD:BLANK	
A26C1	0180-0374	C:FXD TANT 10μF 10% 20VDCW	
A26C2	0160-1305	C:FXD MPC 0.2μF 250VDCW ±10%	
A26C3	0160-1305	C:FXD MPC 0.2μF 250VDCW ±10%	
A26C4	0160-1554	C:FXD MYLAR 0.47μF 10% 200VDCW	
A26C5	0180-0825	C:FXD ALUM 47μF 25VDCW	
A26C6	0180-0374	C:FXD TANT 10μF 10% 20VDCW	
A26CR1	1902-3428	DIODE:BREAKDOWN 100V 5% 400mW	
A26CR2	1902-3428	DIODE:BREAKDOWN 100V 5% 400mW	
A26CR3	1910-0016	DIODE:GERM	
A26CR4	1901-0049	DIODE:SILICON 50PIV .75A	
A26CR5	1901-0049	DIODE:SILICON 50PIV .75A	
A26CR6	1901-0049	DIODE:SILICON 50PIV .75A	
A26CR7	1901-0049	DIODE:SILICON 50PIV .75A	
A26CR8	1902-0064	DIODE:BREAKDOWN 7.5V 5% 400mW	
A26CR9	1902-0049	DIODE:BREAKDOWN 6.19V 5% 400mW	
A26CR10	1902-0041	DIODE:BREAKDOWN 5.11V 5% 400mW	
A26CR11	1901-0025	DIODE:SILICON	
A26CR12	1910-0016	DIODE:GERM	
A26CR13	1910-0016	DIODE:GERM	
A26CR14	1901-0025	DIODE:SILICON	
A26CR15	1901-0025	DIODE:SILICON	
A26CR16	1901-0025	DIODE:SILICON	
A26CR17	1901-0025	DIODE:SILICON	
A26K1	0490-0213	RELAY REED:SRF-13A	
A26K2	0490-0213	RELAY REED:SRF-13A	
A26K3	0490-0213	RELAY REED:SRF-13A	
A26K4	0490-0213	RELAY REED:SRF-13A	
A26K5	0490-0213	RELAY REED:SRF-13A	
A26Q1	1854-0232	TRANSISTOR:NPN SILICON	
A26Q2	1853-0037	TRANSISTOR:PNP SILICON PD 1W FT 100MC	
A26Q3	1854-0221	TRANSISTOR:NPN SILICON DUAL	
A26Q4	1854-0221	TRANSISTOR:NPN SILICON DUAL	
A26Q5	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A26Q6	1854-0039	TRANSISTOR:NPN SILICON EIA 2N3053	
A26Q7	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A26Q8	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A26Q9	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A26Q10	1854-0053	TRANSISTOR NPN SILICON JEDEC 2N2218	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A25R16	0757-0444	R:FXD MET FLM 12.1k OHM 1% 1/8W	
A25R17	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A25R18	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
A25R19	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A25R20	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A25R21	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A25R22	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A25R23	0698-3447	R:FXD MET FLM 422 OHM 1% 1/8W	
A25R24	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A25R25	0698-3226	R:FXD MET FLM 6490 OHM 1% 1/8W	
A25R26	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A25R27	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A25R28	0698-3447	R:FXD MET FLM 422 OHM 1% 1/8W	
A25R29	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A25R30	0698-3226	R:FXD MET FLM 6490 OHM 1% 1/8W	
A25R31	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A25R32	0698-3447	R:FXD MET FLM 422 OHM 1% 1/8W	
A25R33	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A25R34	0698-4471	R:FXD MET FLM 7150 OHM 1% 1/8W	
A25R35	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A25R36	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A25R37	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A25R38	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
A25R39	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A25R40	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A25R41	0698-4014	R:FXD MET FLM 787 OHM 1% 1/8W	
A25R42	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
A25R43	0757-0440	R:FXD MET FLM 7500 OHM 1% 1/8W	
A25R44	0698-4014	R:FXD MET FLM 787 OHM 1% 1/8W	
A25R45	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
A25R46	0757-0440	R:FXD MET FLM 7500 OHM 1% 1/8W	
A25R47	0698-3178	R:FXD MET FLM 487 OHM 1% 1/8W	
A25R48	0757-0421	R:FXD MET FLM 825 OHM 1% 1/8W	
A25R49	0757-0441	R:FXD MET FLM 8250 OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5113	EXTRACTOR:RED	
	5040-5116	EXTRACTOR:GREEN	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A27	04270-7747	POWER SUPPLY (1) ASS'Y	
	04270-8747	BOARD:BLANK P. C.	
A27C1	0160-1544	C:FXD MYLAR 4700pF 100V ±5%	
A27C2	0180-0965	C:FXD ALUM 220μF 25VDCW	
A27C3	0180-0291	C:FXD TANT 1μF ±10% 35VDCW	
A27C4	0160-1544	C:FXD MYLAR 4700pF 100V ±5%	
A27C5	0180-0965	C:FXD ALUM 220μF 25VDCW	
A27C6	0160-1544	C:FXD MYLAR 4700pF 100V ±5%	
A27C7	0180-0104	C:FXD ALUM 200μF 15VDCW	
A27C8	0160-1544	C:FXD MYLAR 4700pF 100V ±5%	
A27C9	0180-0104	C:FXD ALUM 200μF 15VDCW	
A27C10	0160-1271	C:FXD POLYE 0.01μF 5% 100VDCW	
A27C11	0160-1271	C:FXD POLYE 0.01μF 5% 100VDCW	
A27CR1	1902-3171	DIODE:BREAKDOWN 11V 5% 400mW	
A27CR2	1902-3149	DIODE:BREAKDOWN 9.09V 5% 400mW	
A27CR3	1902-0049	DIODE:BREAKDOWN 6.19V 5% 400mW	
A27CR4	1902-3036	DIODE:BREAKDOWN 3.16V 5% 400mW	
A27CR5	1902-3036	DIODE:BREAKDOWN 3.16V 5% 400mW	
A27CR6	1884-0101	DIODE:THYRISTOR 2SF548	
A27CR7	1902-3059	DIODE:BREAKDOWN 3.83V 5% 400mW	
A27Q1	1854-0039	TRANSISTOR:NPN SILICON EIA 2N3053	
A27Q2	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A27Q3	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A27Q4	1854-0039	TRANSISTOR:NPN SILICON EIA 2N3053	
A27Q5	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A27Q6	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A27Q7	1854-0039	TRANSISTOR:NPN SILICON EIA 2N3053	
A27Q8	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A27Q9	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A27Q10	1854-0039	TRANSISTOR:NPN SILICON EIA 2N3053	
A27Q11	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A27Q12	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A27Q13	1854-0039	TRANSISTOR:NPN SILICON EIA 2N3053	
A27Q14	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A27Q15	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A27Q16	1853-0101	TRANSISTOR:PNP SILICON 2SA550A	
A27R1	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A27R2	0811-1553	R:FXD WW 68 OHM 5% 2W	
A27R3	0698-3152	R:FXD MET FLM 3480 OHM 1% 1/8W	
A27R4	0757-1094	R:FXD MET FLM 1.47k OHM 1% 1/8W	
A27R5	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A26R1	0683-1005	R:FXD COMP 10 OHM 5% 1/4W	
A26R2	0698-3700	R:FXD MET FLM 715 OHM 1% 1/8W	
A26R3	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A26R4	0757-0395	R:FXD MET FLM 56.2 OHM 1% 1/8W	
A26R5	0698-3445	R:FXD MET FLM 348 OHM 1% 1/8W	
A26R6	0757-0367	R:FXD MET FLM 100k OHM 1% 1/2W	
A26R7	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A26R8	0698-0083	R:FXD MET FLM 1960 OHM 1% 1/8W	
A26R9	0757-0317	R:FXD MET FLM 1.33k OHM 1% 1/8W	
A26R10	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A26R11	0757-0316	R:FXD MET FLM 42.2 OHM 1% 1/8W	
A26R12	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W	
A26R13	0757-0316	R:FXD MET FLM 42.2 OHM 1% 1/8W	
A26R14	2100-1753	R:VAR WW LIN 20 OHM 10% 1/2W	
A26R15	0698-4433	R:FXD MET FLM 2260 OHM 1% 1/8W	
A26R16	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A26R17	0757-0063	R:FXD MET FLM 196k OHM 1% 1/2W	
A26R18	0757-0447	R:FXD MET FLM 16.2k OHM 1% 1/8W	
A26R19	0698-3258	R:FXD MET FLM 5360 OHM 1% 1/8W	
A26R20	0698-4409	R:FXD MET FLM 127 OHM 1% 1/8W	
A26R21	0757-0367	R:FXD MET FLM 100k OHM 1% 1/2W	
A26R22	0698-3408	R:FXD MET FLM 2150 OHM 1% 1/2W	
A26R23	0757-0367	R:FXD MET FLM 100k OHM 1% 1/2W	
A26R24	0698-0083	R:FXD MET FLM 1960 OHM 1% 1/8W	
A26R25	0698-3498	R:FXD MET FLM 8660 OHM 1% 1/8W	
A26R26	0698-3153	R:FXD MET FLM 3830 OHM 1% 1/8W	
A26R27	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A26R28	2100-1757	R:VAR WW LIN 500 OHM 10% 1/2W	
A26R29	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A26R30	2100-1757	R:VAR WW LIN 500 OHM 10% 1/2W	
A26R31	0698-4444	R:FXD MET FLM 4870 OHM 1% 1/8W	
A26R32	0698-0083	R:FXD MET FLM 1960 OHM 1% 1/8W	
A26R33	0757-0280	R:FXD MET FLM 1k OHM 1% 1/8W	
A26R34	0757-0280	R:FXD MET FLM 1k OHM 1% 1/8W	
A26R35	0757-0280	R:FXD MET FLM 1k OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5111	EXTRACTOR:BLACK	
	5040-5117	EXTRACTOR:BLUE	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
A28	04270-7748	POWER SUPPLY (2) ASS'Y	
	04270-8748	BOARD:BLANK P.C.	
A28C1	0180-0825	C:FXD ALUM 47μF 25VDCW	
A28C2	0180-0988	C:FXD ALUM 22μF 315VDCW	
A28C3	0180-0988	C:FXD ALUM 22μF 315VDCW	
A28CR1	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR2	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR3	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR4	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR5	1902-3149	DIODE:BREAKDOWN 9.09V 5% 400mW	
A28CR6	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR7	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR8	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR9	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR10	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR11	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR12	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR13	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR14	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR15	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR16	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR17	1901-0049	DIODE:SILICON 50PIV .75A	
A28CR18	1901-0200	DIODE:SILICON 100PIV 3A SGL ENDED	
A28CR19	1901-0200	DIODE:SILICON 100PIV 3A SGL ENDED	
A28CR20	1901-0200	DIODE:SILICON 100PIV 3A SGL ENDED	
A28CR21	1901-0200	DIODE:SILICON 100PIV 3A SGL ENDED	
A28CR22	1901-0028	DIODE:SILICON 400PIV .75A	
A28CR23	1901-0028	DIODE:SILICON 400PIV .75A	
A28CR24	1901-0028	DIODE:SILICON 400PIV .75A	
A28CR25	1901-0028	DIODE:SILICON 400PIV .75A	
A28CR26	1901-0028	DIODE:SILICON 400PIV .75A	
A28CR27	1901-0028	DIODE:SILICON 400PIV .75A	
A28CR28	1901-0028	DIODE:SILICON 400PIV .75A	
A28CR29	1901-0028	DIODE:SILICON 400PIV .75A	
A28Q1	1854-0222	TRANSISTOR:NPN SILICON PD 10W FT 10MC	
A28Q2	1854-0232	TRANSISTOR:NPN SILICON	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A27R6	2100-1758	R:VAR WW LIN 1000 OHM 10% 1/2W	
A27R7	0757-0438	R:FXD MET FLM 5100 OHM 1% 1/8W	
A27R8	0683-5115	R:FXD COMP 510 OHM 5% 1/4W	
A27R9	0698-4453	R:FXD MET FLM 402 OHM 1% 1/8W	
A27R10	0683-0395	R:FXD COMP 3.90 OHM 5% 1/4W	
A27R11	0757-0428	R:FXD MET FLM 1620 OHM 1% 1/8W	
A27R12	2100-1758	R:VAR WW LIN 1000 OHM 10% 1/2W	
A27R13	0757-0440	R:FXD MET FLM 7500 OHM 1% 1/8W	
A27R14	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A27R15	0811-2466	R:FXD WW 1.2 OHM 5% 1/2W	
A27R16	0698-3152	R:FXD MET FLM 3480 OHM 1% 1/8W	
A27R17	0757-1094	R:FXD MET FLM 1.47k OHM 1% 1/8W	
A27R18	0757-0428	R:FXD MET FLM 1620 OHM 1% 1/8W	
A27R19	2100-1758	R:VAR WW LIN 1000 OHM 10% 1/2W	
A27R20	0698-3558	R:FXD MET FLM 4.02k OHM 1% 1/8W	
A27R21	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A27R22	0811-1553	R:FXD WW .68 OHM 5% 2W	
A27R23	0757-0273	R:FXD MET FLM 3.01k OHM 1% 1/8W	
A27R24	0757-0416	R:FXD MET FLM 511 OHM 1% 1/8W	
A27R25	0698-4428	R:FXD MET FLM 1.69k OHM 1% 1/8W	
A27R26	2100-1758	R:VAR WW LIN 1000 OHM 10% 1/2W	
A27R27	0757-0434	R:FXD MET FLM 3650 OHM 1% 1/8W	
A27R28	0757-0440	R:FXD MET FLM 7500 OHM 1% 1/8W	
A27R29	0812-0072	R:FXD WW POWER 0.23 OHM 5% 3W	
A27R30	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A27R31	0757-0416	R:FXD MET FLM 511 OHM 1% 1/8W	
A27R32	0757-0280	R:FXD MET FLM 1000 OHM 1% 1/8W	
A27R33	2100-1758	R:VAR WW LIN 1000 OHM 10% 1/2W	
A27R34	0757-0279	R:FXD MET FLM 3.16k OHM 1% 1/8W	
A27R35	0811-2616	R:FXD WW 12 OHM 3% 3W	
A27R36	0757-0397	R:FXD MET FLM 68.1 OHM 1% 1/8W	
A27R37	0698-4406	R:FXD MET FLM 115 OHM 1% 1/8W	
		MISCELLANEOUS	
	5040-5111	EXTRACTOR:BLACK	
	5040-5118	EXTRACTOR:VIOLET	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
B1	3160-0056	MOTOR:FAN	
	3150-0037	AIR FILTER	
C1	0160-1595	CAPACITOR:SM 0. 1μF -0. 02% - -0. 22%	
C2*	0140-0190	C:FXD DIPPED MICA 39pF 5% 300VDCW	
C3	0160-1596	C:FXD SM 0. 01μF -0. 1% - -0. 3%	
C4	0121-1229	C:VAR TRIMMER (AT:SP)	
C5	0160-1599	C:FXD GAS MICA 1000pF	
C6	04270-7028	C:FXD TRIMMER 5pF	
C7	0160-1597	C:FXD GAS MICA 100pF	
C8	04270-7029	C:VAR TRIMMER 2pF	
C9	04270-7027	C:VAR TRIMMER 10pF	
C10	0180-0993	C:FXD ALUM 2200μF 50VDCW	
	1520-0001	PRONG BASE	
C11	0180-0994	C:FXD ALUM 3300μF 25VDCW	
	1520-0001	PRONG BASE	
C12	0180-0992	C:FXD ALUM 2200μF 25VDCW	
	1520-0001	PRONG BASE	
C13	0180-0994	C:FXD ALUM 3300μF 25VDCW	
	1520-0001	PRONG BASE	
C14	0160-0127	C:FXD CER 1. 0μF 20% 25VDCW	
C15	0160-0127	C:FXD CER 1. 0μF 20% 25VDCW	
C16	0160-1544	C:FXD MYLAR 0. 0047μF 5% 100VDCW	
C17	0150-0121	C:FXD CER 0. 1μF -20 +80% 50VDCW	
CR1	1901-0025	DIODE:SILICON	
CR2	1901-0025	DIODE:SILICON	
CR3	1901-0025	DIEDE:SILICON	
DS1		LAMP:NEON NSR PART OF S2	
F1	2110-0339	FUSE:SB 0. 6A 250V FOR 200/230V OPERATION ONLY	
	2110-0305	FUSE:SB 1. 25A 250V FOR 100/115V OPERATION ONLY	
F2	2110-0027	FUSE:NB 1/8A 250V	
J1	1250-0314	CONNECTOR:BNC	
J2	1250-0314	CONNECTOR:BNC	
	04270-5022	INSULATOR	
J3	1510-0038	CONNECTOR:BINDING POST GROUND TERMINAL	
J4	1510-0009	CONNECTOR:BINDING POST BLACK	
	0340-0221	INSULATOR	
J5	5060-4003	CONNECTOR:BINDING POST W/SHORT STRAP	
	0340-0221	INSULATOR	
J6	1250-0118	CONNECTOR:BNC	
	5040-0702	INSULATOR, 2 REQ'D	
J7	1250-0083	CONNECTOR:BNC	
J8	1510-0038	CONNECTOR:BINDING POST, GROUND TERMINAL	
J9	1251-0087	CONNECTOR:FEMALE 50 CONTACTS	
J10	1251-0087	CONNECTOR:FEMALE 50 CONTACTS	
J11	1251-0292	CONNECTOR:FEMALE 24 CONTACTS	
J12	1251-0148	CONNECTOR:LINE 3-PIN MALE	
J13	1251-0711	CONNECTOR:MICROPHONE RECEPTACLE	
J14	1250-0312	CONNECTOR:MTS-RB-171-Au	
J15	1250-0312	CONNECTOR:MTS-RB-171-Au	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
A28R1	0757-0411	R:FXD MET FLM 332 OHM 1% 1/8W	
A28R2	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A28R3	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A28R4	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A28R5	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A28R6	0686-3645	R:FXD COMP 360k OHM 5% 1/2W	
A28R7	0698-3415	R:FXD MET FLM 19. 6k OHM 1% 1/2W	
A28R8	0698-3452	R:FXD MET FLM 147k OHM 1% 1/8W	
A28R9	0698-4431	R:FXD MET FLM 2050 OHM 1% 1/8W	
A28R10	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
A28R11	0686-3645	R:FXD COMP 360k OHM 5% 1/2W	
		MISCELLANEOUS	
	5040-3304	HOLDER:ELECT CAPACITOR: 2 REQ'D	
	5040-5111	EXTRACTOR:BLACK	
	5040-4529	EXTRACTOR:GRAY	
	04270-1055	RADIATION PLATE	
A29		NOT ASSIGNED	
A30	04270-7750	DIODE ASS'Y	
	04270-8750	BOARD:BLANK P. C.	
A30CR1	1901-0040	DIODE:SILICON	
A30CR2	1901-0040	DIODE:SILICON	
A30CR3	1901-0040	DIODE:SILICON	
A30CR4	1901-0040	DIODE:SILICON	
A30CR5	1902-3082	DIODE:BREAKDOWN 4. 64V	
A30CR6	1902-3082	DIODE:BREAKDOWN 4. 64V	
A30CR7	1902-3082	DIODE:BREAKDOWN 4. 64V	
A30CR8	1902-3082	DIODE:BREAKDOWN 4. 64V	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
J16	1250-0312	CONNECTOR:MTS-RB-171-Au	
J17	1250-0312	CONNECTOR:MTS-RS-171-Au	
J18	1250-0083	CONNECTOR:BNC	
J19	1250-0083	CONNECTOR:BNC	
K1	0490-0217	RELAY:SP 4T, SMAT 4-BW	
P1	1250-0109	CONNECTOR:RF PLUG	
P2	1250-0109	CONNECTOR:RF PLUG	
Q1	1854-0063	TRANSISTOR:NPN SILICON 2N3055	
	1200-0077	INSULATOR:TRANSISTOR	
	1200-0041	SOCKET:TRANSISTOR	
Q2	1854-0063	TRANSISTOR:NPN SILICON 2N3055	
	1200-0077	INSULATOR:TRANSISTOR	
	1200-0041	SOCKET:TRANSISTOR	
Q3	1854-0063	TRANSISTOR:NPN SILICON 2N3055	
	1200-0077	INSULATOR:TRANSISTOR	
	1200-0041	SOCKET:TRANSISTOR	
Q4	1854-0063	TRANSISTOR:NPN SILICON 2N3055	
	1200-0077	INSULATOR:TRANSISTOR	
	1200-0041	SOCKET:TRANSISTOR	
R1	2100-1186	R:VAR WW 5k OHM 5%	
	04270-5026	INSULATOR	
	0370-0133	KNOB:SKIRTED BAR BLK 1 ARROW	
R2	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W	
R3	0698-4502	R:FXD MET FLM 64.9k OHM 1% 1/8W	
R4*	0683-5655	R:FXD COMP 5.6M OHM 5% 1/4W	
R5*	0683-4755	R:FXD COMP 5.7M OHM 5% 1/4W	
S1	3101-0063	SWITCH:PUSH BUTTON SPST 100mA 115VAC	
S2	3101-1248	SWITCH:POWER	
S3	3101-0033	SWITCH:SLIDE DPDT	
S4	3101-0063	SWITCH:PUSH BUTTON SPST	
S5	3101-1327	SWITCH:SLIDE DP3T	
T1	9100-0774	TRANSFORMER:POWER	
W1	8120-1348	CABLE ASS'Y 7.5FT POWER CORD	
XA1 L	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA1 R	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA2		NOT ASSIGNED	
XA3	1251-1388	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA4L	1251-0333	CONNECTOR:PRINTED CIRCUIT 20 CONTACTS	
XA4R	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA4T	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	

See list of abbreviations in introduction to this section

Reference Designation	Stock No.	Description	Note
XA5L	1251-0333	CONNECTOR:PRINTED CIRCUIT 20 CONTACTS	
XA5R	1251-0159	CONNECTOR:PRINTED CIRCUIT 20 CONTACTS	
XA5T	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA6		NOT ASSIGNED	
XA7	1251-0194	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA8	1251-0194	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA9		NOT ASSIGNED	
XA10L	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA10R	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA11L	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA11R	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA12L	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA12R	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA13L	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA13R	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA14L	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA14R	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA15L	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA15R	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA16L	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA16R	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA17		NOT ASSIGNED	
XA18L	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA18R	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA19L	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA19R	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA20L	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA20R	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA21L	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA21R	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA22L	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA22R	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA23L	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA23R	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA24L	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA24R	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA25L	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA25R	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA26L	1251-0160	CONNECTOR:PRINTED CIRCUIT 15 CONTACTS	
XA26R	1251-0497	CONNECTOR:PRINTED CIRCUIT 10 CONTACTS	
XA27L	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA27R	1251-0497	CONNECTOR:PRINTED CIRCUIT 10 CONTACTS	

See list of abbreviations in introduction to this section

Table 6-2, Reference Designation Index (Cont'd)

Reference Designation	Stock No.	Description	Note
XA28L	1251-0159	CONNECTOR:PRINTED CIRCUIT 30 CONTACTS	
XA28R	1251-0497	CONNECTOR:PRINTED CIRCUIT 10 CONTACTS	
XF1	1400-0084	HOLDER:FUSE 3AG FUSE EXTRACTOR	
XF2	1400-0008	HOLDER:FUSE, CLIP	
		MISCELLANEOUS	
	04270-7729	EXTENDER	
	04270-7737	EXTENDER	
	04270-7749	SWITCH BOARD CONNECTING	

· See list of abbreviations in introduction to this section

SECTION VII
MANUAL CHANGES AND OPTIONS

7-1. OPTIONS

7-2. Options are standard modifications performed on HP instruments at the factory. Models 4270A Option 001, 002, 003 and 005 are provided with test voltages different from those of the standard instrument. Model 4270A Option 004 has been modified to subtract the extra capacitance and conductance involved in the unknown. The following paragraphs discuss the Model 4270A Options 001, 002, 003, 005 and 004.

7-3. OPTION 001, 002, 003 AND 005.

7-4. DESCRIPTION

7-5. Models 4270A Option 001, 002, 003 and 005 differ from the standard model in the test voltage and accordingly in accuracy and repeatability. Test voltages of these options are shown in Table 7-1. Accuracy and repeatability are shown in Table 7-2 and Table 7-3.

Table 7-1. Test Voltages of Options 001, 002, 003 and 005.

Option No.	Test Voltage (depends on frequency and range)			
		1 kHz		10k, 100k, 1MHz
		1 μF Range	Other Ranges	All Ranges
Option 001	NORM	0.1 V	1 V	1 V
	LOW	20 mV	200 mV	200 mV
Option 002	NORM	0.1 V	1 V	0.5 V
	LOW	5 mV	50 mV	25 mV
Option 003	NORM	0.1 V	1 V	1 V
	LOW	2.5 mV	25 mV	25 mV
Option 005	NORM	0.1 V	1 V	0.5 V
	LOW	8 mV	80 mV	40 mV

Table 7-3. Repeatability of Options 001, 002, 003 and 005

Option No.	Test Voltage	Capacitance & Conductance		Dissipation Factor	
		1kHz	10k, 100k, 1MHz	1kHz	10k, 100k, 1MHz
Option 001	NORM	±2 counts		±2 Cs/Cx counts	
	LOW	±8 counts		±8 Cs/Cx counts	
Option 002	NORM	±2 counts		±2 Cs/Cx counts	
	LOW	±10 counts	±20 counts	±10 Cs/Cx counts	±20 Cs/Cx counts
Option 003	NORM	±2 counts		±2 Cs/Cx counts	
	LOW	±20 counts		±20 Cs/Cx counts	
Option 005	NORM	±2 counts		±2 Cs/Cx counts	
	LOW	±8 counts	±10 counts	±8 Cs/Cx counts	±10 Cs/Cx counts

Note: $\epsilon = 20(\frac{Cx}{Cs} - 1.3)$ If $\epsilon < 0$, let $\epsilon = 0$

Option No.		Test Voltage	1 kHz 1 µF Range	1 kHz All Other Ranges	10 kHz All Ranges	100 kHz All Ranges	1 MHz All Ranges
Option 001	Capacitance	NORM	Same as standard				
		LOW	Same as standard				
	Conductance	NORM	Same as standard				$\pm 3\% + (\pm 10 - \epsilon)$ counts
		LOW	Same as standard				
	Dissipation Factor	NORM	Same as standard				$\pm 3\% + (\pm 10 \pm \frac{Cs}{Cx} - \epsilon)$ counts
		LOW	Same as standard				
Option 002	Capacitance	NORM	Same as standard				
		LOW	$\pm(1\% + 15$ counts)	$\pm(0.3\% + 15$ counts $+ 0.01$pF)	$\pm(0.5\% + 30$ counts $+ 0.01$pF)	$\pm(0.7\% + 0.01$pF $+ 30$ counts)	$\pm(1.4\% + 0.01$pF $+ 30$ counts
	Conductance	NORM	Same as standard				
		LOW	$\pm(2\% + 20$ counts)	$\pm(1.2\% + 20$ counts)	$\pm(1.4\% + 35$ counts)		$\pm(3.4\% + 35$ counts)
	Dissipation Factor	NORM	Same as standard				
		LOW	$\pm\{(3+0.15\frac{Cs}{Cx})\% + (10+10\frac{Cs}{Cx})$counts$\}$	$\pm\{(1.4+0.15\frac{Cs}{Cx})\% + (10+10\frac{Cs}{Cx})$counts$\}$	$\pm\{(1.8+0.3\frac{Cs}{Cx})\% + (10+20\frac{Cs}{Cx})$counts$\}$		$\pm\{(3.8+0.3\frac{Cs}{Cx})\% + (10+20\frac{Cs}{Cx})$counts$\}$
Option 003	Capacitance	NORM	Same as standard				
		LOW	$\pm(2\% + 30$ counts)	$\pm(0.5\% + 30$ counts $+ 0.01$pF)		$\pm(0.7\% + 30$ counts $+ 0.01$pF)	$\pm(1.4\% + 30$ counts $+ 0.01$pF)
	Conductance	NORM	Same as standard				$\pm 3\% + (\pm 10 - \epsilon)$ counts
		LOW	$\pm(3\% + 35$ counts)	$\pm(1.4\% + 35$ counts)			$\pm(3.4\% + 35$ counts)
	Dissipation Factor	NORM	Same as standard				$\pm 3\% + (\pm 10 \pm \frac{Cs}{Cx} - \epsilon)$ counts
		LOW	$\pm\{(5+0.3\frac{Cs}{Cx})\% + (10+20\frac{Cs}{Cx})$counts$\}$	$\pm\{(1.8+0.3\frac{Cs}{Cx})\% + (10+20\frac{Cs}{Cx})$counts$\}$			$\pm\{(3.8+0.3\frac{Cs}{Cx})\% + (10+20\frac{Cs}{Cx})$counts$\}$
Option 005	Capacitance	NORM	Same as standard				
		LOW	$\pm(1\% + 15$ counts)	$\pm(0.2\% + 8$ counts $+ 0.01$pF)	$\pm(0.3\% + 15$ counts $+ 0.01$pF)	$\pm(0.5\% + 15$ counts $+ 0.01$pF)	$\pm(1.2\% + 15$ counts $+ 0.01$pF)
	Conductance	NORM	Same as standard				
		LOW	$\pm(2\% + 20$ counts)	$\pm(1.1\% + 17$ counts)	$\pm(1.2\% + 20$ counts)		$\pm(3.2\% + 20$ counts)
	Dissipation Factor	NORM	Same as standard				
		LOW	$\pm\{(3+0.15\frac{Cs}{Cx})\% + (10+10\frac{Cs}{Cx})$counts$\}$	$\pm\{(1.3+0.1\frac{Cs}{Cx})\% + (10+7\frac{Cs}{Cx})$counts$\}$	$\pm\{(1.4+0.15\frac{Cs}{Cx})\% + (10+10\frac{Cs}{Cx})$counts$\}$		$\pm\{(3.8+0.3\frac{Cs}{Cx})\% + (10+20\frac{Cs}{Cx})$counts$\}$

Table 7-2. Accuracy of 4270A Option 001, 002, 003 and 005.

7-6. DIFFERENCE IN PARTS AND WIRING

7-7. Change in test voltage is given by the change in A13 OSC & BUFFER AMP ASS'Y. Some parts and wiring of the OSC & BUFFER AMP ASS'Y A13 are changed from those of the standard 4270A as shown in Table 7-4. The OSC & BUFFER AMP ASS'Y A13 of each option has different Part Numbers due to the parts change.

7-8. OPTION 004.

7-9. DESCRIPTION.

7-10. The 4270A Option 004 shown in Figure 1 differs from the standard instrument in that it is provided with compensation connectors. When a compensation capacitor with capacitance Cc and conductance Gc is connected to the compensation connectors, the 4270A Option 004 displays Cx-Cc and Gx-Gc, for the unknown capacitor with capacitance Cx and conductance Gx. This off-set function is effective for the cancellation of undesirable stray capacitance in the special test fixture or measuring cables, or for the measurement of the change in capacitance of a variable capacitor from its minimum value with respect to the mechanical deviation such as rotation angle.

7-11. SPECIFICATIONS.

7-12. The specifications for capacitance and conductance measurements of the Model 4270A Option 004 are identical to those of the standard instrument

Table 7-4. Parts and Wiring Change in Options.

Option No. / Part No. of A13	Different Parts in A13	Wiring Change
Option 001 04270-7733	Same as the standard R40: 0698-3442 R:FXD MET FLM 237Ω 1% 1/8W R41: 0757-0421 R:FXD MET FLM 825Ω 1% 1/8W	Delete the wire(9.6.8.) connecting XA13(6L) and XA13(13R). Ground XA13(13R) to the chassis.
Option 002 04270-7751	R40*: 0757-0394 R:FXD MET FLM 51.1Ω 1% 1/8W R41: 0698-4125 R:FXD MET FLM 953Ω 1% 1/8W	Same as the standard.
Option 003 04270-7752	R40*: 0698-3431 R:FXD MET FLM 23.7Ω 1% 1/8W R41: 0698-4125 R:FXD MET FLM 953Ω 1% 1/8W	Delete the wire(9.6.8.) connecting XA13(6L) and XA13(13R). Ground XA13(13R) to the chassis.
Option 005 04270-7754	R40*: 0757-0399 R:FXD MET FLM 82.5Ω 1% 1/8W R41: 0757-0422 R:FXD MET FLM 909Ω 1% 1/8W	Same as the standard.

Figure 7-1. Model 4270A Option 004.

when no capacitance or conductance is connected to the compensation connectors. When a capacitance or conductance is connected to the compensation connectors, the following specifications also apply:

a. Loss Measurement: Loss component can be measured only in conductance G.

b. Measurement accuracy after off-setting the residual capacitance and conductance for both a capacitance and a conductance reading of 0000 by connecting appropriate capacitance and conductance to the compensation connectors: Accuracy of capacitance and conductance is the same as that of the standard 4270A. Maximum value of capacitance Cc and conductance Gc to be connected to the compensation connectors is listed in Table 7-5.

Table 7-5. Maximum Capacitance and Conductance for Compensation Conductor

Frequency	C Range	Cc Max	Gc Max
1, 10, 100kHz	1000pF & above 100pF 10pF	3000pF 300pF 30pF	$\frac{Gs}{100}$
1 MHz	1000pF 100pF 10pF	100pF 50pF 5pF	for all conductance ranges

c. Measurement accuracy after off-setting the residual capacitance to 0000. (without cancelling residual conductance): Capacitance accuracy is about same as that of standard 4270A. conductance accuracy has additional errors that are explained as follows.

at 1kHz and 10kHz
STD 4270A Accuracy $\pm(200\cdot\frac{Gc}{Gs}+1)$ counts

at 100kHz and 1MHz
STD 4270A Accuracy $\pm(1000\cdot\frac{Gc}{Gs}+2)$ counts

d. For measurements with compensation capacitor connected to the compensation connectors: When a capacitor of capacitance Cx and conductance Gx is connected to the unknown connectors and a compensation capacitor of Cc and Gc is connected to the compensation connectors, capacitance display is Cx-Cc and conductance display is Gx-Gc at all ranges except for $1\mu F$ range, Cx-10Cc and Gx-10Gc at $1\mu F$ range. And Cc and Gc in display have errors as follows:

Error in Cc (when Gc is less than $\frac{Gs}{100}$)
within ±2% of Cc value at 1, 10, and 100kHz
within ±10% of Cc value at 1MHz

Error in Gc (when Cc is less than $\frac{Cs}{100}$)
within $\pm(200\cdot\frac{Gc}{Gs}+1)$ counts at 1 and 10kHz

within $\pm(1000\cdot\frac{Gc}{Gs}+2)$ counts at 100kHz and 1MHz

Note

If Cc or Gc is greater than Cx, the display of capacitance or conductance is 0000. the 4270A does not disply negative values.

e. Over compensation display: When Cc is greater than Cx, over compensation lamp is lit (the capacitance display is 0000). No over compensation lamp is provided for conductance. Over compensation lamp illuminates Cc > Cxs just below the OUT OF RANGE display portion.

f. All other specifications are same as those of standard 4270A.

7-13. OPERATION.

7-14. Front panel controls, connectors and indicators of the Model 4270A Option 004 which are different from those of the standard 4270A are shown in Figure 7-2.

7-15. CANCELLATION OF STRAY CAPACITANCE.

7-16. When a measurement using test fixture or measuring cable is performed on the unknown capacitor Cx, and cancellation of the stray capacitance Cxs in the test fixture or measuring cable is required, capacitance equal to Cxs should be connected to a COMPENSATION connectors. For an accurate compensation, a stable and fine adjustable capacitor should be used. The procedures for compensation with a variable capacitor connected to the COMPENSATION connectors are:

a. Connect the test fixture or measuring cable with no capacitor mounted on it to the UNKNOWN connectors. Stray capacitance of the test fixture or measuring cable is read on the capacitance display.

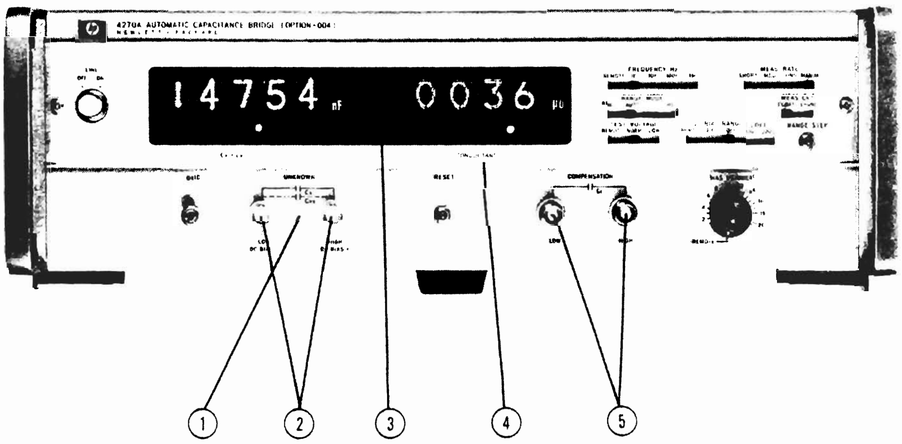
b. Connect a variable capacitor to the COMPENSATION connectors. Increase the capacitance of the variable capacitor and observe that the reading decreases for an increase in the variable capacitance. Stop increasing the variable capacitance when the reading becomes zero and the Over Compensation indicator is lit.

c. Mount a sample with capacitance Cx on the test fixture or measuring cable. Cx is displayed, with stray capacitance Cxs excluded, in the accuracy specified for the standard Model 4270A.

7-17. THEORY OF OPERATION.

7-18. BRIDGE SECTION

7-19. The simplified block diagram of the Model 4270A Option 004 is shown in Figure 7-3. This description of operating principles utilizes Figure 7-3. The Cc Amplifier A8 has been modified to be an inverting amplifier with unity gain by changing the feedback network of the D Amplifier in the standard 4270A. The output of the Cc Amplifier is 180 degrees out of phase with respect to the voltage ex for the unknown and is connected to the HIGH terminal of the



1. Cx + Cxs - Cc indicates that the capacitance display shows the difference between the capacitance across the UNKNOWN connectors (Cx + Cxs) and the COMPENSATION connector (Cx).

2. UNKNOWN connectors: Panel Markings for Cx and Cxs across connectors indicate that the capacitance connected to the UNKNOWN connectors includes a stray capacitance Cxs introduced by special test fixtures or measuring cables.

3. Cc > Cxs when illuminated, indicates that the capacitance connected to the COMPENSATION connectors is greater than the stray capacitance Cxs across the UNKNOWN connectors when no sample with capacitance Cx is connected to the UNKNOWN connectors. If some capacitance Cx is connected to the UNKNOWN connectors, this indicator is illuminated when the capacitance across the COMPENSATION connectors(Cc) is greater than that across the UNKNOWN connectors(Cx + Cxs).

4. CONDUCTANCE indicates that the loss component is measured only in conductance Therefore LOSS MEAS switch is eliminated.

5. COMPENSATION connectors are provided in place of REMOTE RESET connector for cancelling the undesirable extra capacitance included in the capacitance across the UNKNOWN connectors. The remote reset function is performed through ENCODE / RESET connector or REMOTE connector on the rear panel, as shown in Figure 3-7.

Figure 7-2. Front Panel Controls, Connectors and Indicators

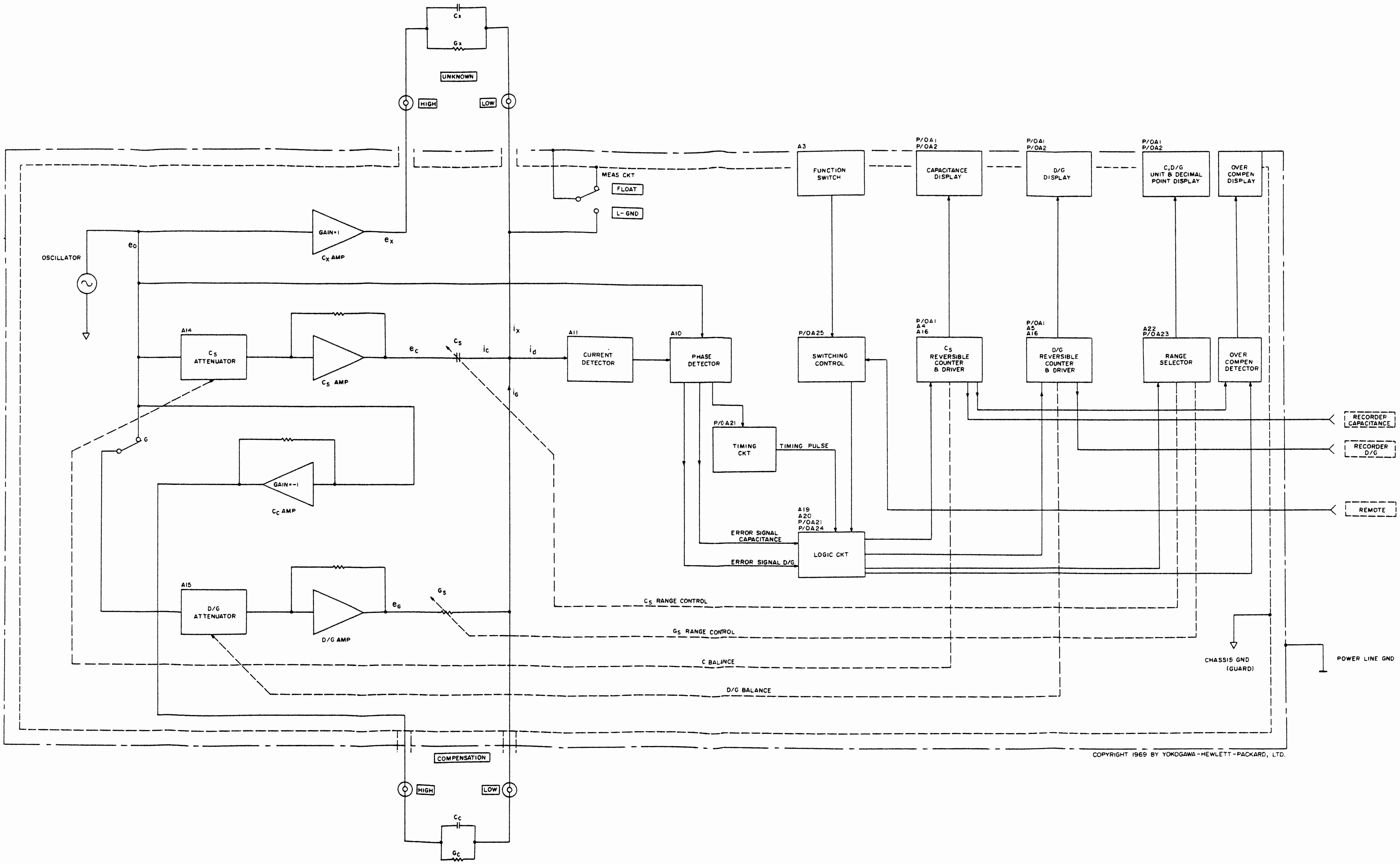


Figure 7-3. Simplified Block Diagram of Model 4270A Option 004.

COMPENSATION connectors. The current through the compensation capacitor Cc is:

$$-j\omega Cc \cdot e_x - Gc \cdot e_x$$

At the bridge balance, the sum of the currents through the unknown and the current through the compensation capacitor are equal to the current through the standard capacitance and conductance. Therefore,

$$j\omega Cx \cdot e_x - j\omega Cc \cdot e_x + Gx \cdot e_x - Gc \cdot e_x = j\omega Cs \cdot e_c + Gs \cdot e_G$$

$$\therefore Cx - Cc = Cs \cdot \frac{e_c}{e_x}$$

$$Gx - Gc = Gs \cdot \frac{e_G}{e_x}$$

These equations apparently indicate that the values (Cx - Cc) and (Gx - Gc) are shown by the ratios e_c/e_x and e_G/e_x, which are determined by the Cs and D/G attenuator settings. The attenuators are numerically controlled by Cs and D/G Reversible Counter & Driver so that the values (Cx-Cc) and (Gx-Gc) determined by the e_c/e_x and e_G/e_x equal to the capacitance and D/G display. Figure 7-5 shows the circuit diagram of the Cc Amplifier.

7-20. LOGIC SECTION (OVER COMPENSATION DETECTOR).

7-21. The function of A31 Over Compensation Detector Ass'y (shown in Figure 7-4) is to detect the point where the capacitance for compensation is equal to the capacitance connected to the UNKNOWN connectors and then produce a pulse to drive the lamp for the over compensation indicator (Cc>Cxs). The Over Compensation Detector provides a lamp driving pulse only when the Null Circuit in A20 detects the null condition and produces the Balancing Out signal (P_N) by receiving the Down signal(D1) from the C Sampling Gate circuit in A19 under the condition of Cs(00000). The Balancing Out signal(P_N) is inverted to a positive-going pulse by IC1A and is connected to one of the inputs of IC1B. Under the above mentioned null condition, the other input to IC1B is high during the Balancing Out signal duration. Therefore the output signal at IC1B6 is a negative-going signal synchronous with the Balancing Out signal and is differentiated by the capacitor C1. The signal connected to the resistor R2 is of 0V level so the input of IC1C13 is a signal differentiated on a DC level of about 2.5V, as shown in Figure 7-6. The duration when the waveform at IC1C13 is under the logic "0" level determines the width of the pulse at IC1C11. This is dependent on the time constant of C1, R1 and R2. The output pulse of IC1C charges the capacitor C2 through the resistor R3. When the charged voltage across the capacitor C2 exceeds the threshold level of the transistor Q1, the driving current for the over compensation indicator lamp flows through Q1.

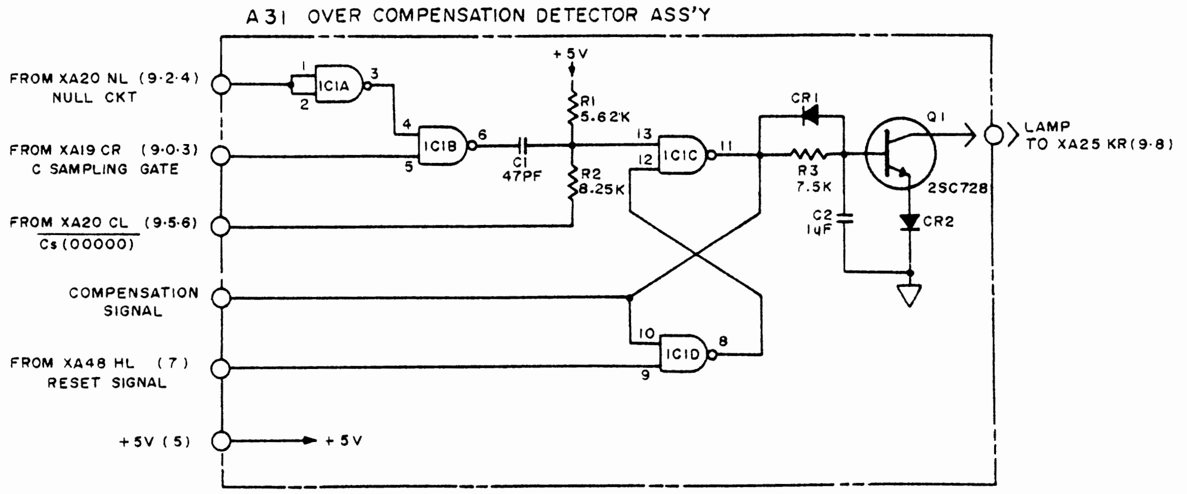


Figure 7-4. Over Compensation Detector

7-22. PERFORMANCE CHECK AND ADJUSTMENT.

7-23. 1 kHz CHECK

a. Set 4270A Opt 004 as follows:

FREQ .... 1 kHz
MEAS RATE .... SHORT or MED
RANGE MODE .... HOLD
MEAS CKT .... FLOAT
TEST VOLTAGE .... NORM
DC BIAS RANGE .... OFF

b. Depress RANGE STEP button to obtain 10.000 nF range.

c. Connect a 4440B set at .0100 μF to UNKNOWN connectors, read capacitance(C_1) and conductance(G_1) and record them.

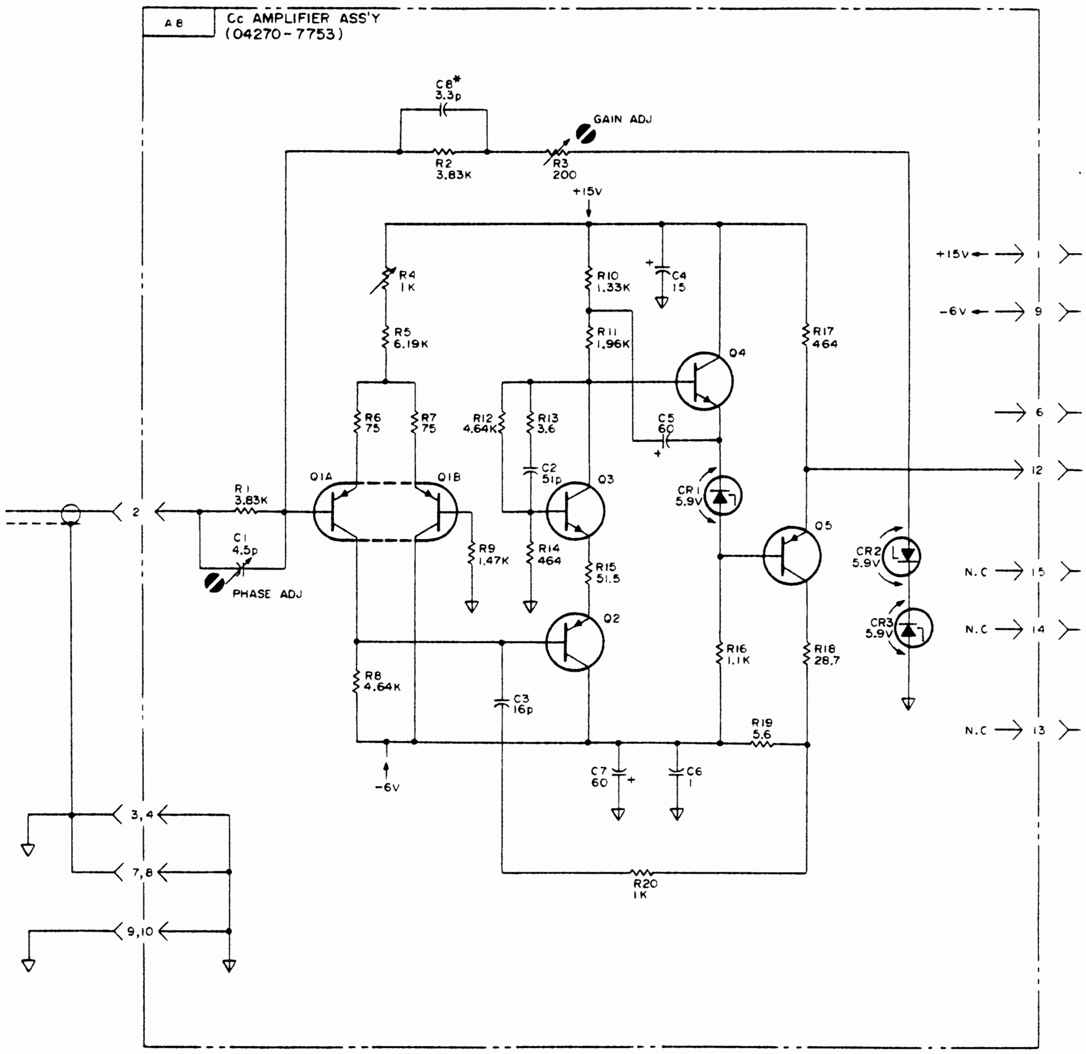


Figure 7-6. Cc Amplifier

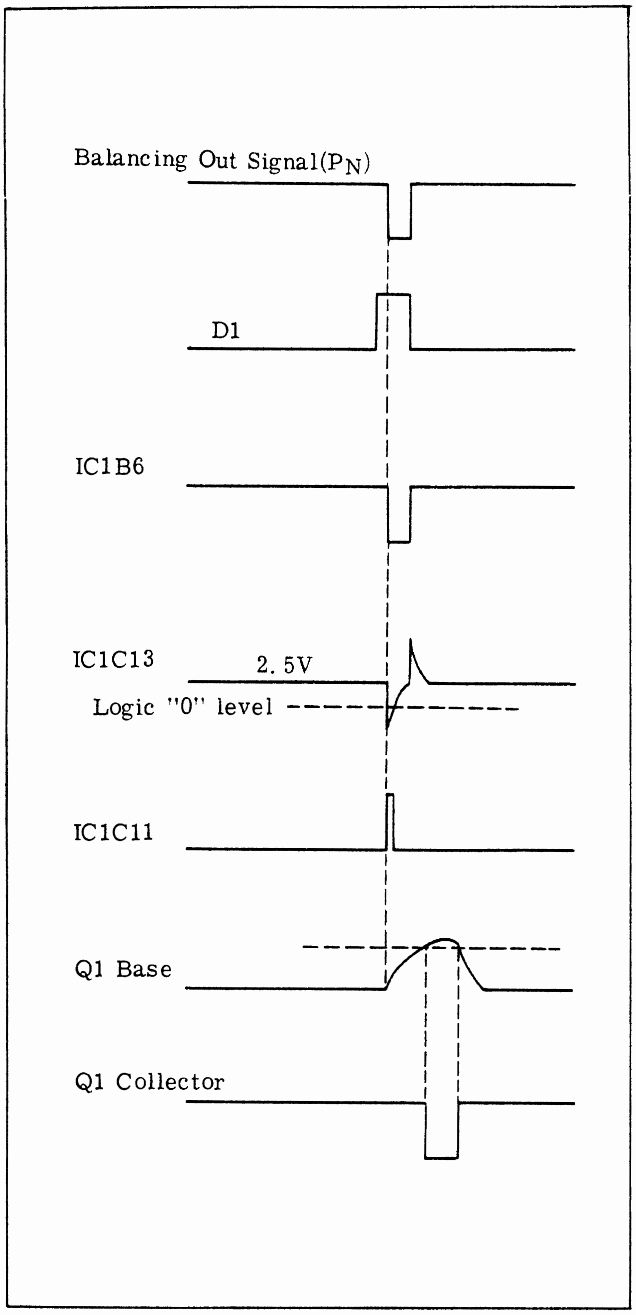


Figure 7-5. Timing Diagram of Over Compensation Detector

d. Disconnect the 4440B used in step c, and connect another 4440B to UNKNOWN connectors. Set the 4440B and record capacitance and conductance of each setting as shown in Table 7-6. And then disconnect the 4440B and connect it to COMPENSATION connectors.

Note

Don't move the setting of 4440B VERNIER control.

7-24. 100 KHz CHECK.

a. Disconnect two 4440B's from UNKNOWN and COMPENSATION connectors. Connect two BNC tees(HP Part No. 1250-0781) to UNKNOWN connectors. Set FREQ of 4270A Opt 004 to 100 kHz. Depress RANGE STEP button until 10.000 nF range is obtained.

b. Connect a 4440B set at .0029 μF across each end of two BNC tees and adjust 4440B VERNIER control for 4270A Opt 004 reading of 03.000nF.

c. Connect another 4440B to COMPENSATION connectors and set it at .0009μF. Change 4440B setting by .001 μF step until the setting becomes .0029μF, and observe that the 4270A readings decrease by about 1nF step in the process. Adjust 4440B VERNIER control for 4270A Opt 004 reading of 00.000nF.

d. Connect a capacitor with calibrated capacitance and conductance values to the other ends of two BNC tees connected to UNKNOWN connectors. Check that the readings of capacitance and conductance are within the accuracy specified for the standard 4270A:

Capacitance accuracy at 100 kHz
0.3% of reading + 1 count ±0.01 pF

Conductance accuracy at 100 kHz
1% of reading -10 counts

e. Connect the 4440B used in step c with the same settings. Check that the readings at the settings of 4440B connected to COMPENSATION connectors are within the tolerances shown in Table 7-6.

Table 7-6. 4270A Opt 004, 1 kHz Check

4440B Setting	4270A Opt 004 Reading		Reading of Difference		
	Capacitance	Conductance	Capacitance	Conductance	
.0009	C_{21}	G_{21}	$C_1 - C_{21}$ ±20 counts	$G_1 - 3G_{21}$	$G_1 + G_{21}$
.0019	C_{22}	G_{22}	$C_1 - C_{22}$ ±40 counts	$G_1 - 3G_{22}$	$G_1 + G_{22}$
.0029	C_{23}	G_{23}	$C_1 - C_{23}$ ±60 counts	$G_1 - 3G_{23}$	$G_1 + G_{23}$

7-25. 1 MHz CHECK

a. Disconnect the capacitor and the two 4440B's from UNKNOWN and COMPENSATION connectors. Set FREQ of 4270A Opt 004 to 1 MHz. Depress RANGE STEP button until 10.000pF range is obtained.

b. Connect a capacitor with capacitance Cs of about around 3pF and a conductance Gs less than 1 $\mu℧$, across each end of two BNC tees. Connect a variable capacitor and a variable resistor in parallel to COMPENSATION connectors.

c. Adjust the variable capacitor and variable resistor for a capacitance reading of 00.000 pF and a conductance reading of 00.00 $\mu℧$.

d. Connect a capacitor with calibrated capacitance and conductance values to the other ends of the two BNC tees connected to UNKNOWN connectors. Check that the readings of capacitance and conductance are within the accuracy specified for a standard 4270A:

Capacitance accuracy at 1 MHz
1% of reading + 1 count + 0.01 pF

Conductance accuracy at 1 MHz
3% of reading + 10 counts

7-26. GAIN ADJUSTMENT FOR Cc AMPLIFIER.

a. Set 4270A Opt 004 as follows

FREQ	1kHz
MEAS RATE	SHORT or MED
RANGE MODE	HOLD
MEAS CKT	FLOAT
TEST VOLTAGE	NORM
DC BIAS RANGE	OFF

Depress RANGE STEP button to obtain 10.000nF range.

b. Connect a 4440B set at .0029 to UNKNOWN connectors and adjust 4440B VERNIER for the 4270A Opt 004 reading of 3.000 nF. Record the conductance reading, G_1 $\mu℧$. Disconnect 4440B from the 4270A Opt 004 and keep the digital and VERNIER Settings unchanged.

c. Connect another 4440B set at .0100 to UNKNOWN connectors and record capacitance and conductance readings, C_2 nF and G_2 $\mu℧$.

d. Connect the 4440B used in step b to COMPENSATION connectors. Adjust A8R3 for a capacitance reading of $(C_2 - 3.000)$ nF.

7-27. 1 MHz PHASE ADJUSTMENT

a. Change 4270A Opt 004 FREQ to 1MHz and depress RANGE STEP button to obtain 100.00-pF range. Disconnect the 4440B from COMPENSATION connectors, set the VERNIER dial of the 4440B connected to UNKNOWN connectors at 50pF and record the 4270A Opt 004 readings of capacitance C1 and conductance G1.

b. Disconnect the 4440B from UNKNOWN connectors, connect another 4440B to UNKNOWN connectors, set the VERNIER dial at 100pF and read capacitance (C2) and conductance (G2) readings.

c. Connect the 4440B the capacitance and the conductance of which is measured in step a to COMPENSATION connectors. Adjust A8C1 for the conductance reading of $(G_2 - G_1)$ ±1 count, and make sure that the capacitance reading is $(C_2 - C_1)$ ±100 counts.

7-28. PARTS LIST

7-29. The parts listed in Table 7-7 are the parts that were changed or added to the standard 4270A to make the Option 004. Components for A8 Cc Amplifier and A31 Over Compensation Detector are listed in Table 7-8.

Table 7-7. Parts Change for Option 004

Description of Change	Parts Peculiar to Opt 004	Equivalent Parts in the Standard 4270A
Cc Amplifier is added.	A8 04270-7753 Cc AMP ASS'Y	A8 04270-7728 AMP ASS'Y
COMPENSATION connectors are installed.	J20, J21 1250-0118	None (REMOTE RESET connector 1251-0711 is deleted)
Over Compensation Detector is added.	A31 04270-7755 OVER COMPENSATION DETECTOR ASS'Y	None
Over Compensation indicator is added to A2.	A2 04270-7756 UNIT ETC DISPLAY ASS'Y	A2 04270-7722
D-G switch in Function Switch is deleted.	A3 04270-7757 FUNCTION SWITCH	A3 04270-7723
Strip pattern of A24 RESET & DC BIAS CONTROL ASS'Y is changed.	A48 04270-7768 RESET & DC BIAS CONTROL ASS'Y	A24 04270-7744

Table 7-8. Parts of A8 and A31(Cont'd).

Reference Designation	Part No.	Description	Note
A8	04270-7753	Cc AMPLIFIER ASS'Y	
	04270-8753	BOARD:BLANK P.C.	
A8C1	0121-0422	C:VAR GLASS 0.8-4.5pF	
A8C2	0160-2201	C:FXD MICA 51pF 5% 300VDCW	
A8C3	0160-2262	C:FXD CER 16pF 5% 500VDCW	
A8C4	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A8C5	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A8C6	0160-0127	C:FXD CER 1.0μF 20% 25VDCW	
A8C7	0180-0106	C:FXD TANT 60μF 20% 6VDCW	
A8C8	0150-0059	C:FXD CER 3.3pF ±0.25pF 500VDCW	
A8CR1	1902-3110	DIODE:SILICON BREAKDOWN 5.90V 2% 400mW	
A8CR2	1902-3110	DIODE:SILICON BREAKDOWN 5.90V 2% 400mW	
A8CR3	1902-3110	DIODE:SILICON BREAKDOWN 5.90V 2% 400mW	
A8Q1	1853-0075	TRANSISTOR:SILICON PNP DUAL	
A8Q2	1853-0015	TRANSISTOR:SILICON PNP JEDEC 2N3640	
A8Q3	1854-0073	TRANSISTOR:SILICON NPN	
A8Q4	1854-0120	TRANSISTOR:SILICON NPN 2SC979	
A8Q5	1853-0012	TRANSISTOR:SILICON PNP 2N2904A	
A8R1	0698-3153	R:FXD MET FLM 3.83kΩ 1% 1/8W	
A8R2	0698-3153	R:FXD MET FLM 3.83kΩ 1% 1/8W	
A8R3	2100-1756	R:VAR WW LIN 200Ω 10% 1/2W	
A8R4	2100-0806	R:VAR WW LIN 5kΩ 5% 1W	
A8R5	0757-0290	R:FXD MET FLM 6.19kΩ 1% 1/8W	
A8R6	0757-0398	R:FXD MET FLM 75.0Ω 1% 1/8W	
A8R7	0757-0398	R:FXD MET FLM 75.0Ω 1% 1/8W	
A8R8	0698-3155	R:FXD MET FLM 4.64kΩ 1% 1/8W	
A8R9	0757-1094	R:FXD MET FLM 1.47kΩ 1% 1/8W	
A8R10	0757-0317	R:FXD MET FLM 1.33kΩ 1% 1/8W	
A8R11	0698-0083	R:FXD MET FLM 1.96kΩ 1% 1/8W	
A8R12	0698-3155	R:FXD MET FLM 4.64kΩ 1% 1/8W	
A8R13	0683-0365	R:FXD COMP 3.6Ω 5% 1/4W	
A8R14	0698-0082	R:FXD MET FLM 464Ω 1% 1/8W	
A8R15	0757-0394	R:FXD MET FLM 51.1Ω 1% 1/8W	
A8R16	0757-0424	R:FXD MET FLM 1.1kΩ 1% 1/8W	
A8R17	0698-0090	R:FXD MET FLM 464Ω 1% 1/2W	
A8R18	0698-3433	R:FXD MET FLM 28.7Ω 1% 1/8W	
A8R19	0683-0565	R:FXD COMP 5.6Ω 5% 1/4W	
A8R20	0683-0565	R:FXD COMP 5.6Ω 5% 1/4W	

See list of abbreviations in introduction to this section

Table 7-8. Parts of A8 and A31.

Reference Designation	Part No.	Description	Note
A31	04270-7755	OVER COMPENSATION DETECTOR ASS'Y	
	04270-8755	BOARD:BLANK P.C.	
A31C1	0160-2307	C:FXD MICA 47pF 5% 300WV	
A31C2	0180-0291	C:FXD TANT 1μF 10% 35VDCW	
A31CR1	1901-0025	DIODE:SILICON	
A31CR2	1901-0025	DIODE:SILICON	
A31IC1	1820-0054	IC:TTL QUAD 2-INPUT NAND GATE	
A31Q1	1854-0118	TRANSISTOR NPN SILICON 2SC728	
A31R1	0757-0200	R:FXD MET FLM 5620Ω 1% 1/8W	
A31R2	0757-0441	R:FXD MET FLM 8250Ω 1% 1/8W	
A31R3	0757-0440	R:FXD MET FLM 7500Ω 1% 1/8W	

See list of abbreviations in introduction to this section

7-30. MANUAL CHANGES.

7-31. This manual applies directly to the Model 4270A with serials prefixed 1127J. The following paragraphs explain how to adapt this manual to apply to later instruments with a higher serials prefix, or earlier instruments with a lower serial prefix. Technical corrections to this manual (if any) are called errata and are listed on a separate "Manual Changes" sheet supplied with this manual.

7-32. LATER INSTRUMENTS: If the serial prefix of your Model 4270A is above 1146J, refer to a separate "Manual Changes" sheet supplied with this manual. Locate the serial prefix of your instrument and make the indicated changes.

7-33. EARLIER INSTRUMENTS (Backdating Changes): If the serial prefix of your Model 4270A is below 1115J, refer to Table 7-9 for the changes necessary to adapt this manual to your particular instrument. Locate the serial prefix of your instrument in the table and make the indicated changes. Note that instrument-component values that differ from those in this manual, yet are not listed in this backdating changes, should be replaced using the part number given in this manual.

Table 7-9. Backdating Changes.

Instrument Serial Prefix or Number	Make Changes
933/934J00060 and below	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
933/934J "	2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12
951/952J00120 "	3, 4, 5, 6, 7, 8, 9, 10, 11, 12
951/952J00130 "	4, 5, 6, 7, 8, 9, 10, 11, 12
1017/1018J "	5, 6, 7, 8, 9, 10, 11, 12
1019/1020J00195 "	6, 7, 8, 9, 10, 11, 12
1019/1020J "	7, 8, 9, 10, 11, 12
1031/1032J00230 "	8, 9, 10, 11, 12
1031/1032J00270 "	9, 10, 11, 12
1031J "	10, 11, 12
1107/1108J "	11, 12
1115/1116J00320 "	12

CHANGE 1

Page 6-5, Table 6-2.
Delete A6C8.

Page 8-11, Figure 8-7.
Delete C8 75p in the schematic diagram of A6.

Page 6-5, Table 6-2.
Change A7K1 and A7K2 to HP Part No. 0490-0216.
Change A7K4 and A7K5 to HP Part No. 0490-0215.

Page 6-6, Table 6-2.
Change A8K1 and A8K2 to HP Part No. 0490-0215.

Page 6-10, Table 6-2.
Change A12K1 through A12K4 to HP Part No. 0490-0215.

Page 6-2, Table 6-2.
Change A2R1, A2R2, A2R8 and A2R9 to HP Part No. 0698-4502 R:FXD MET FLM 64.9k OHM 1% 1/8W.

Page 8-53, Figure 8-27.
Change the values of R1 and R2 in the schematic diagram of A2 to 64.9k.

Page 8-55, Figure 8-28.
Change the values of R8 and R9 in the schematic diagram of A2 to 64.9k.

Page 6-23, Table 6-2.
Change A21C9 to HP Part No. 0160-2205 C:FXD MICA 120pF 5% 300VDCW.

Page 8-47, Figure 8-25.
Change the value of A21C9 to 120p.

Page 6-28, Table 6-2.
Change A23R37 to HP Part No. 0757-0428 R:FXD MET FLM 1620 OHM 1% 1/8W.

Page 8-81, Figure 8-27.
Change the value of R37 in the schematic diagram of A23 to 1.62k.

Page 6-30, Table 6-2.
Change A24R26 to HP Part No. 0757-0459 R:FXD MET FLM 56.2k OHM 1% 1/8W.
Change A24R32 to HP Part No. 0757-0442 R:FXD MET FLM 10k OHM 1% 1/8W.
Change A24R33 to HP Part No. 0757-0274 R:FXD MET FLM 1.21k OHM 1% 1/8W.

Page 8-55, Figure 8-29.
Change the value of A24R26 to 56.2k.
Change a part of A24 schematic diagram as shown in Figure 7-8.

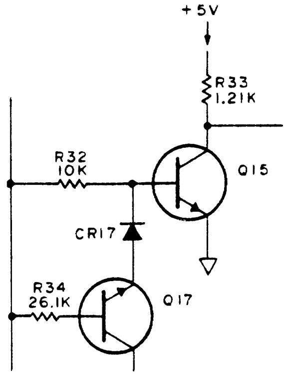


Figure 7-8. P/O Reset & DC Bias Control Ass'y A24

CHANGE 2

Page 6-35, Table 6-2.
Delete CR1.

Page 8-11, Figure 8-7.
Delete CR1 across Pin 13 and Pin 14 of K1(relay for MEAS CKT).

Page 6-11, Table 6-2.
Change A13C11 to 0150-0121 C:FXD CER 0.1μF.

Page 6-12, Table 6-2.
Change A13R14 to 0698-3153 R:FXD MET FLM 3830 OHM 1% 1/8W.

Page 6-12, Table 6-2.
Delete A13R59.

Page 8-21, Figure 8-12.
Change the value of A13R14 to 3.83k.
Change the schematic diagram of A13 as shown in Figure 7-9.

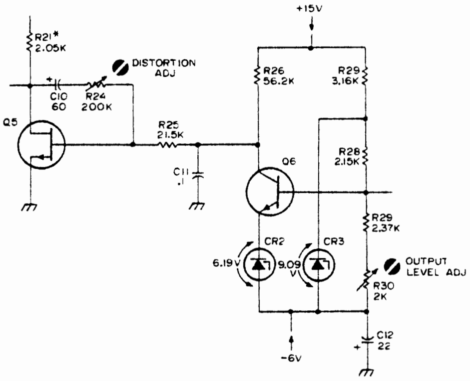


Figure 7-9. P/O OSC & Buffer Ass'y A13

CHANGE 3

Page 6-23, Table 6-2.
Change A21C1 to HP Part No. 0160-2307 C:FXD MICA 47pF 5% 300VDCW.

Page 8-47, Figure 8-25.
Change the value of A21C1 to 47p.

Page 6-34, Table 6-2.
Change A27R28 to HP Part No. 0757-0438 R:FXD MET FLM 5.11k OHM 1% 1/8W.

Page 8-65, Figure 8-34.
Change the value of A27R28 to 5.11k.

Page 6-35, Table 6-2.
Delete C16.

Page 8-47, Figure 8-25.
Delete C16 0.0047 connected to Pin 15R.

CHANGE 4

Page 6-35, Table 6-2.
Change B1 to 3160-0026 MOTOR:FAN.

CHANGE 5

Page 6-35, Table 6-2.
Change J9 and J10 to HP Part No. 1251-0085 CONNECTOR:FEMALE 36 CONTACTS
Change the part number of F1 as follows:
2110-0001 FUSE:NB 1A 250V FOR 115V OPERATION ONLY
2110-0021 FUSE:SB 1.25A 125V FOR 100V OPERATION ONLY

Page 6-36, Table 6-2.
Change S2 to HP Part No. 3101-0100 SWITCH:POWER.
Change W1 to HP Part No. 8120-0078 CABLE ASS'Y:POWER CORD 7.5FT.

Page 8-67, Figure 8-35
Change the schematic diagram of J9 and J10 as shown in Figure 7-10.

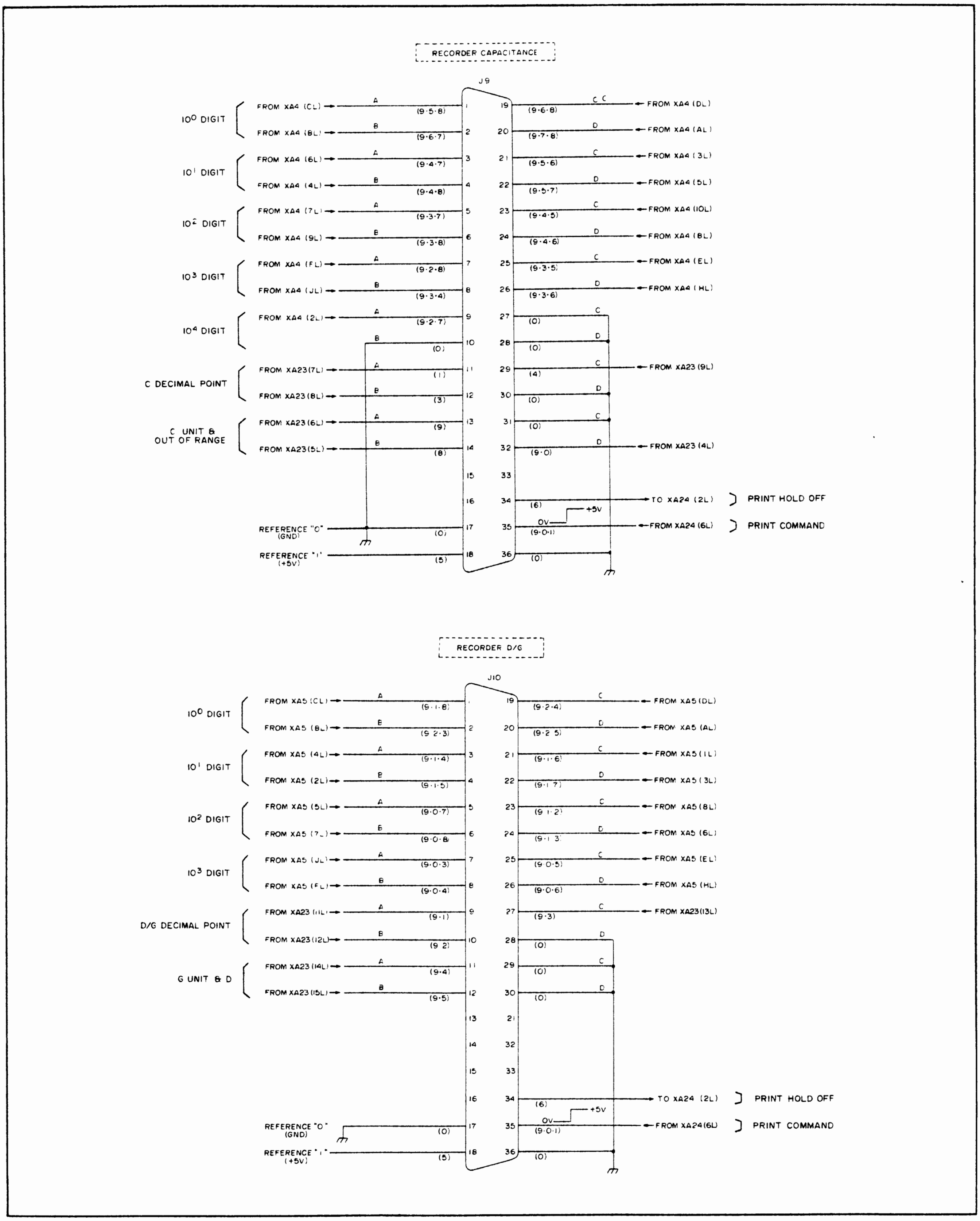


Figure 7-10. P/O Rear Panel Connectors J9, J10, J11

Page 3-9, Paragraph 3-47.

Change the statement of paragraph 3-47 as follows:

For system application where automatic recording or computing control is required, binary coded decimal equivalents of capacitance and dissipation factor/conductance are provided at RECORDER connector J9 (upper) and J10 (lower) on the rear panel.

To supply information to the HP Model 5050B Digital Recorder or Model 580A/581A Digital-to-Analog Converter, use interconnecting cable HP Part No. 16122A: 36-contact male on one end and 50-contact male on the other, 6 feet long. Two cables are required for recording both capacitance and loss component.

Cables can be fabricated for connection to other equipment using Amphenol 57-30360 connector HP Part No. 1251-0084 36-pin male to mate with the RECORDER jack. Signals available and external signals required are given in Table 3-8 and 3-9. Tables 3-10, 3-11 and 3-12 provide output information for decimal point and measurement units recording.

Page 3-10 and 3-11, Tables 3-8 through 3-12.

Change the contents of Tables 3-8 through 3-12 as shown in Tables 7-10 through 7-14.

Page 6-24, Table 6-2.

Change A21R20 to HP Part No. 0698-3398 R:FXD 46.4 OHM 1/2W.

Page 8-47, Figure 8-25.

Change the value of A21R20 to 46.4.

Table 7-10. Summary of Capacitance Information at Digital Recorder Output.

Function		J9	Function		J9
Display, Signal & Level	BCD Weight	Pin No.	Display, Signal & Level	BCD Weight	Pin No.
Display 10^0 Digit Units	1 2 4 8	1 2 19 20	Measurement Units & Out of Range Signal	1 2 4 8	13 14 31 32
Display 10^1 Digit Tens	1 2 4 8	3 4 21 22	Hold off input; -10V min, -15V max supplied from external source to prevent reset; causes measurement to hold.		34
Display 10^2 Digit Hundreds	1 2 4 8	5 6 23 24	Print command output; 0V to +5V step, DC-coupled, measured signals available for readout.		35
Display 10^3 Digit Thousands	1 2 4 8	7 8 25 26	Reference output; about +5V dc indicates "1" level for BCD output.		18
Display 10^4 Digit Ten Thousands	1 2 4 8	9 10 27 28	Reference output; 0V indicates "0" level for BCD output, connected to guard chassis.		17
			Ground; connected to guard chassis.		36
Decimal Point	1 2 4 8	11 12 29 30	Encode(Reset).		15
			No connection.		16 33

Table 7-11. Summary of Loss Component Information at Digital Recorder Output.

Function		J10
Display, Signal & Level	BCD Weight	Pin No.
Display 10^0 Digit Units	1 2 4 8	1 2 19 20
Display 10^1 Digit Tens	1 2 4 8	3 4 21 22
Display 10^2 Digit Hundreds	1 2 4 8	5 6 23 24
Display 10^3 Digit Thousands	1 2 4 8	7 8 25 26
Decimal Point	1 2 4 8	9 10 27 28
Measurement Units	1 2 4 8	11 12 29 30
Hold off input; -10V min, -15V max supplied from external source to prevent reset; causes measurement to hold.		34
Print command output; 0V to +5V stop, DC-coupled, signals that completed measurement is available for readout.		35
Reference output; about +5V dc indicates "1" level for BCD output.		18
Reference output: 0V indicates "0" level for BCD output, connected to guard chassis.		17
Ground; connected to guard chassis.		36
Encode(Reset).		15
No connection.		13 14 16 31 32 33

Table 7-12. Decimal Point BCD Output for Capacitance (Dissipation Factor and Conductance).

Display	J9 (J10) Output Volts				Printed Digit
	Pin 30 (28)	Pin 29 (27)	Pin 12 (10)	Pin 11 (9)	
0 0 0 0.0	0	0	0	+5	1
0 0 0.0 0	0	0	+5	0	2
0 0.0 0 0	0	0	+5	+5	3
0.0 0 0 0	0	+5	0	0	4

Table 7-13. BCD Output for Capacitance Measurement Units.

Display	J9 Output Volts				Printed Digit
	Pin 32	Pin 31	Pin 14	Pin 13	
μF	0	0	0	0	0
nF	0	0	0	+5	1
pF	0	0	+5	0	2
Out of Range	+5	0	0	0	8

Table 7-14. BCD Output for Loss Measurement Units.

Display	J10 Output Volts				Printed Digit
	Pin 30	Pin 29	Pin 12	Pin 11	
D	0	0	0	0	0
m	0	0	0	+5	1
μ	0	0	+5	0	2
n	0	0	+5	+5	3

CHANGE 6

Page 6-6, Table 6-2
Change the parts list of A8 as shown in Table 7-15.

Page 8-13, Figure 8-8
Change the schematic diagram of A8 as shown in Figure 7-11.

Page 7-10, Table 7-8
Change Table 7-8 as shown in Table 7-16.

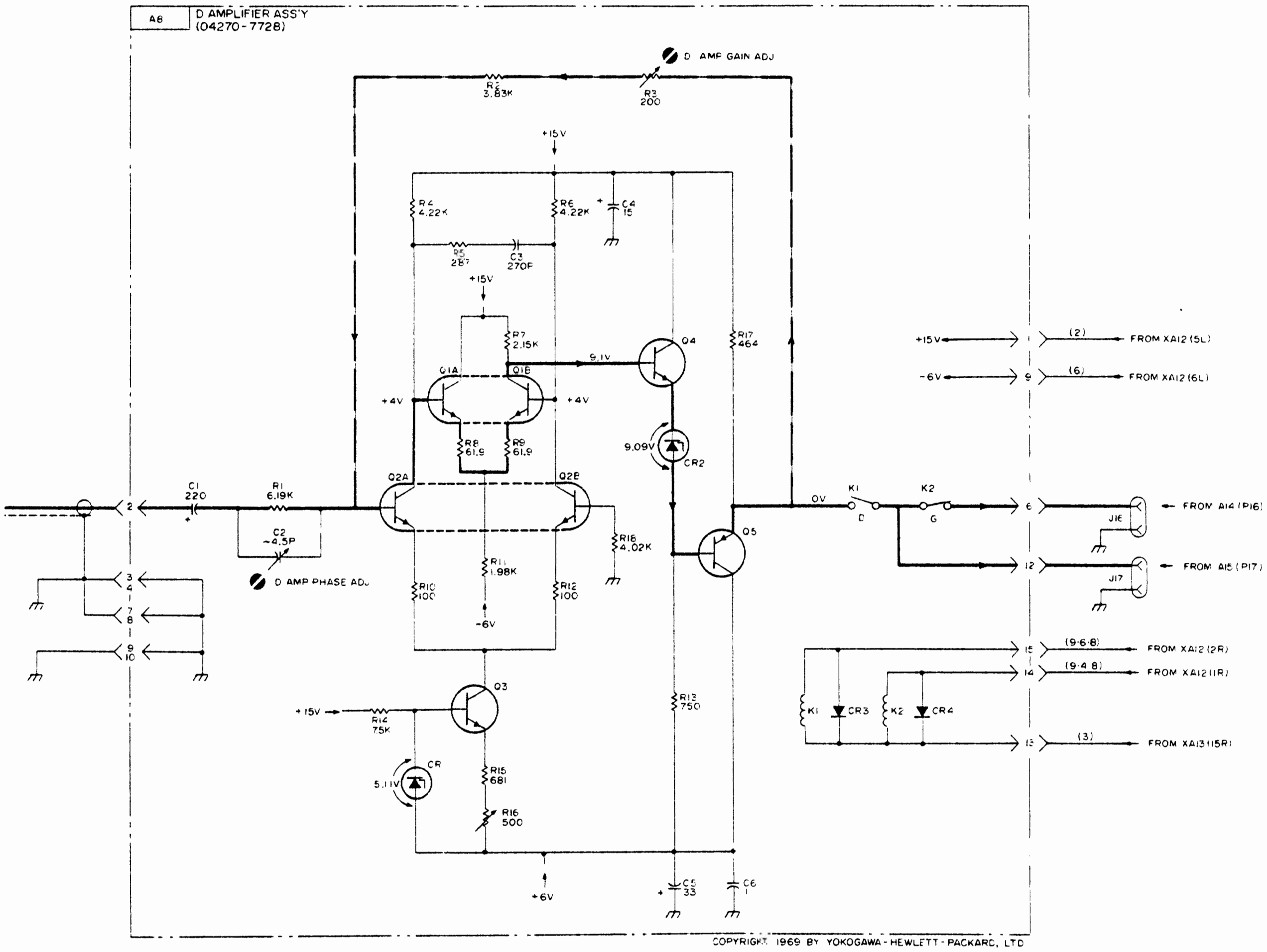


Figure 7-11. P/O D Amp Ass'y A8

Table 7-15. Parts List of A8.

Reference Designation	Part No.	Description	Note
A8	04270-7728	D AMP ASS'Y	
	04270-8728	BOARD:BLANK P.C.	
A8C1	0180-0936	C:FXD ALUM 220μF 6.3VDCW	
A8C2	0121-0422	C:VAR GLASS 0.8 - 4.5pF	
A8C3	0140-0210	C:FXD MICA 270pF 5% 300VDCW	
A8C4	0180-1746	C:FXD TANT 15μF 10% 20VDCW	
A8C5	0180-0229	C:FXD TANT 33μF 10% 100VDCW	
A8C6	0160-0127	C:FXD CER 1μF 20% 25VDCW	
A8CR1	1902-0041	SEMICON DEVICE:DIODE SILICON 5.11V 5% 400mW	
A8CR2	1902-3149	SEMICON DEVICE:DIODE SILICON 9.09V 400mW	
A8CR3	1901-0025	SEMICON DEVICE:DIODE SILICON	
A8CR4	1901-0025	SEMICON DEVICE:DIODE SILICON	
A8K1	0490-0213	RELAY REED:SRF - 13A	
A8K2	0490-0213	RELAY REED:SRF - 13A	
A8Q1	1854-0221	TRANSISTOR:NPN SILICON DUAL	
A8Q2	1854-0221	TRANSISTOR:NPN SILICON DUAL	
A8Q3	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A8Q4	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A8Q5	1853-0012	TRANSISTOR:PNP SILICON 2N2904A	
A8R1	0757-0290	R:FXD MET FLM 6.19k OHM 1% 1/8W	
A8R2	0698-3153	R:FXD MET FLM 3.83k OHM 1% 1/8W	
A8R3	2100-1756	R:VAR WW LIN 200 OHM 10% 1/2W	
A8R4	0698-3154	R:FXD MET FLM 4.22k OHM 1% 1/8W	
A8R5	0698-3443	R:FXD MET FLM 287 OHM 1% 1/8W	
A8R6	0698-3154	R:FXD MET FLM 4.22k OHM 1% 1/8W	
A8R7	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A8R8	0757-0276	R:FXD MET FLM 61.9k OHM 1% 1/8W	
A8R9	0757-0276	R:FXD MET FLM 61.9k OHM 1% 1/8W	
A8R10	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A8R11	0757-0278	R:FXD MET FLM 1.78k OHM 1% 1/8W	
A8R12	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A8R13	0698-3558	R:FXD MET FLM 4.02k OHM 1% 1/8W	
A8R14	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A8R15	0757-0419	R:FXD MET FLM 681 OHM 1% 1/8W	
A8R16	2100-1757	R:VAR WW LIN 500 OHM 10% 1/2W	
A8R17	0698-0090	R:FXD MET FLM 464 OHM 1% 1/2W	
A8R18	0757-0420	R:FXD MET FLM 750 OHM 1% 1/8W	

See list of abbreviations in introduction to this section.

Table 7-16. Parts List of A8 and A31(Cont'd).

Reference Designation	Part No.	Description	Note
A8	04270-7753	Cc AMPLIFIER ASS'Y	
	04270-8753	BOARD:BLANK P.C.	
A8C1		NOT ASSIGNED	
A8C2	0121-0422	C:VAR GLASS 0.8 - 4.5 pF	
A8C3	0140-0210	C:FXD MICA 270pF 5% 300VDCW	
A8C4	0180-1746	C:FXD TANT 15 μF 10% 20VDCW	
A8C5	0180-0229	C:FXD TANT 33 μF 10% 100VDCW	
A8C6	0160-0127	C:FXD CER 1 μF 20% 25VDCW	
A8CR1	1902-0041	DIODE:SILICON 5.11V 5% 400mW	
A8CR2	1902-3149	DIODE:SILICON 9.09V 400mW	
A8CR3	1901-0025	DIODE:SILICON	
A8CR4	1901-0025	DIODE:SILICON	
A8Q1	1854-0221	TRANSISTOR:NPN SILICON DUAL	
A8Q2	1854-0221	TRANSISTOR:NPN SILICON DUAL	
A8Q3	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A8Q4	1854-0115	TRANSISTOR:NPN SILICON 2SC538A	
A8Q5	1853-0012	TRANSISTOR:PNP SILICON 2N2904A	
A8R1	0757-0290	R:FXD MET FLM 6.19k OHM 1% 1/8W	
A8R2	0698-3153	R:FXD MET FLM 3.83k OHM 1% 1/8W	
A8R3	2100-1756	R:VAR WW LIN 200 OHM 10% 1/2W	
A8R4	0698-3154	R:FXD MET FLM 4.22k OHM 1% 1/8W	
A8R5	0698-3443	R:FXD MET FLM 287 OHM 1% 1/8W	
A8R6	0698-3154	R:FXD MET FLM 4.22k OHM 1% 1/8W	
A8R7	0698-0084	R:FXD MET FLM 2.15k OHM 1% 1/8W	
A8R8	0757-0276	R:FXD MET FLM 61.9k OHM 1% 1/8W	
A8R9	0757-0276	R:FXD MET FLM 61.9k OHM 1% 1/8W	
A8R10	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A8R11	0757-0278	R:FXD MET FLM 1.78k OHM 1% 1/8W	
A8R12	0757-0401	R:FXD MET FLM 100 OHM 1% 1/8W	
A8R13	0698-3558	R:FXD MET FLM 4.02k OHM 1% 1/8W	
A8R14	0757-0440	R:FXD MET FLM 7.5k OHM 1% 1/8W	
A8R15	0757-0419	R:FXD MET FLM 681 OHM 1% 1/8W	
A8R16	2100-1757	R:VAR WW LIN 500 OHM 10% 1/2W	
A8R17	0698-0090	R:FXD MET FLM 464 OHM 1% 1/2W	
A8R18	0757-0420	R:FXD MET FLM 750 OHM 1% 1/8W	

See list of abbreviations in introduction to this section.

Table 7-16. Parts List of A8 and A13.

Reference Designation	Part No.	Description	Note
A31	04270-7755	OVER COMPENSATION DETECTOR ASS'Y	
	04270-8755	BOARD:BLANK P.C.	
A31C1	0160-2307	C:FXD MICA 47pF 5% 300VDCW	
A31C2	0180-0291	C:FXD TANT 1μF 10% 35VDCW	
A31CR1	1901-0025	DIODE:SILICON	
A31CR2	1901-0025	DIODE:SILICON	
A31IC1	1820-0054	IC:TTL QUAD 2 INPUT NAND GATE	
A31Q1	1854-0118	TRANSISTOR:NPN SILICON 2SC728	
A31R1	0757-0200	R:FXD MET FLM 5620Ω 1% 1/8W	
A31R2	0757-0441	R:FXD MET FLM 8250Ω 1% 1/8W	
A31R3	0757-0440	R:FXD MET FLM 7500Ω 1% 1/8W	

See list of abbreviations in introduction to this section.

Page 7-7, Figure 7-6
Change Figure 7-6 as shown in Figure 7-12.

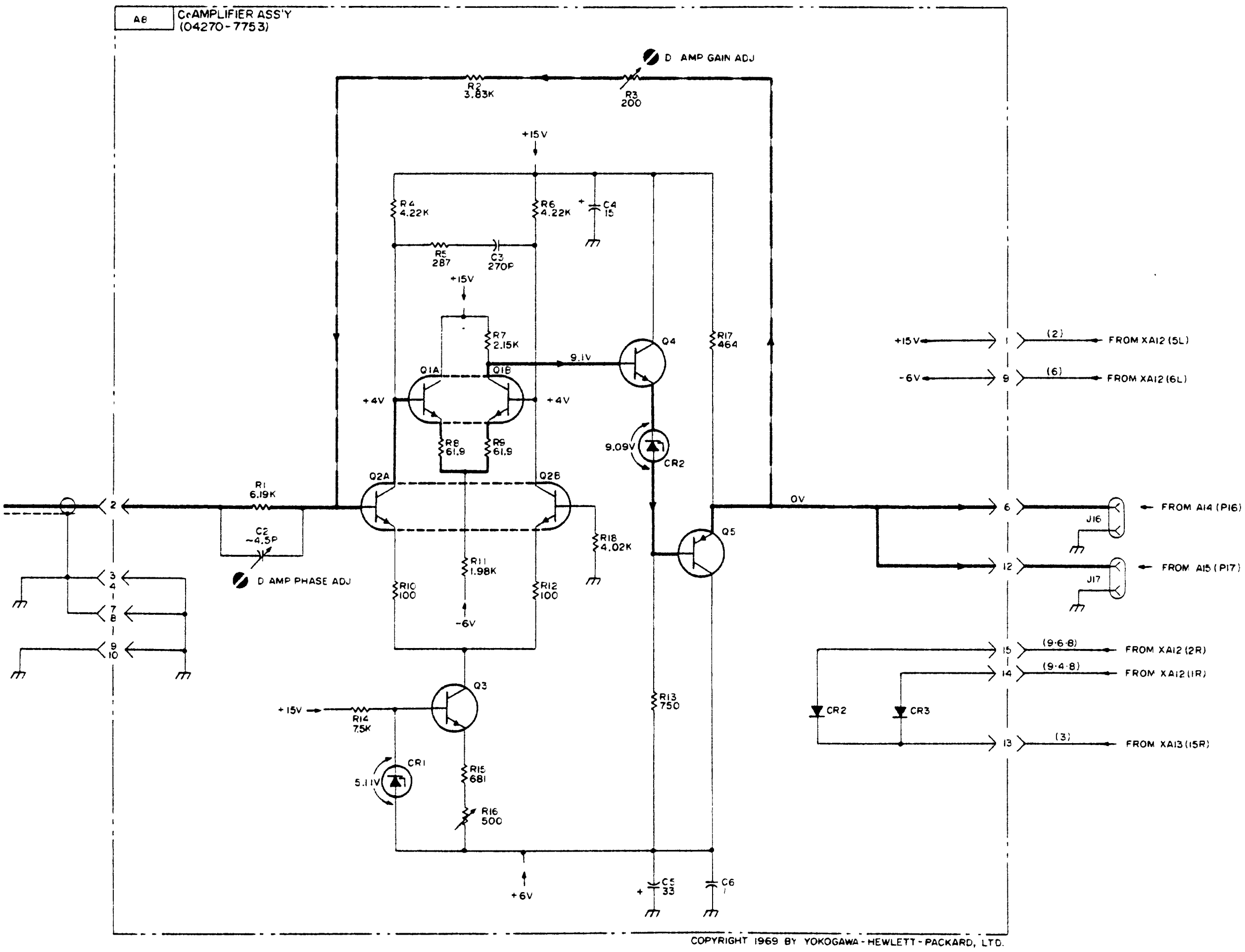


Figure 7-12. P/O Cc Amplifier

Page 6-6, Table 6-2 and Page 7-12, Table 7-8.
Delete A8C8*.
Change A8R4 to HP Part No. 2100-1758 R:VAR WW LIN 1k OHM 10% 1/2W.
Change A8R9 to HP Part No. 0698-3558 R:FXD MET FLM 4.02k OHM 1% 1/8W.
Change A8R14 to HP Part No. 0757-0402 R:FXD MET FLM 110 OHM 1% 1/8W.
Change A8R20 to HP Part No. 0757-0280 R:FXD MET FLM 1k OHM 1% 1/8W.

Page 8-13, Figure 8-8 and Page 7-12, Table 7-8.
Delete A8C8*.
Change the values of A8R4, R9, R14 and R20 to 1k, 4.02k, 110 and 1k respectively.

Page 8-55, Figure 8-29.
Change the schematic diagram of A24 as shown in Figure 7-13.

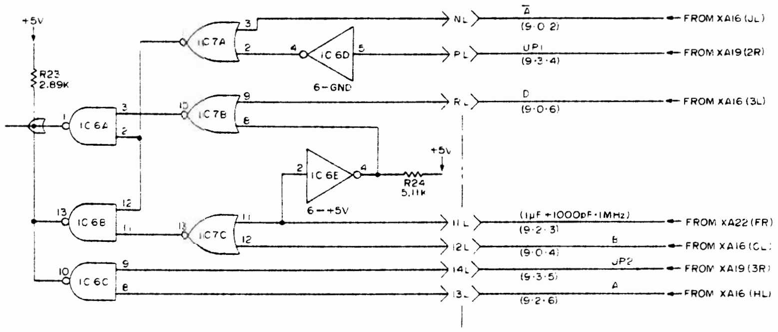


Figure 7-13. P/O Reset & DC Bias Control Ass'y A24

Add a jumper connection to pin 2R as follows:

→ 2R〉 G_{LC} (9. 2. 4) ← FROM XA20 (11R)

Page 8-45, Figure 8-24.
Add a jumper connection to pin 11R as follows:

→ 11R〉 G_{LC} (9. 2. 4) → TO XA24 (2R)

CHANGE 7

Page 6-7, Table 6-2.
Change the part number of A10 to 04270-7730 and 04270-8730.

Page 6-8, Table 6-2.
Change A10R25 and A10R28 to HP Part No. 0698-0084 R:FXD MET FLM 2.15k OHM 1% 1/8W.

Page 6-8, Table 6-2.
Change A10R50 and A10R53 to HP Part No. 0757-0280 R:FXD MET FLM 1000 OHM 1% 1/8W.

Page 8-15, Figure 8-9.
Change the values of A10R25 and A10R28 to 2.15k.
Change the values of A10R50 and A10R53 to 1k.

Page 6-8, Table 6-2.
Change the part number of A11 to 04270-7731 and 04270-8731.

Page 6-9, Table 6-2.
Delete A11C27, CR10, CR11, and Q12.

Page 6-9, Table 6-2.
Delete A11R39 through R41.

Page 8-17, Figure 8-10.
Change the schematic diagram of A11 as shown in Figure 7-14.

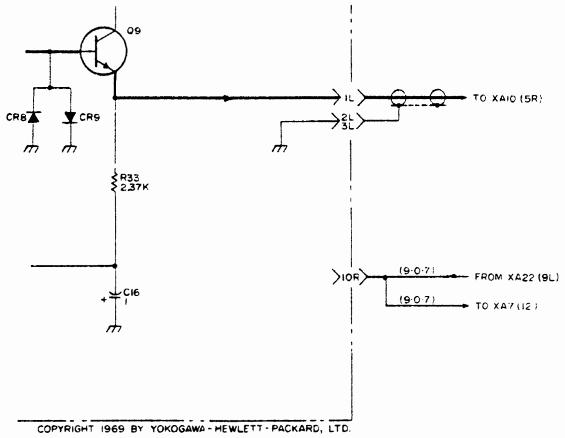


Figure 7-14. P/O Current Detector Ass'y A11

Page 6-35, Table 6-2.
Change A28R6 and A28R11 to HP Part No. 0757-0482 R:FXD MET FLM 511k OHM 1% 1/8W.

Page 8-63, Figure 8-33.
Change the values of A28R6 and R11 to 511k.

Page 6-4, Table 6-2.
Change A4CR1 and A4CR2 to HP Part No. 1910-0016 DIODE:GERM.
Add A4CR3 and A4CR4 1910-0016 DIODE:GERM.
Change A4IC1 to HP Part No. 1820-0077 IC:QUAD 2-INPUT NAND GATE.
Change A4Q2 to HP Part No. 1854-0119 TRANSISTOR:PNP GERM EIA 2N2635.
Change the resistors A4R1 through A4R7 as follows:

A4R1	0698-3152	R:FXD MET FLM 3480 OHM 1% 1/8W
A4R2	0757-0452	R:FXD MET FLM 27.4k OHM 1% 1/8W
A4R3	0757-0428	R:FXD MET FLM 1620 OHM 1% 1/8W
A4R4	0698-4471	R:FXD MET FLM 7150 OHM 1% 1/8W
A4R5	0757-0442	R:FXD MET FLM 10k OHM 1% 1/8W
A4R6	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W
A4R7	0757-0438	R:FXD MET FLM 5110 OHM 1% 1/8W

Add the following resistors.

A4R8	0698-3152	R:FXD MET FLM 3480 OHM 1% 1/8W
A4R9	0757-0452	R:FXD MET FLM 27.4k OHM 1% 1/8W
A4R10	0757-0428	R:FXD MET FLM 1620 OHM 1% 1/8W

Page 8-7, Figure 8-5.
Change the schematic diagram of A4 as shown in Figure 7-15.

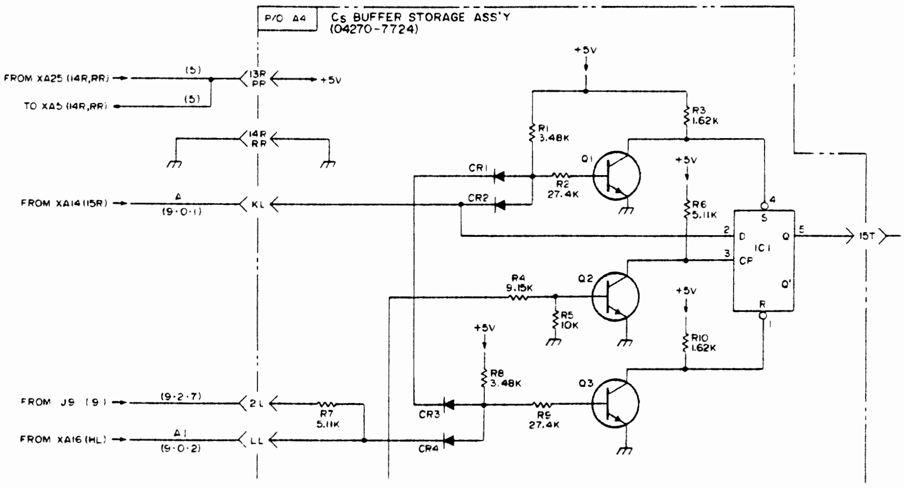


Figure 7-15. P/O Cs Buffer Storage Ass'y A4

CHANGE 8

Page 7-10, Table 7-8.
Change A31C1 to HP Part No. 0160-2204 C:FXD MICA 100pF.

Page 7-6, Figure 7-4.
Change the value of A31C1 to 100p.

Page 7-11, Table 7-8.
Change A31R1 and A31R2 to HP Part No. 0757-0442 R:FXD MET FLM 10k OHM 1% 1/8W.

Page 7-6, Figure 7-4.
Change the values of A31R1 and A31R2 to 10k.

Page 6-28, Table 6-2.
Add the resistors A23R1, R5, R9, R13, R17 and R18 with HP Part No. 0698-0085 R:FXD MET FLM 2610 OHM 1% 1/8W.

Page 6-28, Table 6-2.
Add the resistors A23R46, R50, R54, R58 and R62 with HP Part No. 0698-0085 R:FXD MET FLM 2610 OHM 1% 1/8W.

Page 8-51, Figure 8-27.
Add the resistors A23R1, R5, R9, R13, R17 and R18 as shown in Figure 7-16.

Page 8-53, Figure 8-28.
Add the resistors A23R46, R50, R54, R58 and R62 as shown in Figure 7-17.

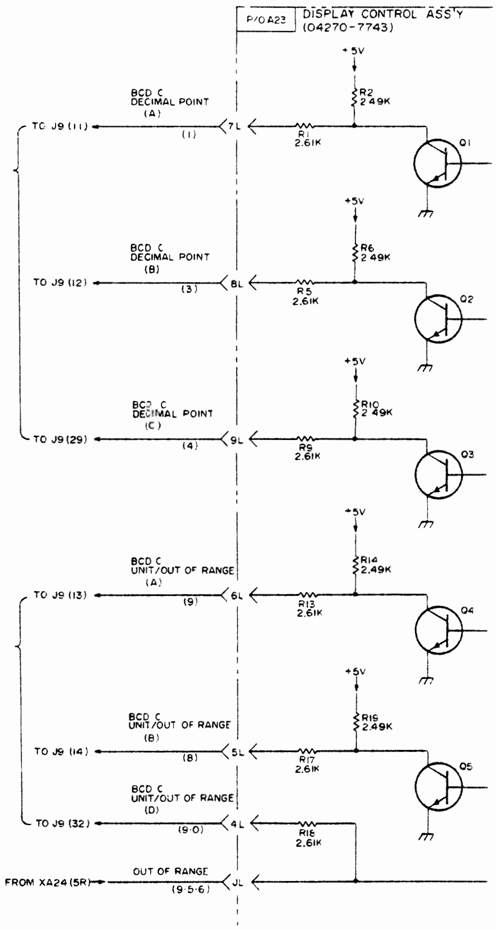


Figure 7-16. P/O Display Control Ass'y A23

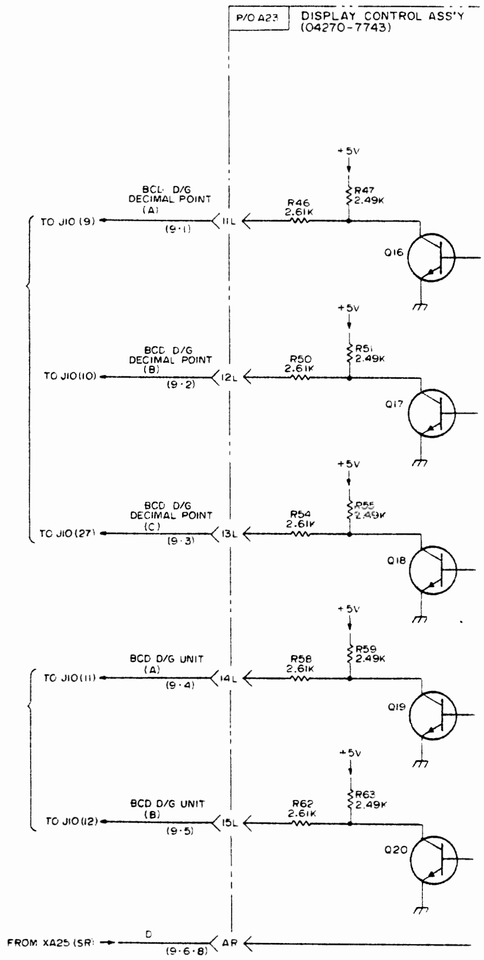


Figure 7-17. P/O Desplay Control Ass'y A23

Page 6-30, Table 6-2.
Change A24R20 to HP Part No. 0698-3151 R:FXD MET FLM 2870 OHM 1% 1/8W.
Change A24R21 to HP Part No. 0757-0443 R:FXD MET FLM 11k OHM 1% 1/8W.

Page 8-55, Figure 8-29.
Change the value of A24R20 to 2.87k.
Change the value of A24R21 to 11k.
Change the value of A3R3 to 196k.

Page 6-3, Table 6-2.
Change A3R3 to HP Part No. 0698-3453 R:FXD MET FLM 196k OHM 1% 1/8W.

Page 6-8, Table 6-2.
Change the part number of A11 to 04270-7759 and 04270-8759.

Page 6-9, Table 6-2.
Delete A11C27, A11CR10 and A11CR11.

Page 6-9, Table 6-2.
Change A11R39 to HP Part No. 0698-3155 R:FXD MET FLM 4.64k OHM 1% 1/8W.

Page 8-17, Figure 8-10.
Change the schematic diagram as shown in Figure 7-18.

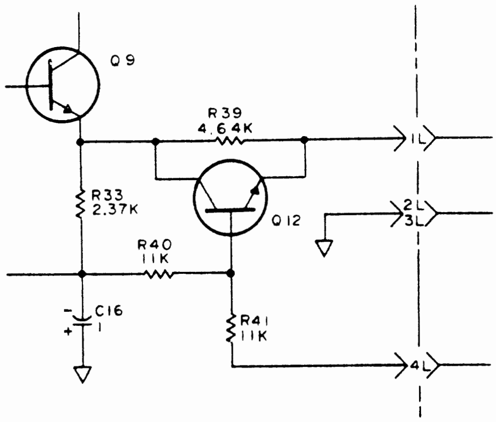


Figure 7-18. P/O Current Detector Ass'y A11

CHANGE 9

Page 6-6, Table 6-2 and Page 7-12, Table 7-8.
Change A8R4 to HP Part No. 2100-1759 R:VAR WW LIN 2k OHM 5%.

Page 8-13, Figure 8-8 and Page 7-9, Figure 7-6.
Change the value of A8R4 to 2k.

Page 6-5, Table 6-2.
Change A6R5 to HP Part No. 2100-1773 R:VAR WW LIN 1000 OHM 10% 1/2W.

Page 8-11, Figure 8-7.
Change the value of A6R5 to 1k.

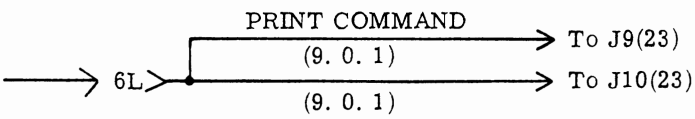
Page 6-6, Table 6-2.
Change A7R1 to HP Part No. 2100-1758 R:VAR WW LIN 1000 OHM 1% 1/2W.
Change A7R16 to HP Part No. 0757-0424 R:FXD MET FLM 1.1k OHM 1% 1/8W.

Page 8-13, Figure 8-8.
Change the value of A7R1 to 1k.
Change the value of A7R16 to 1.1k.

CHANGE 10

Page 6-36, Table 6-2.
Delete S5.

Page 8-55, Figure 8-29.
Change the jumper connection from pin 6L as follows.



Page 8-67, Figure 8-35.
Change the statement and wire color code for J9 pin 23 to "FROM XA24(6L)" and (9. 0. 2).
Change the statement and wire color code for J10 pin 28 to "FROM XA24(6L)" and (9. 0. 3).
Delete the schematic diagram of S5.

Page 3-3, Figure 3-2.
Delete the illustration and description for Print Command Selector switch 13.

Page 6-33, Table 6-2.
Change A27C7 and C9 to HP Part No. 0180-0947 C:FXD ALUM 200μF 15VDCW.

Page 8-65, Figure 8-34.
Change the value of A27C7 and C9 to 200.

CHANGE 11

Page 6-9, Table 6-2.
Change the part number of A11 to 04270-7759 and 04270-8759.
Delete A11C27, A11CR10 and CR11.

Page 8-17, Figure 8-10.
Change the schematic diagram as shown in Figure 7-19.

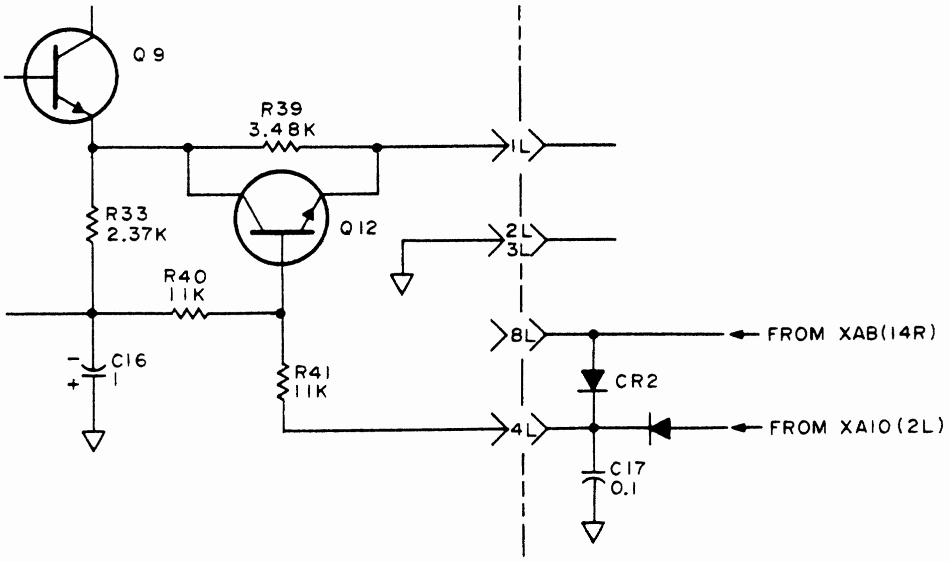


Figure 7-19. P/O Current Detector Ass'y A11

Page 6-35, Table 6-2.
Add the following capacitor and diodes;
C17 0150-0121 C:FXD CER 0.1μF -20+80% 50VDCW
CR2 1901-0025 DIODE:SILICON
CR3 1901-0025 DIODE:SILICON

Page 6-4, Table 6-2.
Add seventeen resistors A4R8 and A4R11 through A4R26 with HP Part No. 0757-0438
R:FXD MET FLM 5110 OHM 1% 1/8W.

Page 6-4, Table 6-2.
Add sixteen resistors A5R1 through A5R16 with HP Part No. 0757-0438 R:FXD MET FLM 5110 OHM 1% 1/8W.

Page 6-28, Table 6-2.
Add six resistors A23R1, R5, R9, R13, R17, R18 with HP Part No. 0757-0438 R:FXD MET FLM 5110 OHM 1% 1/8W.

Page 6-28, Table 6-2.
Add five resistors A23R46, R50, R54, R58, R62 with HP Part No. 0757-0438 R:FXD MET FLM 5110 OHM 1% 1/8W.

Page 8-7, Figure 8-5.
Change the schematic diagram of A4 as shown in Figure 7-20.

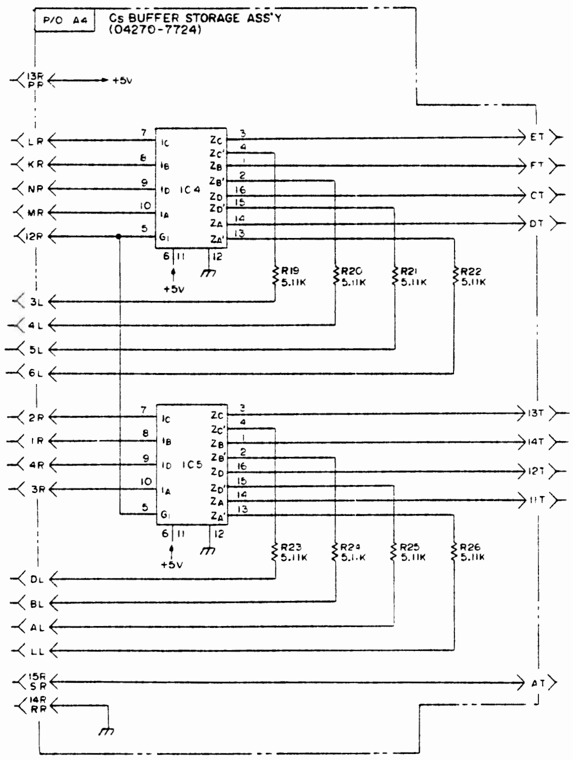


Figure 7-20. Cs Buffer Storage Ass'y A4

Page 8-9, Figure 8-6.
Change the schematic diagram of A5 as shown in Figure 7-21.

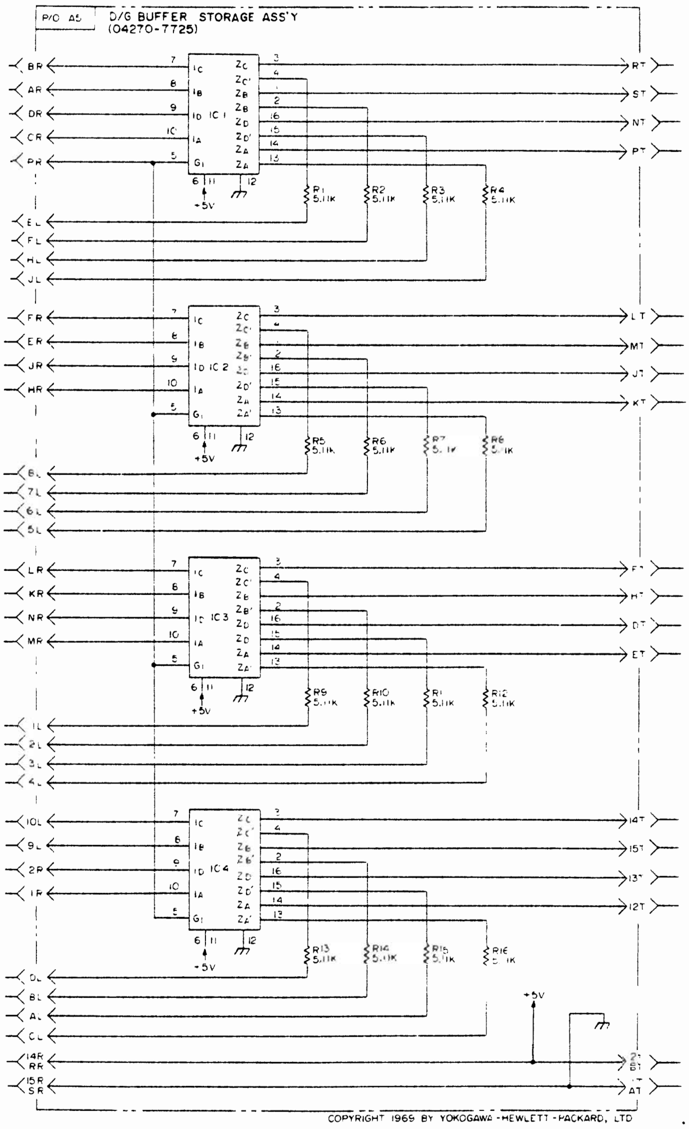


Figure 7-21. P/O D/G Buffer Storage Ass'y A5

Page 8-51, Figure 8-27.
Change the schematic diagram as shown in Figure 7-22(a).

Page 8-53, Figure 8-28.
Change the schematic diagram as shown in Figure 7-22(b).

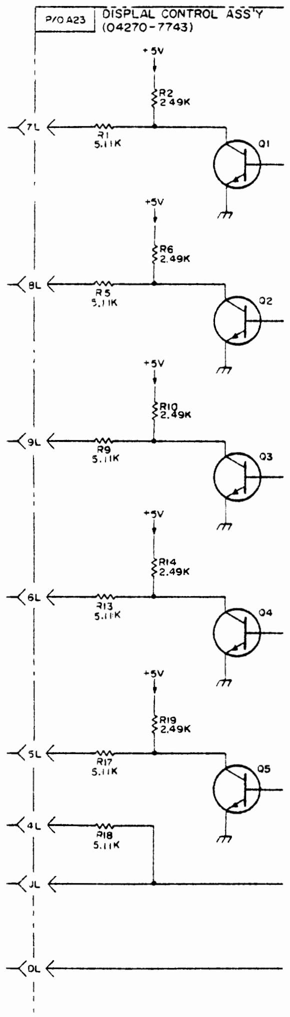


Figure 7-22(a). P/O Display Control Ass'y A23

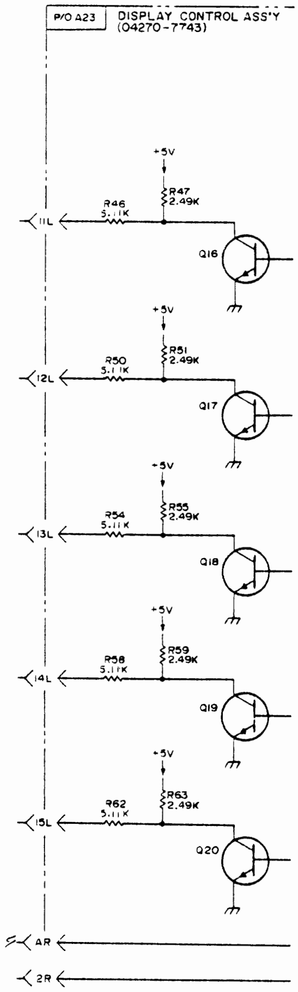


Figure 7-22(b). P/O Display Control Ass'y A23

CHANGE 12

Page 6-32, Table 6-2.
Change A26C4 to HP Part No. 0180-0376 C:FXD TANT 0.47μF 10% 35VDCW.

Page 6-33, Table 6-2.
Change A26R1 to HP Part No. 0757-0346
Delete A26R33, R34 and R35.

Page 8-63, Figure 8-33.
Delete A26R33, R34 and R35.

Page 6-29, Table 6-2.
Change A24C10 to HP Part No. 0140-0199 C:FXD MICA 240pF 5% 300VDCW.

Page 6-29, Table 6-2.
Delete A24CR37.

Page 8-55, Figure 8-29.
Delete CR37.
Change the value of C10 to 240pF.

Page 8-47, Figure 8-25.
Delete the wire connection at IC2B Pin 4 and connect it to IC2B Pin 5.
Delete the wire connection at IC3D Pin 5 and connect it to IC6A Pin 3.

Page 7-6, Figure 7-4.
Change the statement for Pin(7) to "FROM XA20(SL)".

Page 7-9, Table 7-7.
Delete the column of the change in A24 strip pattern.

SECTION VIII
CIRCUIT DIAGRAMS

8-1. INTRODUCTION

8-2. This section includes the following:

a. General Notes for schematic diagrams.

b. Simplified Block Diagram (Figure 8-2).

c. Detailed Block Diagrams (Figure 8-3 and 8-4).

d. Schematic Diagrams and Parts Location Illustrations. Waveforms and voltages at indicated test points are also included.

8-3. GENERAL NOTES

a. Unless otherwise indicated, resistance in ohms, capacitance in microfarads and inductance in microhenries.

b. Components assigned an asterisk (*) are factory selected, average values shown.

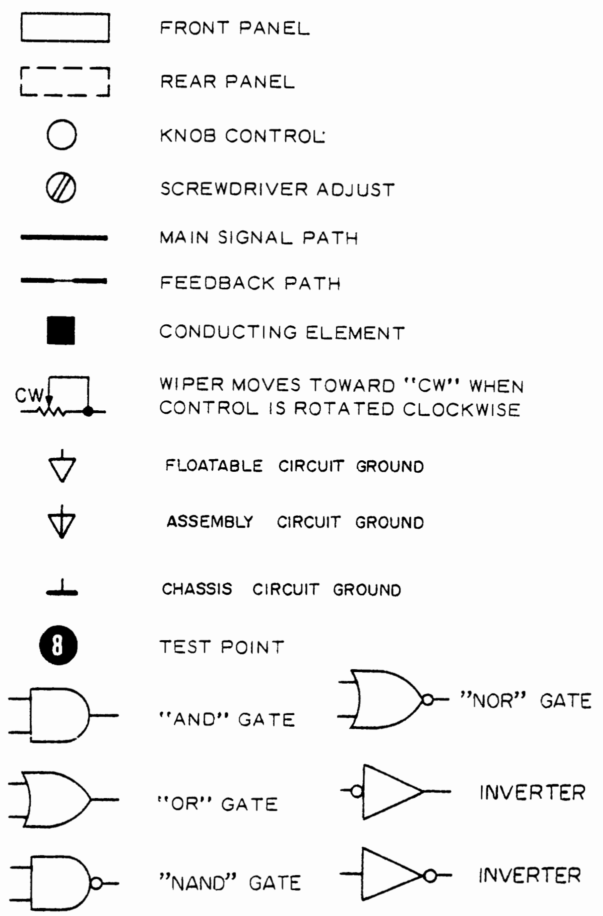
c. (9.4.7) indicates wire color code. Wire color code (MIL-STD-681) same as resistor color code. First number identifies ground color, second number identifies wide stripe, third number identifies narrow stripe. e.g. (9.4.7) denotes white ground, yellow wide stripe, violet narrow stripe.

d. The components mounted on chassis or mainframe parts are not assigned an assembly designation (i.e. R1, Q1, etc.)

e. Reference designations (R1, Q1, etc.) within assembly (A1, A2... etc.) use assembly designation as prefix to form complete designation. (e.g. R1, in A1 assembly is A1R1).

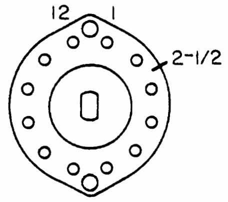
8-4. Additional notes are shown in Figure 8-1.

SYMBOLS



SWITCH DESIGNATIONS

A3S1BR(2-1/2)



A3S1	SWITCH S1 WITHIN ASSEMBLY A3
B	2ND WAFER FROM FRONT (A=1ST, ETC)
R	REAR OF WAFER (F=FRONT)
(2-1/2)	TERMINAL LOCATION (2½) (VIEWED FROM FRONT)

REFERENCE DESIGNATIONS

REFERENCE DESIGNATIONS WITHIN ASSEMBLIES ARE ABBREVIATED.
ADD ASSEMBLY NUMBER TO ABBREVIATION FOR COMPLETE DESCRIPTION.

ASSEMBLY	ABBREVIATION	COMPLETE DESCRIPTION
A25	C1	A25C1
A25A1	CR1	A25A1CR1
NO PREFIX	J3	J3

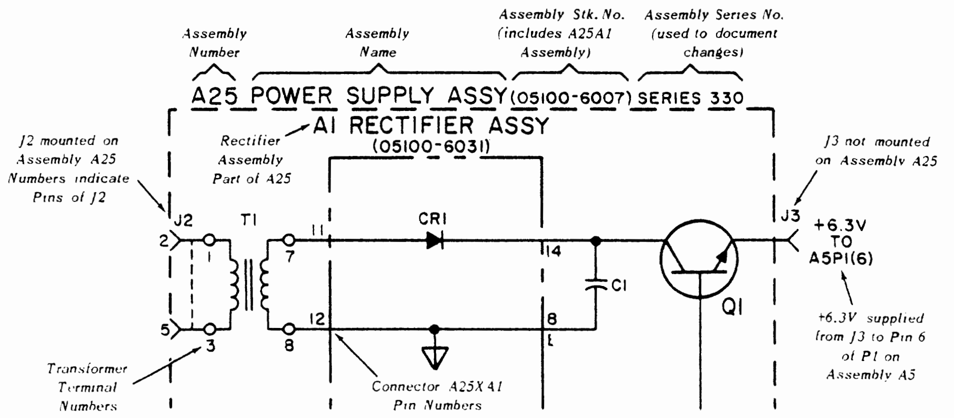


Figure 8-1. Schematic Diagram Notes

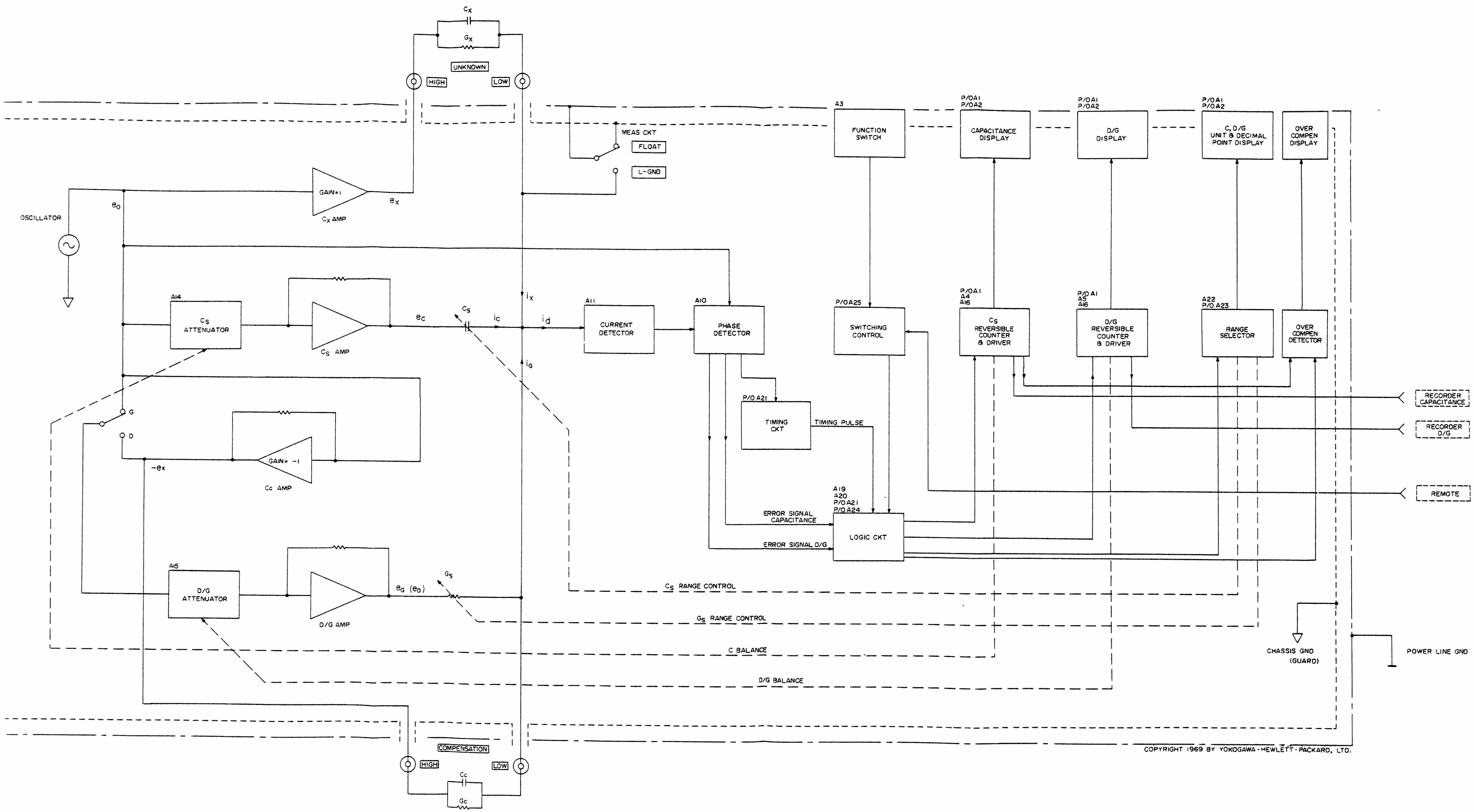
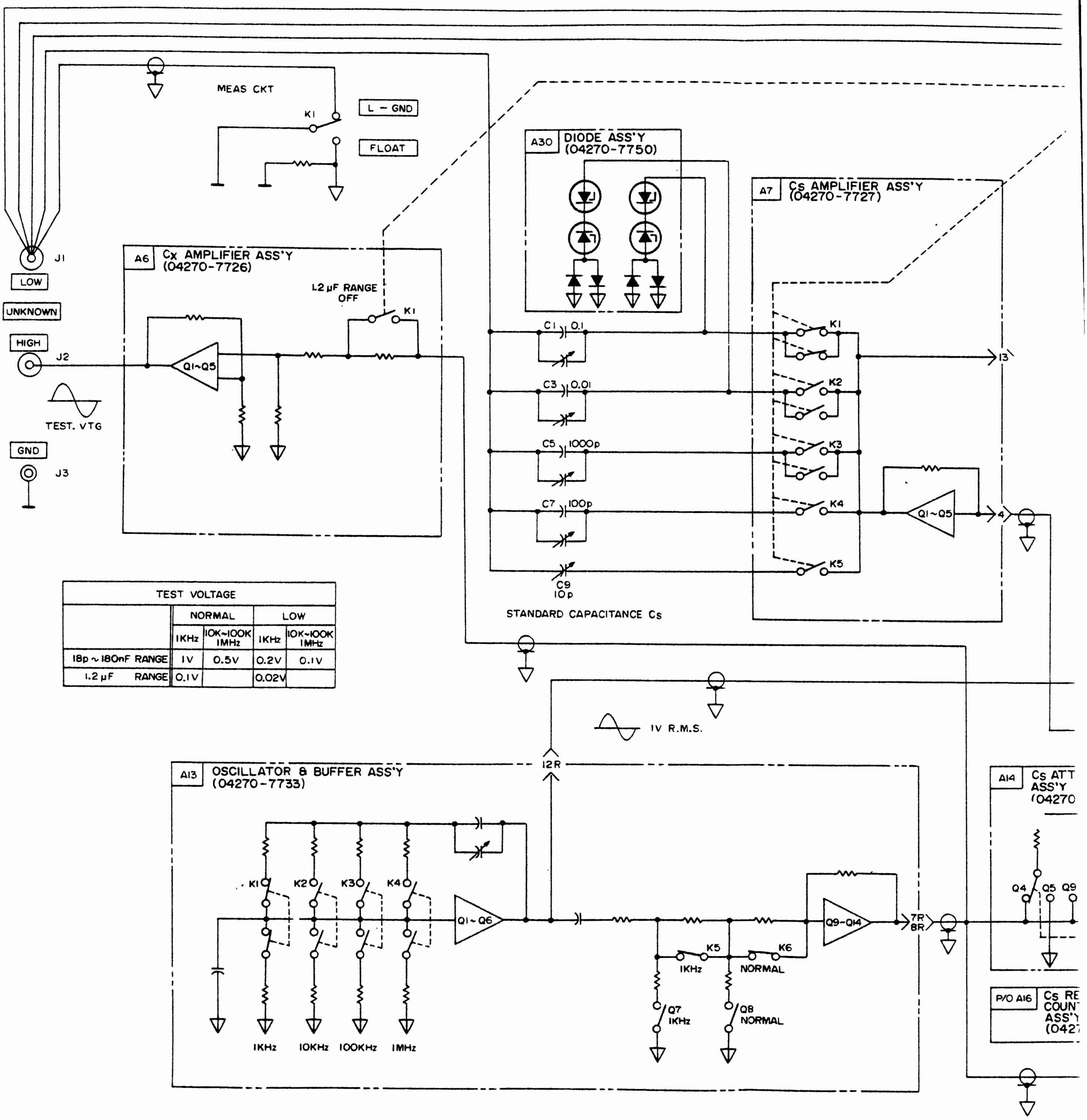
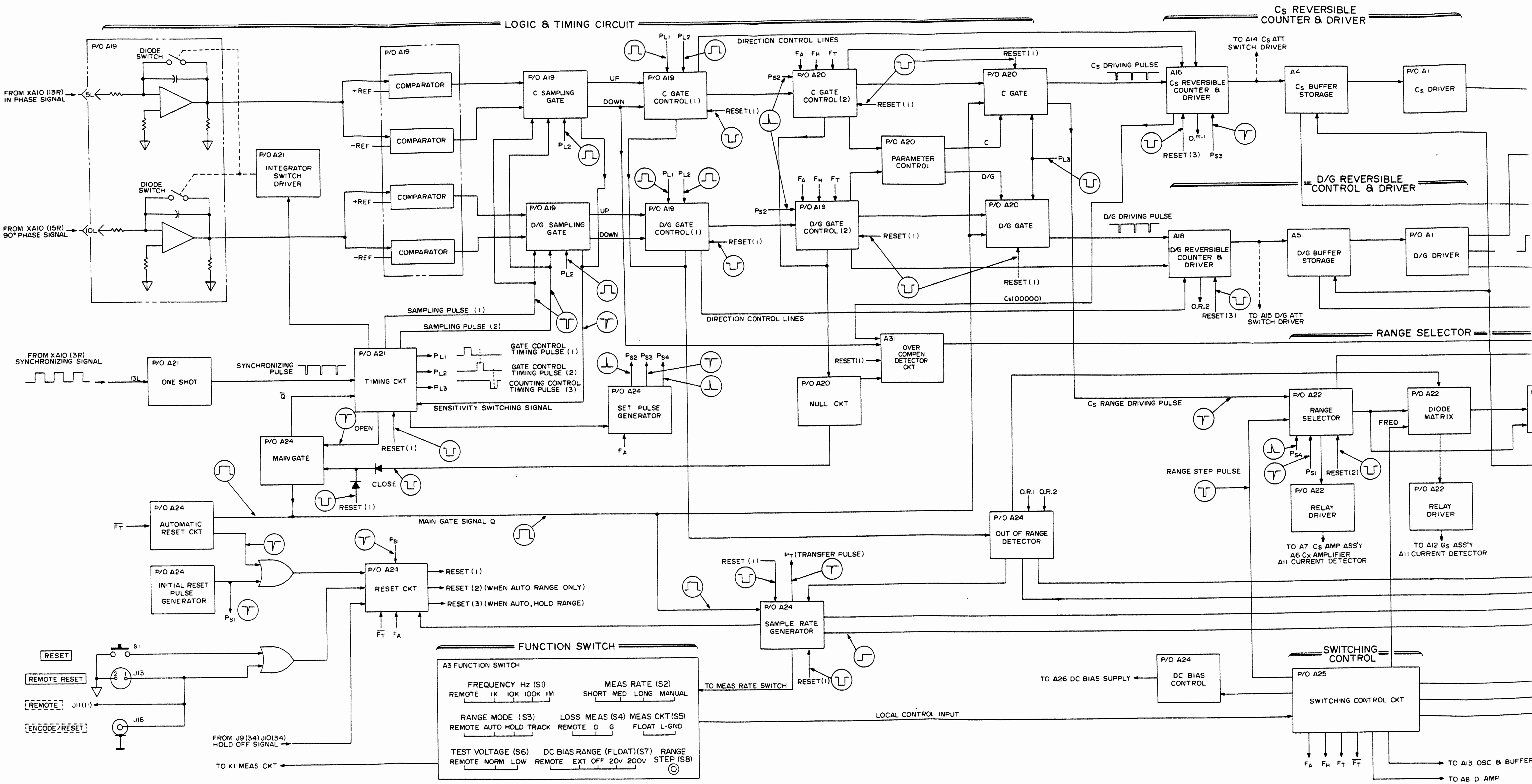


Figure 8-2. Simplified Block Diagram

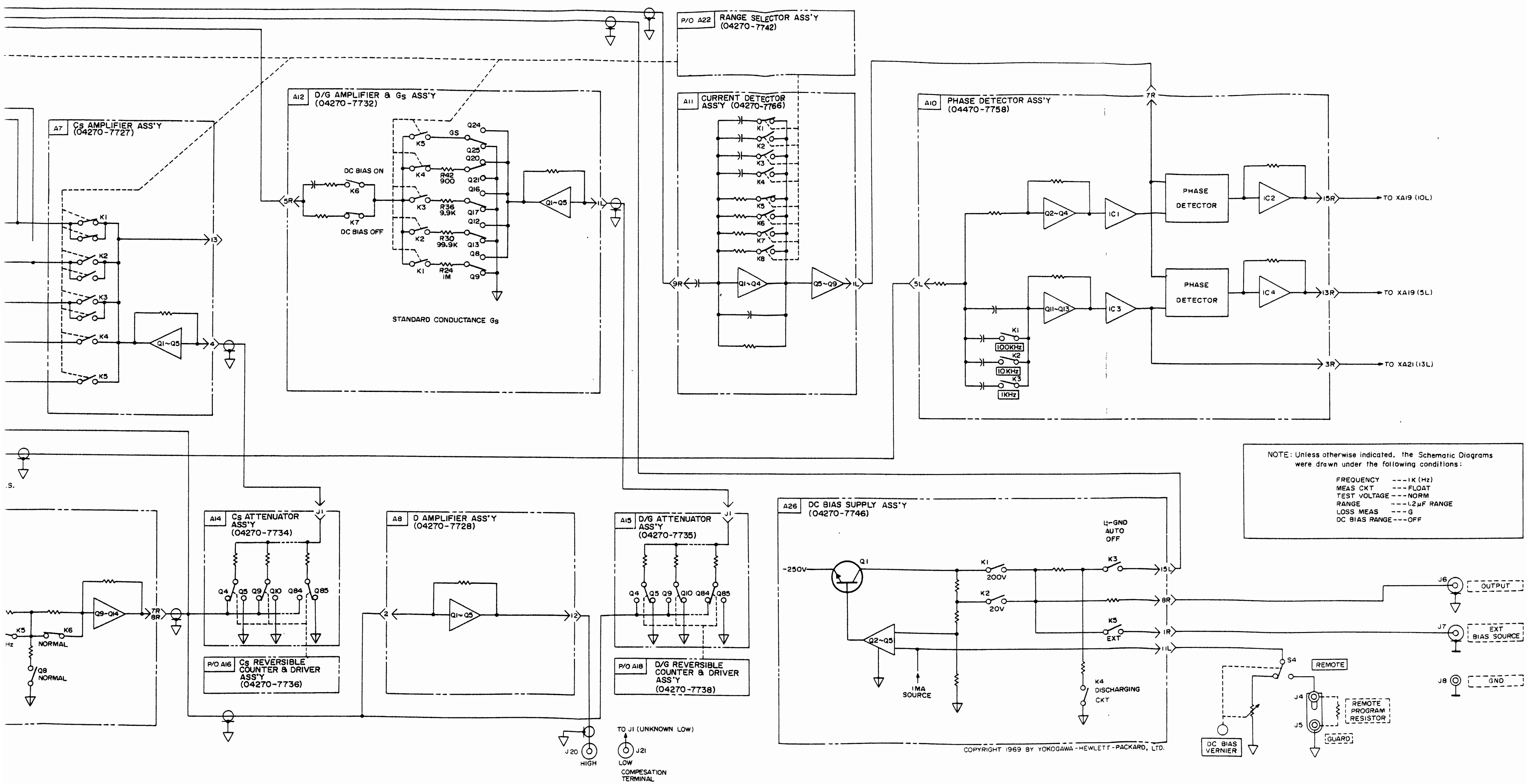


TEST VOLTAGE				
	NORMAL		LOW	
	1KHz	10K~100K 1MHz	1KHz	10K~100K 1MHz
18p ~ 180nF RANGE	1V	0.5V	0.2V	0.1V
1.2 µF RANGE	0.1V		0.02V	

Figure 8-3. Detailed Block Diagram



LOGIC & TIMING CIRCUIT
Cs REVERSIBLE COUNTER & DRIVER
D/G REVERSIBLE CONTROL & DRIVER
RANGE SELECTOR
FUNCTION SWITCH
SWITCHING CONTROL
FROM XA10 (13R) IN PHASE SIGNAL
FROM XA10 (15R) 90° PHASE SIGNAL
P/O A19
DIODE SWITCH
P/O A21 INTEGRATOR SWITCH DRIVER
COMPARATOR
+REF
-REF
P/O A19 C SAMPLING GATE
P/O A19 D/G SAMPLING GATE
UP
DOWN
P/O A19 C GATE CONTROL (1)
P/O A19 D/G GATE CONTROL (1)
DIRECTION CONTROL LINES
P/O A20 C GATE CONTROL (2)
P/O A19 D/G GATE CONTROL (2)
P/O A20 PARAMETER CONTROL
P/O A20 C GATE
P/O A20 D/G GATE
RESET (1)
Cs DRIVING PULSE
D/G DRIVING PULSE
A16 Cs REVERSIBLE COUNTER & DRIVER
A18 D/G REVERSIBLE COUNTER & DRIVER
TO A14 Cs ATT SWITCH DRIVER
TO A15 D/G ATT SWITCH DRIVER
A4 Cs BUFFER STORAGE
A5 D/G BUFFER STORAGE
P/O A1 Cs DRIVER
P/O A1 D/G DRIVER
RESET (3)
Cs(00000)
FROM XA10 (3R) SYNCHRONIZING SIGNAL
P/O A21 ONE SHOT
SYNCHRONIZING PULSE
P/O A21 TIMING CKT
SAMPLING PULSE (1)
SAMPLING PULSE (2)
GATE CONTROL TIMING PULSE (1)
GATE CONTROL TIMING PULSE (2)
COUNTING CONTROL TIMING PULSE (3)
SENSITIVITY SWITCHING SIGNAL
P/O A24 SET PULSE GENERATOR
A31 OVER COMPEN DETECTOR CKT
P/O A20 NULL CKT
Cs RANGE DRIVING PULSE
P/O A22 RANGE SELECTOR
P/O A22 DIODE MATRIX
FREQ
RANGE STEP PULSE
RESET (2)
P/O A22 RELAY DRIVER
TO A7 Cs AMP ASS'Y A6 Cx AMPLIFIER A11 CURRENT DETECTOR
TO A12 Gs ASS'Y A11 CURRENT DETECTOR
P/O A24 MAIN GATE
OPEN
CLOSE
P/O A24 AUTOMATIC RESET CKT
MAIN GATE SIGNAL Q
P/O A24 INITIAL RESET PULSE GENERATOR
P/O A24 RESET CKT
RESET (1)
RESET (2) (WHEN AUTO RANGE ONLY)
RESET (3) (WHEN AUTO, HOLD RANGE)
O.R.1 O.R.2
P/O A24 OUT OF RANGE DETECTOR
PT (TRANSFER PULSE)
P/O A24 SAMPLE RATE GENERATOR
TO MEAS RATE SWITCH
TO A26 DC BIAS SUPPLY
P/O A24 DC BIAS CONTROL
P/O A25 SWITCHING CONTROL CKT
LOCAL CONTROL INPUT
TO A13 OSC & BUFFER
TO A8 D AMP
RESET
REMOTE RESET
REMOTE
ENCODE/RESET
S1
J13
J11(11)
J16
FROM J9(34) J10(34) HOLD OFF SIGNAL
TO K1 MEAS CKT
A3 FUNCTION SWITCH
FREQUENCY Hz (S1) REMOTE 1K 10K 100K 1M
MEAS RATE (S2) SHORT MED LONG MANUAL
RANGE MODE (S3) REMOTE AUTO HOLD TRACK
LOSS MEAS (S4) REMOTE D G
MEAS CKT (S5) FLOAT L-GND
TEST VOLTAGE (S6) REMOTE NORM LOW
DC BIAS RANGE (FLOAT) (S7) REMOTE EXT OFF 20V 200V
RANGE STEP (S8)



A7 Cs AMPLIFIER ASS'Y (04270-7727)
A12 D/G AMPLIFIER & Gs ASS'Y (04270-7732)
DC BIAS ON
DC BIAS OFF
R42 900
R36 9.9K
R30 99.9K
R24 1M
STANDARD CONDUCTANCE Gs
P/O A22 RANGE SELECTOR ASS'Y (04270-7742)
A11 CURRENT DETECTOR ASS'Y (04270-7766)
A10 PHASE DETECTOR ASS'Y (04470-7758)
PHASE DETECTOR
PHASE DETECTOR
100KHz
10KHz
1KHz
TO XA19 (10L)
TO XA19 (5L)
TO XA21 (13L)
NORMAL
A14 Cs ATTENUATOR ASS'Y (04270-7734)
P/O A16 Cs REVERSIBLE COUNTER & DRIVER ASS'Y (04270-7736)
A8 D AMPLIFIER ASS'Y (04270-7728)
A15 D/G ATTENUATOR ASS'Y (04270-7735)
P/O A18 D/G REVERSIBLE COUNTER & DRIVER ASS'Y (04270-7738)
J20 HIGH
TO J1 (UNKNOWN LOW)
J21 LOW COMPESATION TERMINAL
A26 DC BIAS SUPPLY ASS'Y (04270-7746)
-250V
200V
20V
EXT
1MA SOURCE
K4 DISCHARGING CKT
L-GND AUTO OFF
NOTE: Unless otherwise indicated, the Schematic Diagrams were drawn under the following conditions:
FREQUENCY ---1K (Hz)
MEAS CKT ---FLOAT
TEST VOLTAGE---NORM
RANGE ---1.2μF RANGE
LOSS MEAS ---G
DC BIAS RANGE---OFF
OUTPUT
EXT BIAS SOURCE
GND
REMOTE
REMOTE PROGRAM RESISTOR
GUARD
DC BIAS VERNIER
COPYRIGHT 1969 BY YOKOGAWA-HEWLETT-PACKARD, LTD.

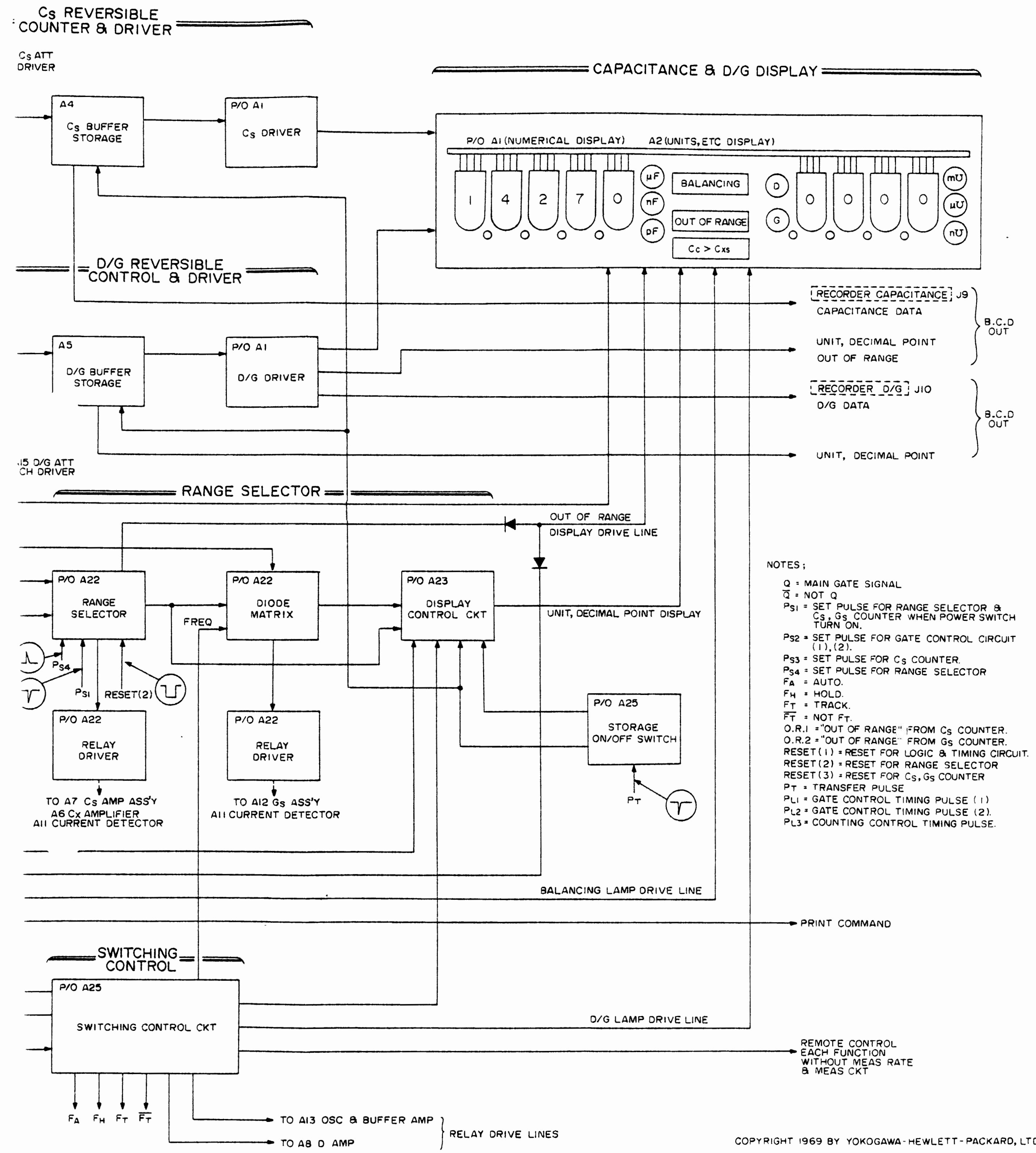


Figure 8-4. Detailed Block Diagram

A1 TROUBLESHOOTING

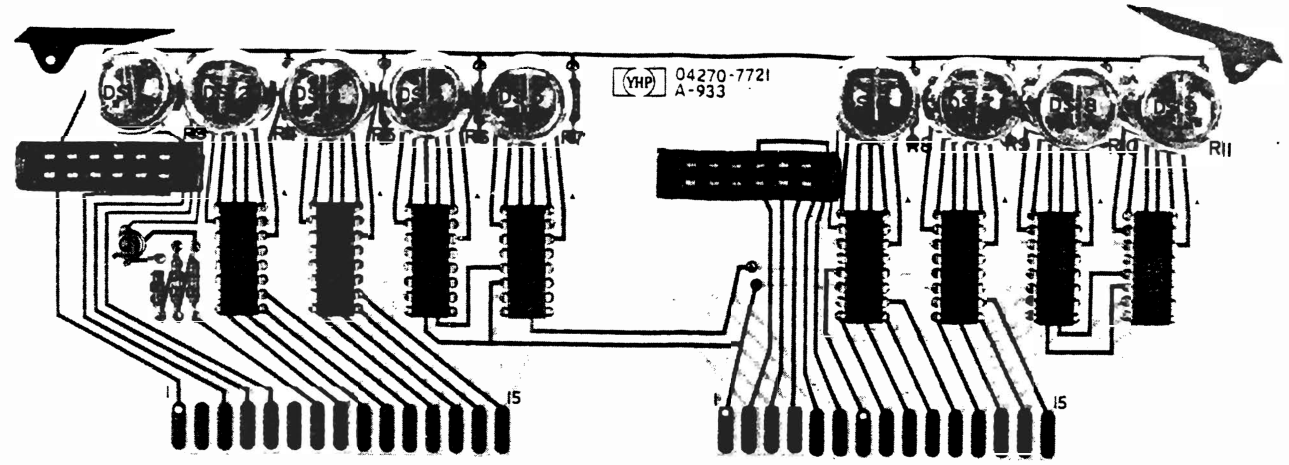
Check the +175Vdc at pins I-L and A-L, and the +5Vdc at pins 1-R and A-R. Use Logic Probe to check inputs to BCD to Decimal Decoder/Drivers. Use a DC Voltmeter to check outputs of Decoder/Drivers; enabling digit voltage should be approximately +2Vdc and disabling digit voltage should be betweem 30Vdc and 95Vdc. The display tubes can be checked by substitution or interchanging.

A4, A5 TROUBLESHOOTING

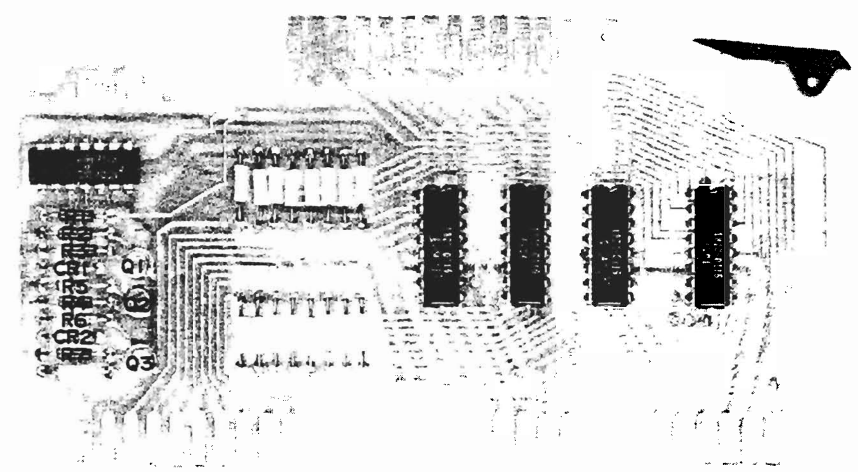
If a trouble exists with A4 or A5, the 4270A should balance but incorrect digits may be displayed. To check operation of Buffer Storages, set MEAS RATE to MANUAL and Storage ON/OFF Switch on A25 to OFF. Depress RESET button. If the display digits remain incorrect, check BCD inputs to A4 or A5 and output to A1 by using Logic Probe before replacing Buffer Storage IC. The inputs and outputs are negative true. If correct display digit is obtained, set MEAS RATE to SHORT, STORAGE ON/OFF to ON and verify that Transfer Pulse (1. 5Vp-p 2. 5μS width negative) occurs and replace the Buffer Storage IC.

SEE INSIDE

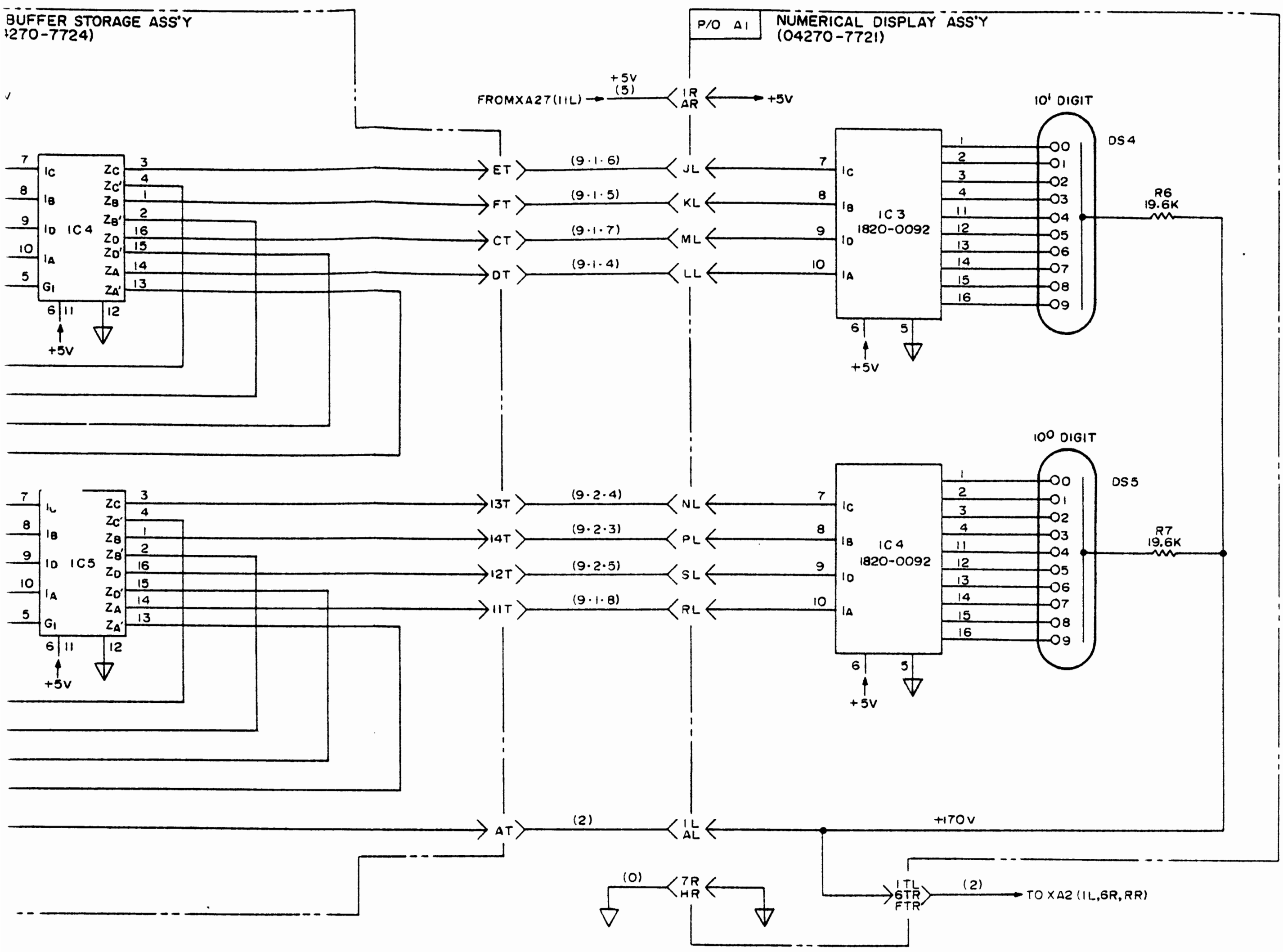
Figure 8-4
DETAILED BLOCK DIAGRAM

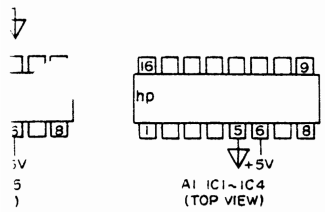


Numerical Display Ass'y A1
(04270-7721)



Cs Buffer Storage Ass'y A4
(04270-7724)



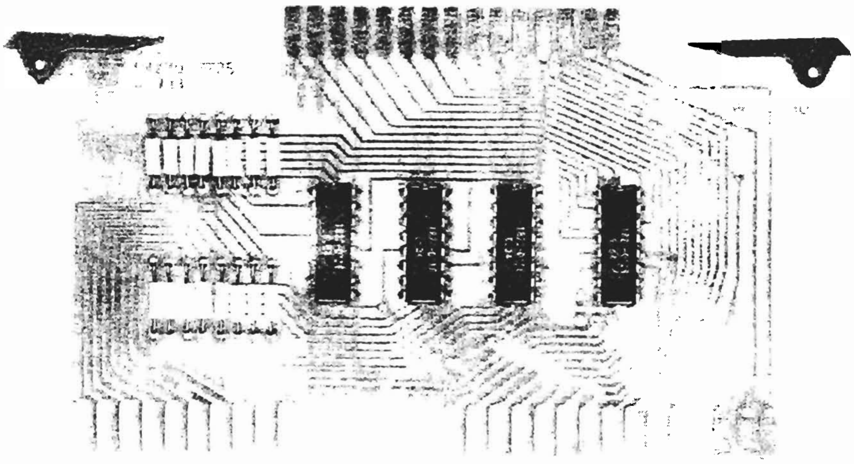


REFERENCE DESIGNATIONS

NO PREFIX	A1 ASS'Y	A4 ASS'Y
	CR1 DS1-DS5 IC1-IC4 Q1 R1-R7	CR1-CR2 Q1-Q3 IC1-IC5 R1-R7

DELETED;

Figure 8-5. Numerical Display Ass'y A1
Cs Buffer Storage Ass'y A4

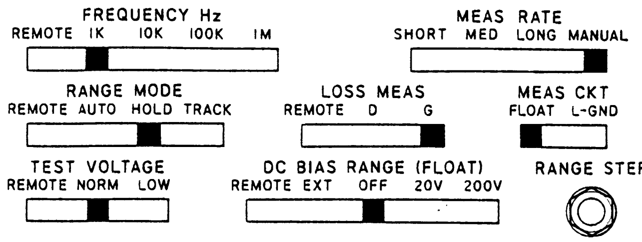


D/G Buffer Storage Ass'y A5
(04270-7725)

A6 TROUBLESHOOTING

Check +15Vdc at pin 2, +10Vdc at pin 8 and the -6Vdc at pin 6. If a trouble is found (except on 1μF capacitance range), check relay control signal which should be +0.1V and relay K1. If trouble is found (including the 1μF range), make waveform checks to determine which stage is not working. When trouble has been isolated to a stage, make voltage and resistance measurements.

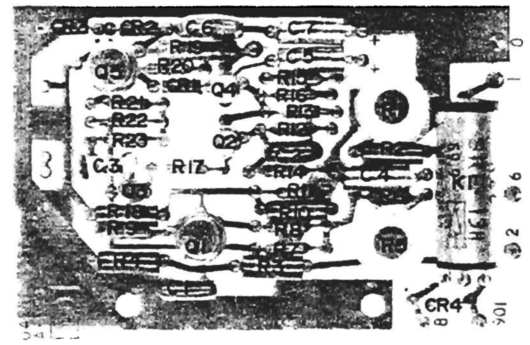
Set Controls for waveform and DC bias check as follows:
(Capacitance Range 1000pF)



All waveforms are taken with HP 180A Oscilloscope, HP 1801A Vertical Plug-in, HP 1821A Time Base Plug-in, and HP 10004A 10 : 1 Divider Probe.

Table 8-1. Cx Amp Waveform Measurement Conditions.

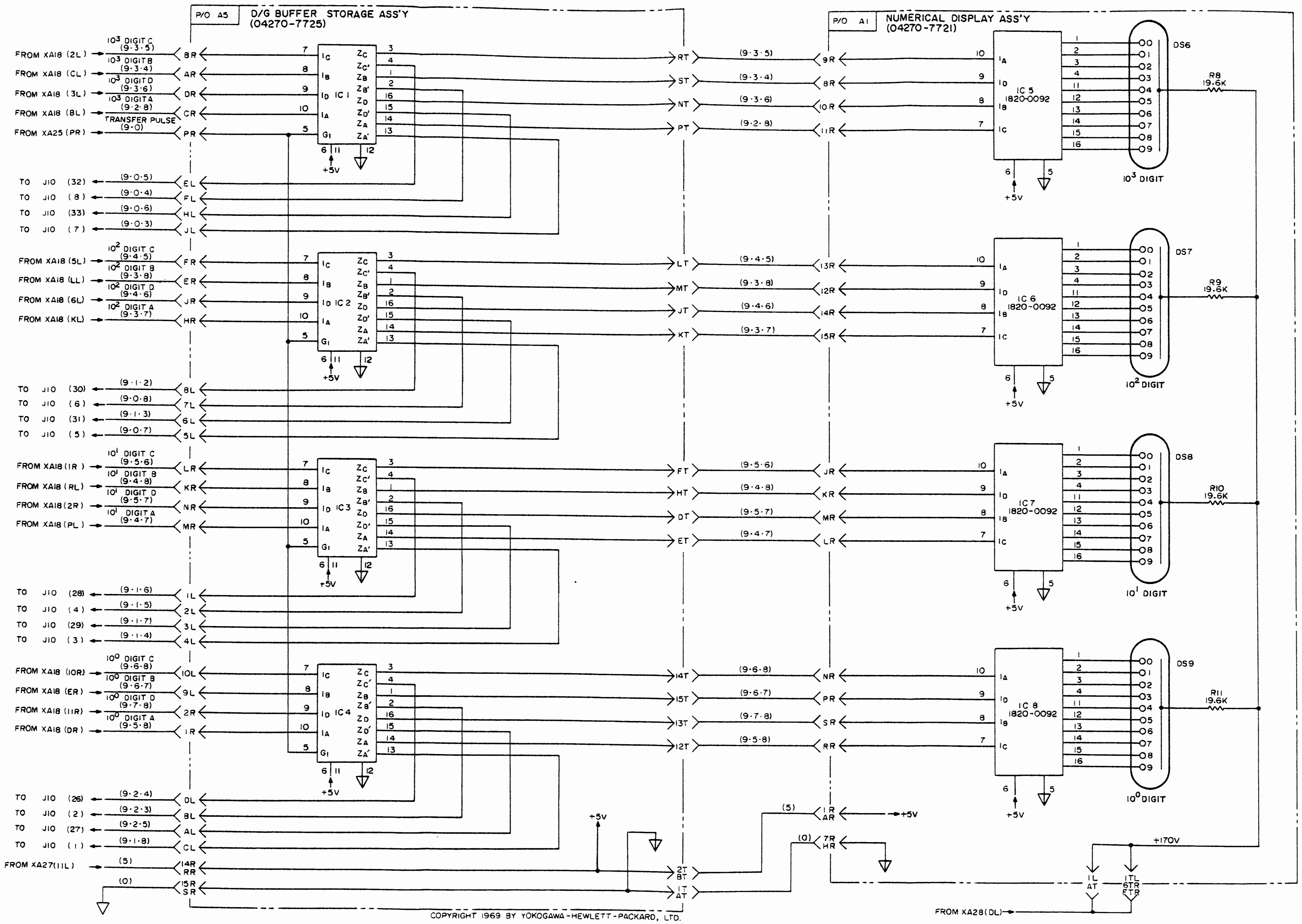
Waveform No.	1801A		1821A			
	V/Cm	Ac/ Dc	Time/ Cm	Main Trigger	Slope	Sweep Mode
1	.1	AC	.5ms	INT	—	Auto
2	.005	AC	.5ms	INT	—	Auto
3	.1	AC	.5ms	INT	—	Auto
4	.1	AC	.5ms	INT	—	Auto



Cx Amplifier Ass'Y A6
(04270-7726)

SEE INSIDE

Figure 8-6
NUMERICAL DISPLAY ASS'Y A1
D/G BUFFER STORAGE ASS'Y A5

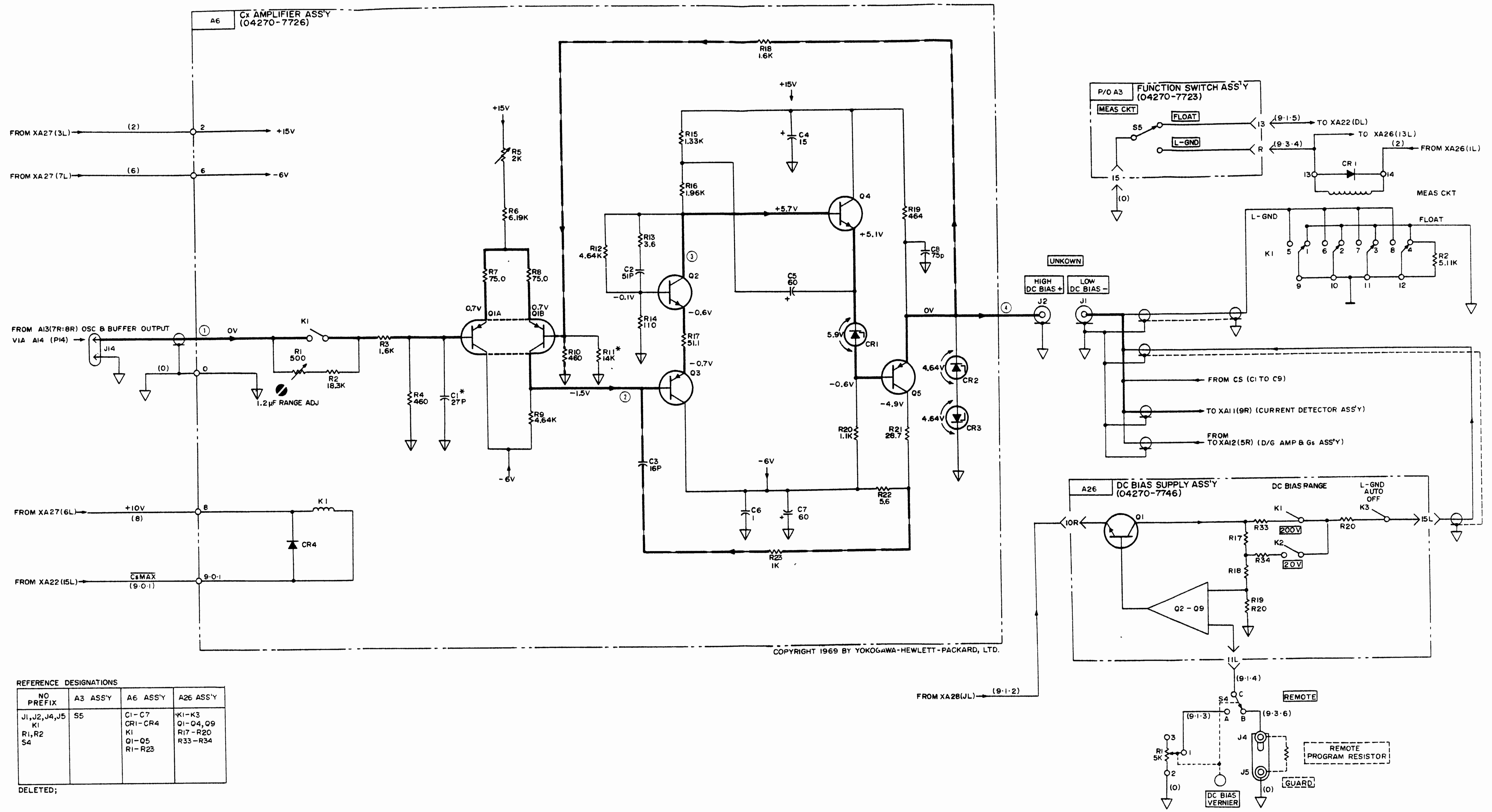


REFERENCE DESIGNATIONS

NO PREFIX	A1 ASS'Y	A5 ASS'Y
	DS6 - DS9 IC5 - IC8 R8 - R11	IC1 - IC4

DELETED;

Figure 8-6. Numerical Display Ass'y A1
D/G Buffer Storage Ass'y A5



REFERENCE DESIGNATIONS

NO PREFIX	A3 ASS'Y	A6 ASS'Y	A26 ASS'Y
J1,J2,J4,J5 K1 R1,R2 S4	S5	C1-C7 CR1-CR4 K1 Q1-Q5 R1-R23	K1-K3 Q1-Q4,Q9 R17-R20 R33-R34

DELETED;

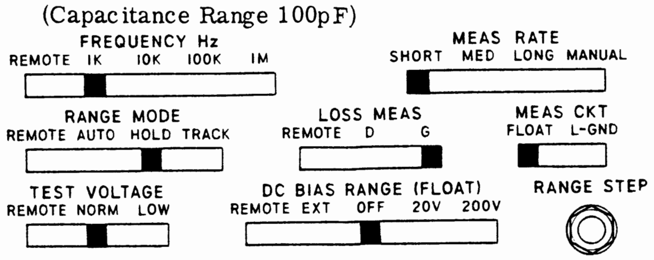
Figure 8-7. Cx Amp Ass'y A6

A8 TROUBLESHOOTING

Check +15Vdc at pin 1, +10Vdc at pin 13, and 16Vdc at pin 9. If trouble is found only on G measurement range, check relay control signals and K2 relay. If trouble is found only on D measurement range, make waveform check at Q5 emitter as described below. If a correct waveform obtained, check relay control signal and relay. If not, make dc bias measurement.

Waveform Check Steps:

a. Set controls as shown below.
(Capacitance Range 100pF)



b. Disconnect cable from A14J1.

c. Set *external oscillator output to 10mVrms.

d. Connect oscillator output to P1 of cable.

e. Connect oscilloscope to Q5 emitter.

*External oscillator listed in Table 5-1 should be used.

Table 8-3. Relay Control Signals

Loss Meas	K1 Pin 15	K2 Pin 14
G	+10V	+0.1V
D	+0.1V	+10V

All waveforms are taken with HP 180A Oscilloscope, HP 1801A Vertical Plug-in, HP 1821A Time Base Plug-in, and HP 10004A 10 : 1 Divider Probe.

Table 8-4. Cs & D Amp Waveform Measurement Conditions

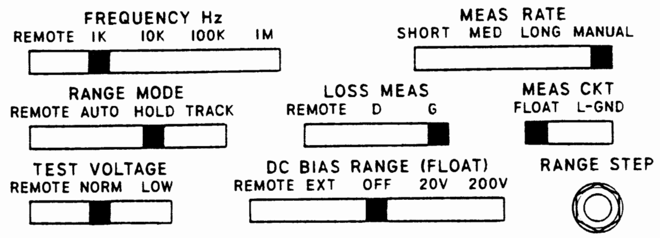
Waveform No.	1801A		1821A			
	V/Cm	Ac/Dc	Time/Cm	Main Trigger	Slope	Sweep Mode
5	.005	AC	.5ms	INT	——	Auto
6	.05	AC	.5ms	INT	——	Auto
7	.005	AC	.5ms	INT	——	Auto
8	.05	AC	.5ms	INT	——	Auto

A7 TROUBLESHOOTING

The first thing to do is to make sure that the trouble is a result of A7 malfunction as leads of relays should be unsoldered from standard capacitors for tracing the circuit. Make waveform checks as described below, and if the correct waveform at Q5 emitter is not obtained. unsolder leads of relays from standard capacitors, place A7 on an extender board and make dc bias measurement to isolate the defective component. If the waveform at Q5 emitter is correct, check relay control signals and waveform at relay output.

Waveform Check Steps:

a. Step controls as shown below.
(Capacitance Range 100pF)



b. Disconnect cable from A14J1.

c. Set an external *oscillator output to 10mVrms on the output monitor.

d. Connect oscillator output to P1 of cable.

e. Connect oscilloscope input to each test point.

*An external oscillator listed in Table 5-1 should be used.

Table 8-2. Relay Control Signals

Selected Capacitance Range	Relays				
	K1	K2	K3	K4	K5
10pF	+10V	+10V	+10V	+10V	+0.1V
100pF	+10V	+10V	+10V	+0.1V	+10V
1000pF	+10V	+10V	+0.1V	+10V	+10V
10nF	+10V	+0.1V	+10V	+10V	+10V
100nF	+0.1V	+10V	+10V	+10V	+10V
1μF	+0.1V	+10V	+10V	+10V	+10V

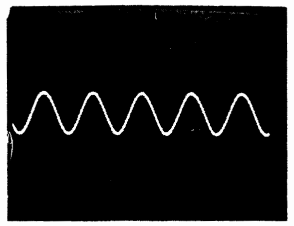
All waveforms are taken with HP 180A Oscilloscope, HP 1801A Vertical Plug-in, HP 1821A Time Base Plug-in, and HP 10004A 10 : 1 Divider Probe.

Table 8-4. Cs & D Amp Waveform Measurement Conditions

Waveform No.	1801A		1821A			
	V/Cm	Ac/Dc	Time/Cm	Main Trigger	Slope	Sweep Mode
5	.005	AC	.5ms	INT	——	Auto
6	.05	AC	.5ms	INT	——	Auto
7	.005	AC	.5ms	INT	——	Auto
8	.05	AC	.5ms	INT	——	Auto

SEE INSIDE

⑤



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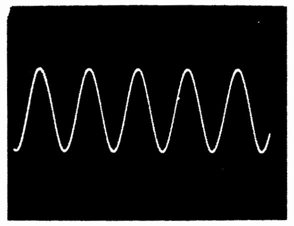

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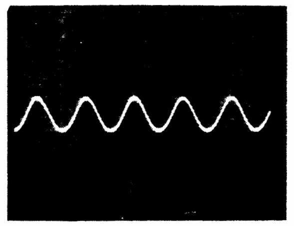

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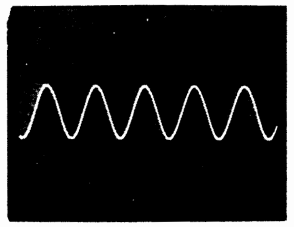

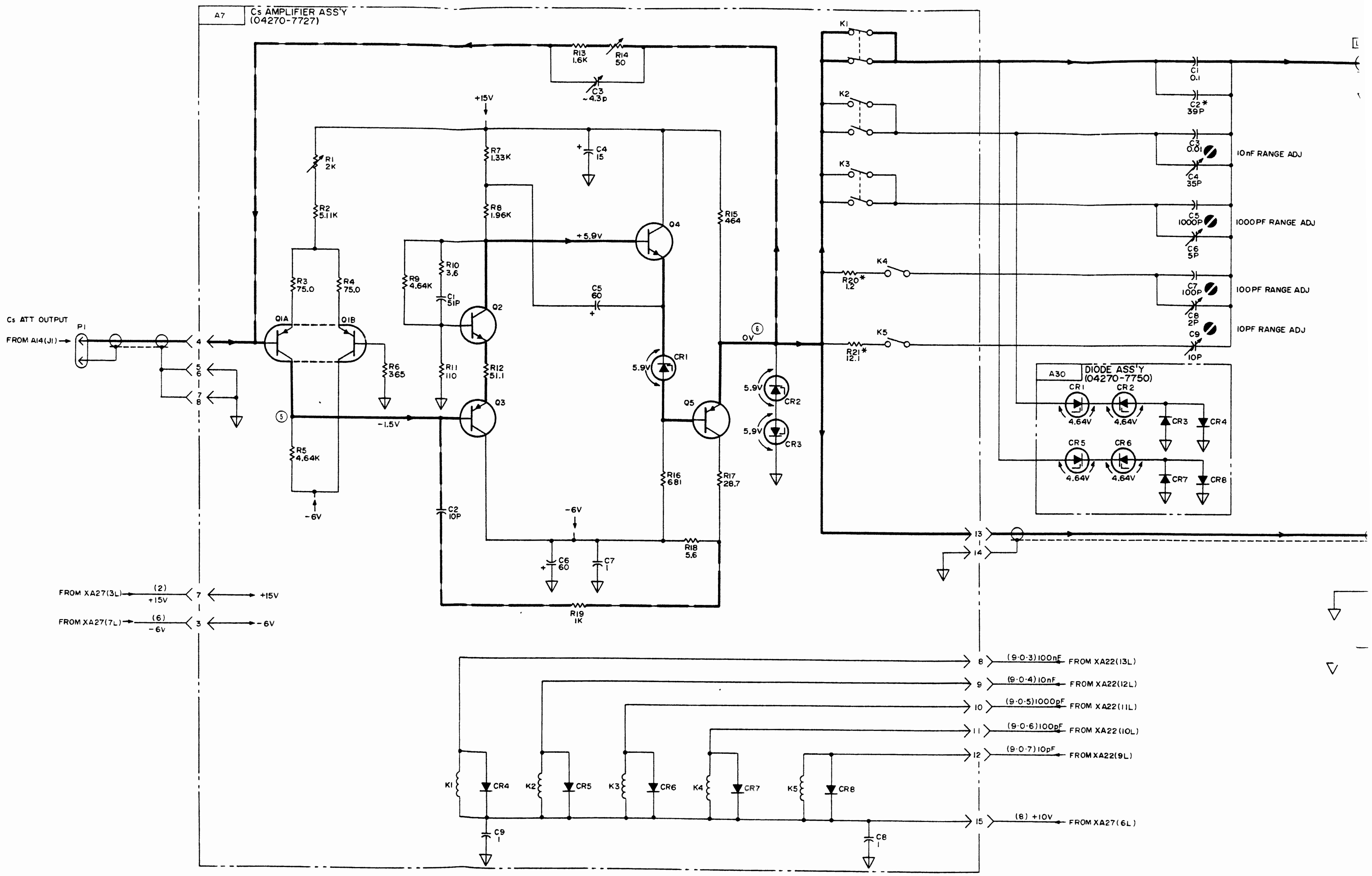

A7
Cs AMPLIFIER ASS'Y
(04270-7727)
Cs ATT OUTPUT
FROM A14(J1)
P1
R13 1.6K
R14 50
C3 ~4.3p
+15V
R1 2K
R2 5.11K
R3 75.0
R4 75.0
R5 4.64K
R6 365
R7 1.33K
R8 1.96K
R9 4.64K
R10 3.6
R11 110
R12 51.1
R15 464
R16 681
R17 28.7
R18 5.6
R19 1K
C1 51P
C2 10P
C4 15
C5 60
C6 60
C7 1
+5.9V
-1.5V
-6V
0V
5.9V
Q1A
Q1B
Q2
Q3
Q4
Q5
CR1
CR2
CR3
FROM XA27(3L)
(2) +15V
FROM XA27(7L)
(6) -6V
K1
K2
K3
K4
K5
R20* 1.2
R21* 12.1
C1 0.1
C2* 39P
C3 0.01
C4 35P
C5 1000P
C6 5P
C7 100P
C8 2P
C9 10P
10nF RANGE ADJ
1000PF RANGE ADJ
100PF RANGE ADJ
10PF RANGE ADJ
A30
DIODE ASS'Y
(04270-7750)
CR1 4.64V
CR2 4.64V
CR3
CR4
CR5 4.64V
CR6 4.64V
CR7
CR8
(9-0-3)100nF FROM XA22(13L)
(9-0-4)10nF FROM XA22(12L)
(9-0-5)1000pF FROM XA22(11L)
(9-0-6)100pF FROM XA22(10L)
(9-0-7)10pF FROM XA22(9L)
(8) +10V FROM XA27(6L)
C9 1
C8 1

REFERENCE DESIGNATIONS

NO PREFIX	A7 ASS'Y	A8 ASS'Y	A30 ASS'Y
C1-C10 J1,J2,J16,J17 P1	C1-C8 CR1-CR8 K1-K5 Q1-Q5 R1-R21	C1-C8 CR1-CR3 K1,K2 Q1-Q5 R1-R20	CR1-CR8

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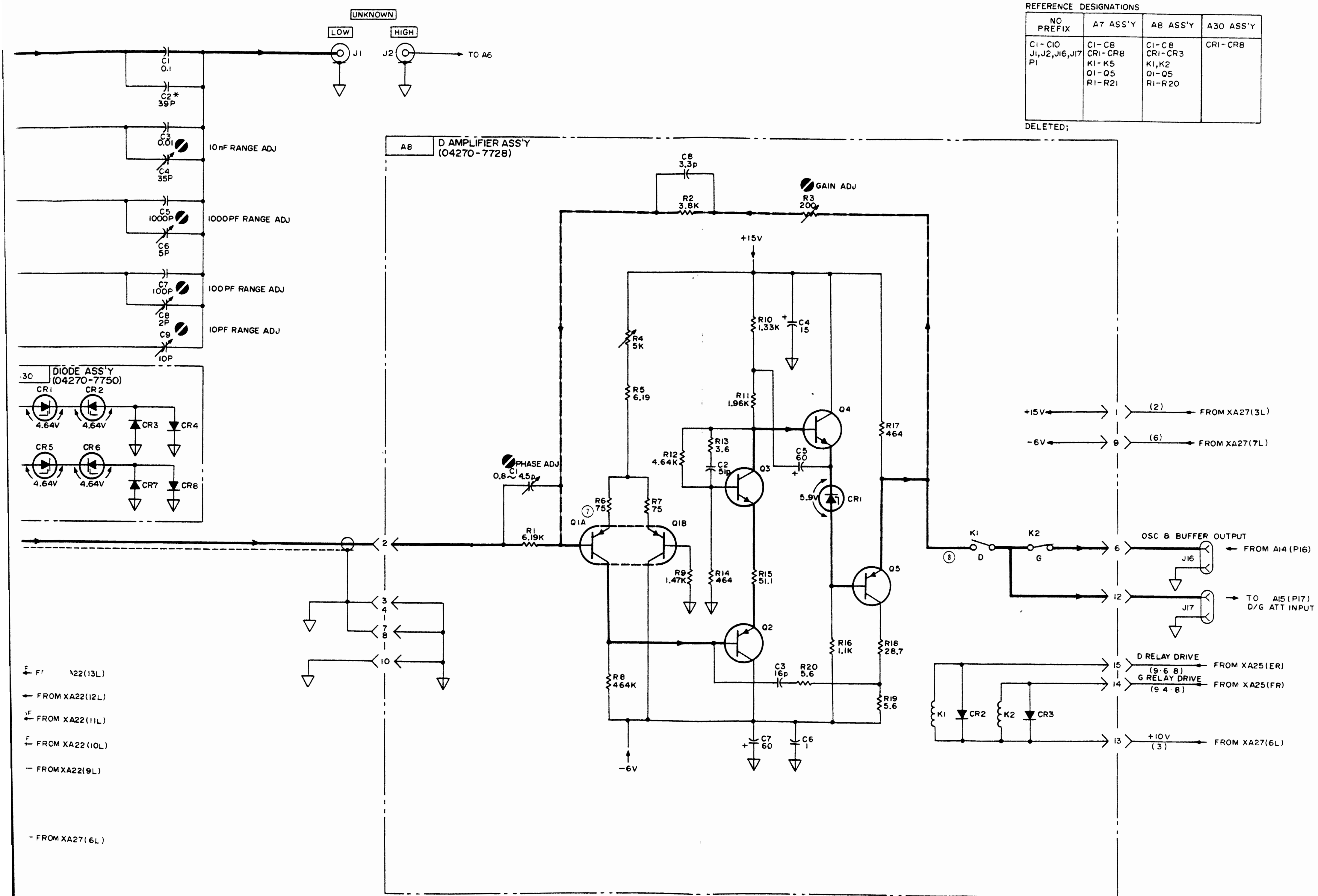


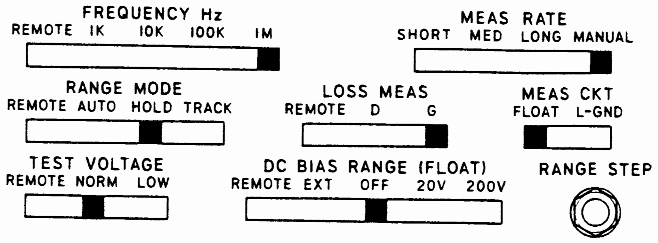
Figure 8-8. Cs Amp Ass'y A7
D Amp Ass'y A8

A10 TROUBLESHOOTING

Check the +15Vdc at pin 12-L, the +10Vdc at pin 1-L, and the -6Vdc at pin 7-L. Check relay control signal, see Table 8-5. Now check input signal at pin 5-L which should be 2.8Vp-p. Make waveform checks described below to determine which stage is not operating.

Waveform Check Steps:

a. Step controls as shown below.
   (Capacitance Range 100pF)



b. Connect 2pF capacitor (HP Part No. 0160-2240) to UNKNOWN.
c. Connect oscilloscope channel A vertical input to XA-10 pin 5-L and channel B vertical input to each check point.
d. Depress and hold RESET button while taking the waveforms.

Table 8-5. Relay Control Signals

FREQUENCY	TEST POINTS		
	K3	K2	K1
	PIN(2-L)	PIN(3-L)	PIN(4-L)
1kHz	+0.1V	+10V	+10V
10kHz	+10V	+0.1V	+10V
100kHz	+10V	+10V	+0.1V
1MHz	+10V	+10V	+10V

All waveforms are taken with HP 180A Oscilloscope, HP 1801A Vertical Plug-in, HP 1821A Time Base Plug-in, and HP 10004A 10 : 1 Divider Probe.

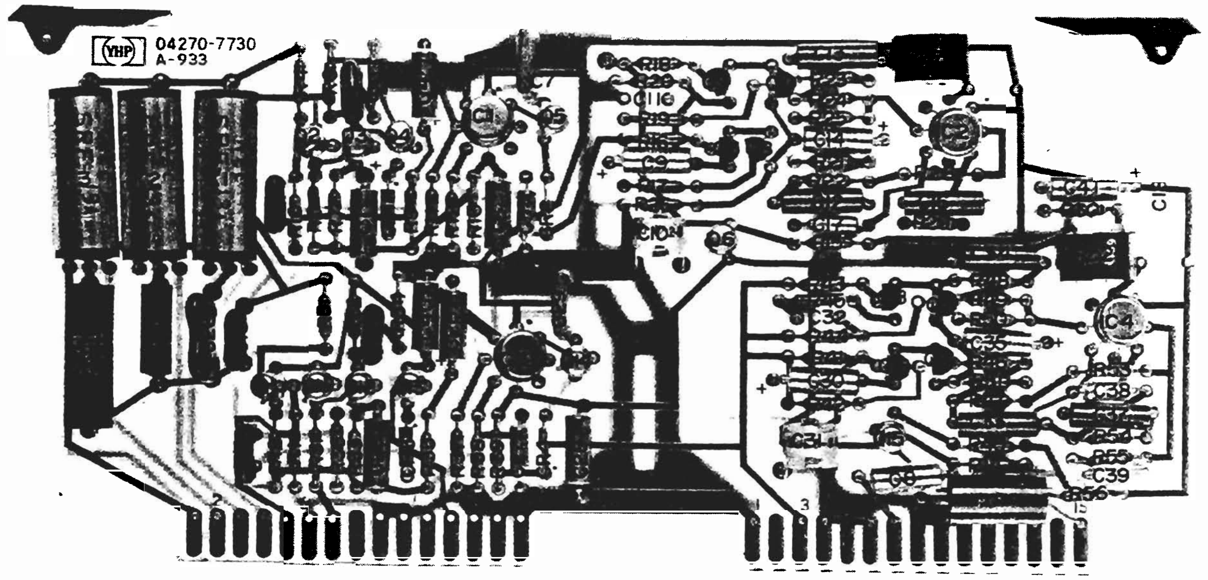
Table 8-6. Phase Detector Waveform Measurement Conditions

Waveform No.	1801A		1821A			
	V/Cm	Ac/ Dc	Time/ Cm	Main Trigger	Slope	Sweep Mode
9U	.1	AC	.5μs	INT(9u)	——	Auto
9L	.2	AC	.5μs	INT(9u)	——	Auto
10L*	.2	AC	.5μs	INT(9u)	——	Auto
11L*	.05	AC	.5μs	INT(9u)	——	Auto
12L*	.05	DC**	.5μs	INT(9u)	——	Auto
13L*	.05	DC	.5μs	INT(9u)	——	Auto
14L*	.05	DC	.5μs	INT(9u)	——	Auto
15L*	.05	DC	.5μs	INT(9u)	——	Auto

* The upper waveform is taken from XA10 pin 5-L same as 9U.
** 2cm lower line then center line is gero volt.

SEE INSIDE

Figure 8-8
CS AMP ASS'Y A7
D AMP ASS'Y A8



Phase Detector Ass'Y A10
(04270-7730)

⑨ U L

⑩

⑪

⑫

⑬

⑭

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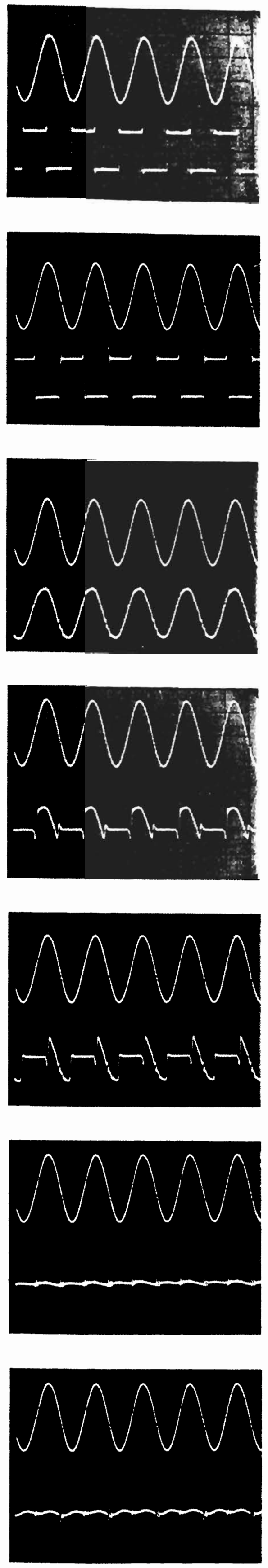
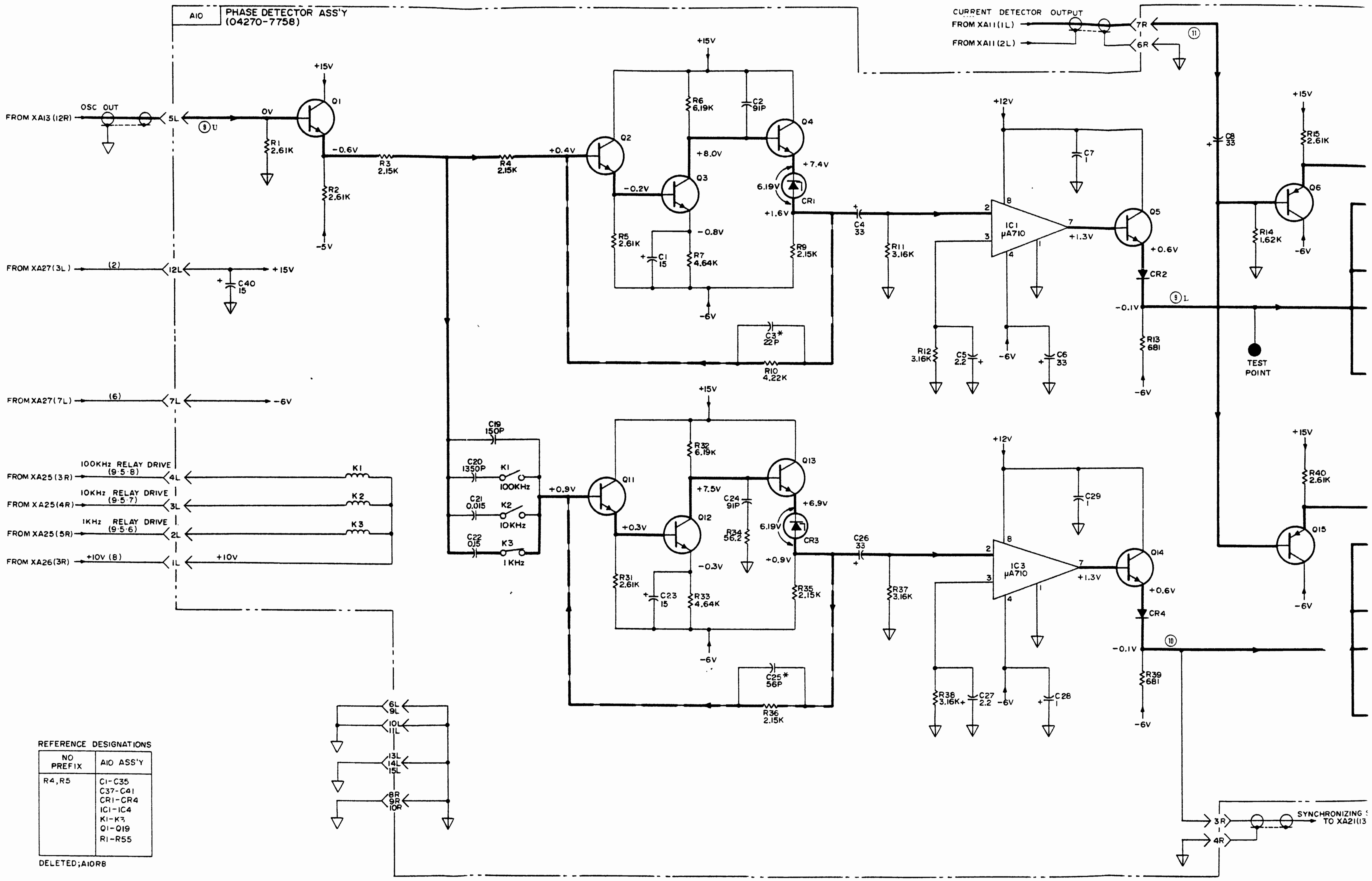




REFERENCE DESIGNATIONS

NO PREFIX	A10 ASS'Y
R4,R5	C1-C35 C37-C41 CR1-CR4 IC1-IC4 K1-K3 Q1-Q19 R1-R55

DELETED;A10R8

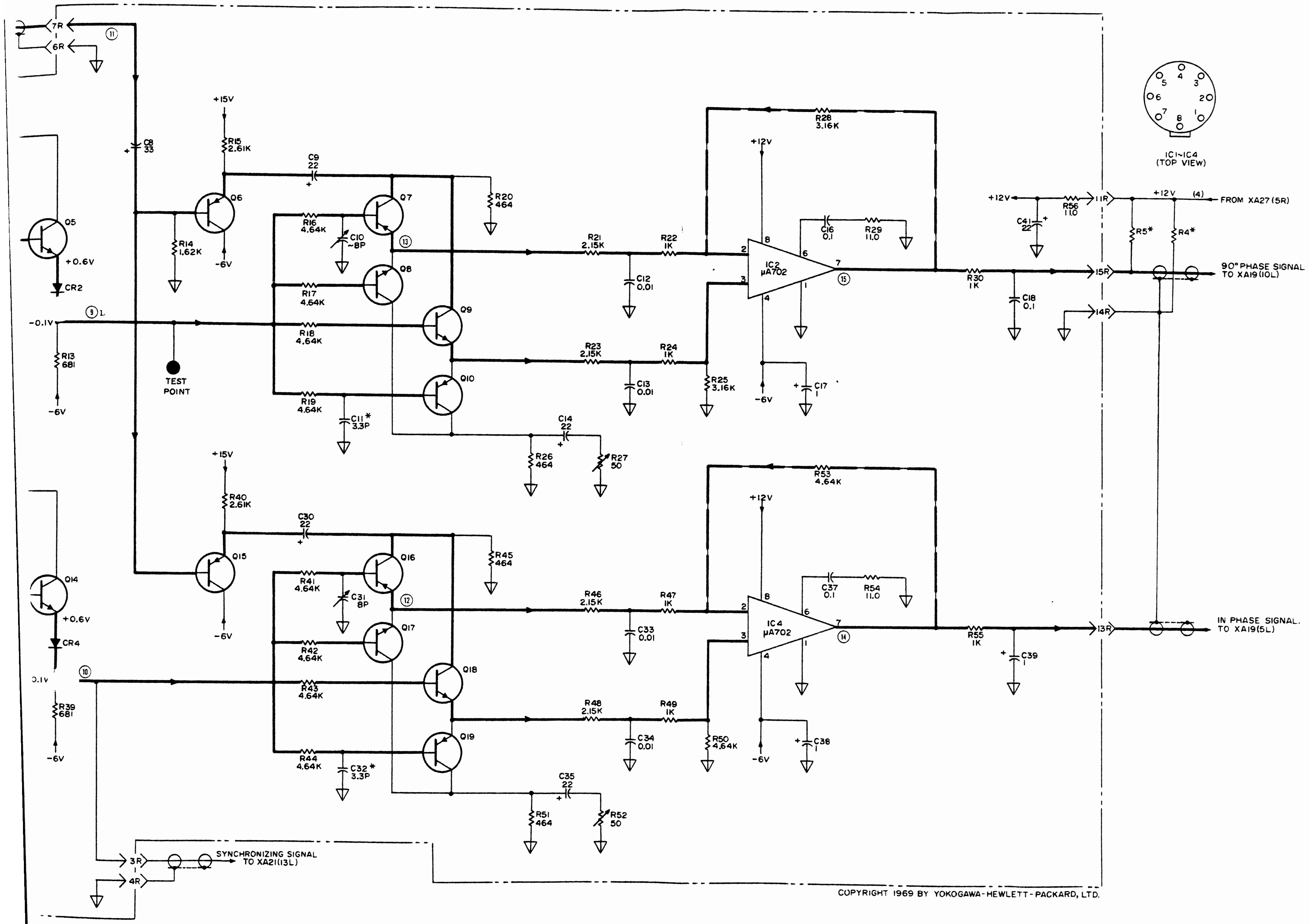


Figure 8-9. Phase Detector Ass'y A10

A11 TROUBLESHOOTING

Check the +15Vdc at PIN 9-L, the +10Vdc at pin 15-R, and the -6Vdc at PIN 15-L. To check the input relay control signal, set the RANGE MODE control to HOLD. Verify that the control signals for energized relays are LOW (+0.1V) and the other control signals are HIGH (+10V), see Table 8-7.

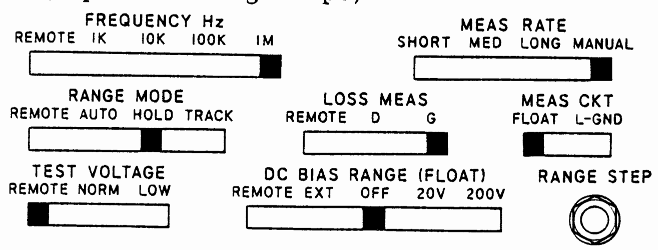
Table 8-7. Energized Relays

FREQ	Selected Capacitance Range					
	10pF	100pF	1000pF	10nF	100nF	1μF
1kHz	—	K1	K2. K5	K3. K6	K4. K7	K8
10kHz	—	K1. K5	K2. K6	K3. K7	K4. K8	—
100kHz	K5	K1. K6	K2. K7	K3. K8	—	—
1MHz	K6	K1. K7	L2. K8	—	—	—

Make waveform checks described below to determine which stage is not operating.

Waveform check steps:

a. Step controls as shown below.
(Capacitance Range 100pF)



b. Connect 5pF (HP Part No. 0180-2250) to UNKNOWN.
c. Connect oscilloscope channel A vertical input to HIGH UNKNOWN and channel B vertical input to each check point.
d. Depress and hold the RESET button while taking the waveforms.

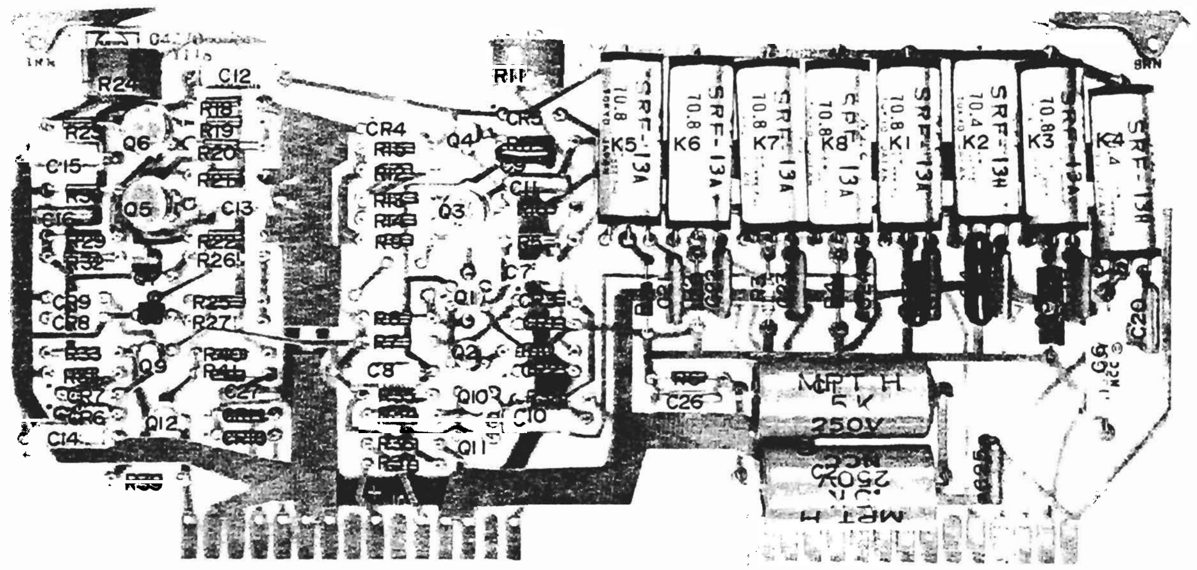
All waveforms are taken with HP 180A Oscilloscope, HP 1801A Vertical Plug-in, HP 1821A Time Base Plug-in, and HP 10004A 10 : 1 Divider Probe.

Table 8-8. Current Detector Waveform Measurement Conditions

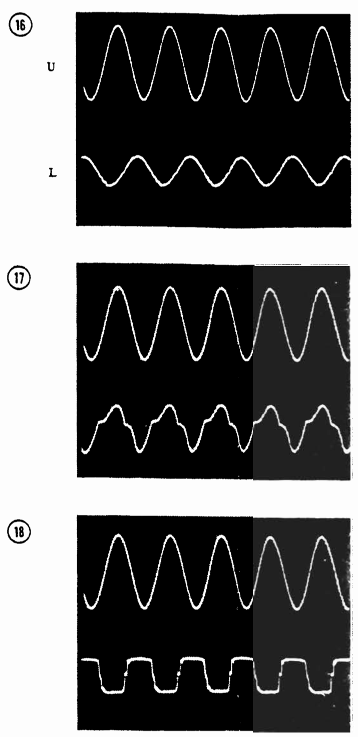
Waveform No.	1801A		1821A			
	V/Cm	AC/DC	Time/Cm	Main Trigger	Slope	Sweep Mode
16U	.05	AC	.5μs	Int(16u)	—	Auto
16L	.005	AC	.5μs	Int(16u)	—	Auto
17L	.1	AC	.5μs	Int(16u)	—	Auto
18L	.1	AC	.5μs	Int(16u)	—	Auto

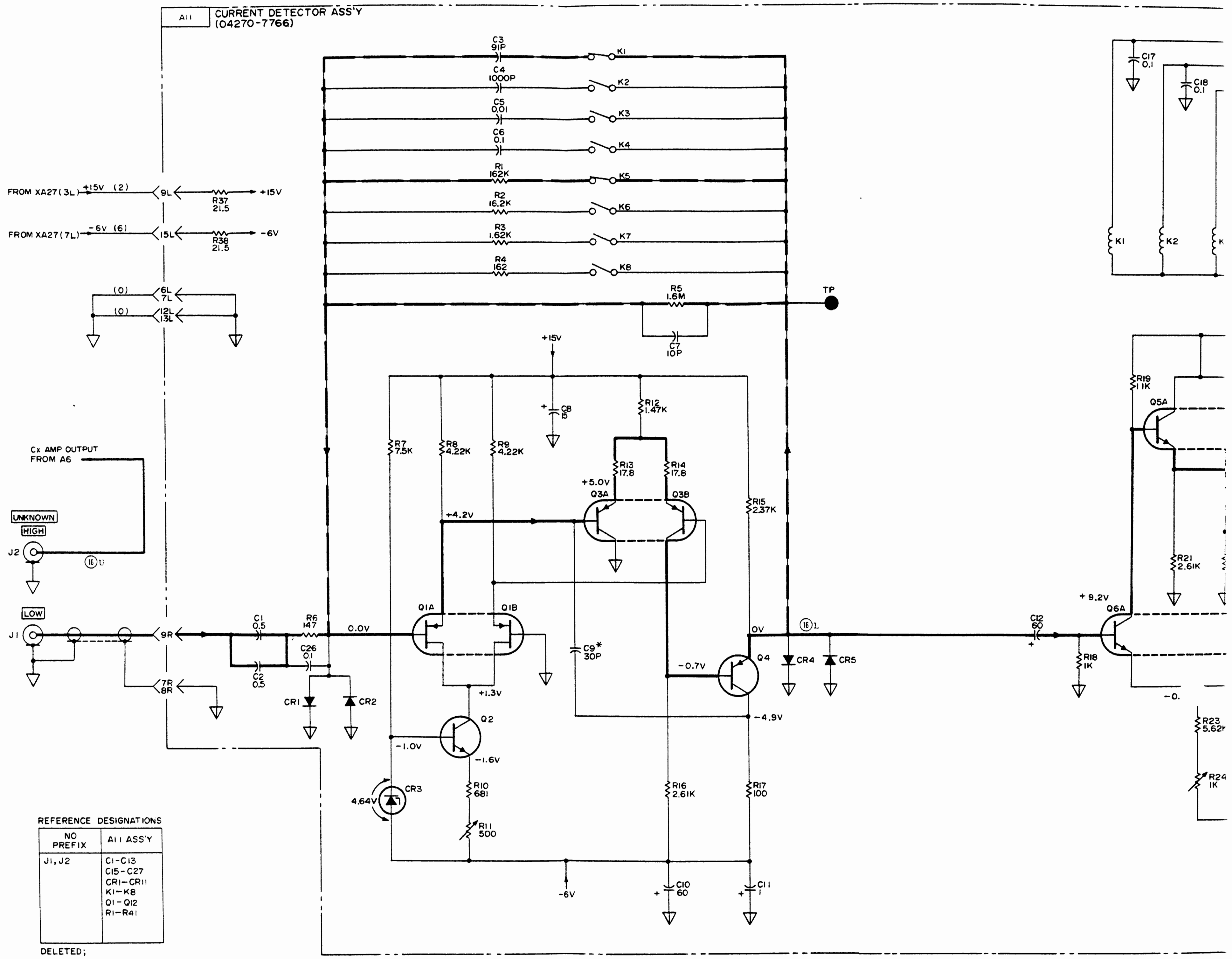
SEE INSIDE

Figure 8-9
PHASE DETECTOR ASS'Y A10



Current Detector Ass'y A11
(04270-7731)





REFERENCE DESIGNATIONS

NO PREFIX	A11 ASS'Y
J1, J2	C1-C13 C15-C27 CR1-CR11 K1-K8 Q1-Q12 R1-R41

DELETED;

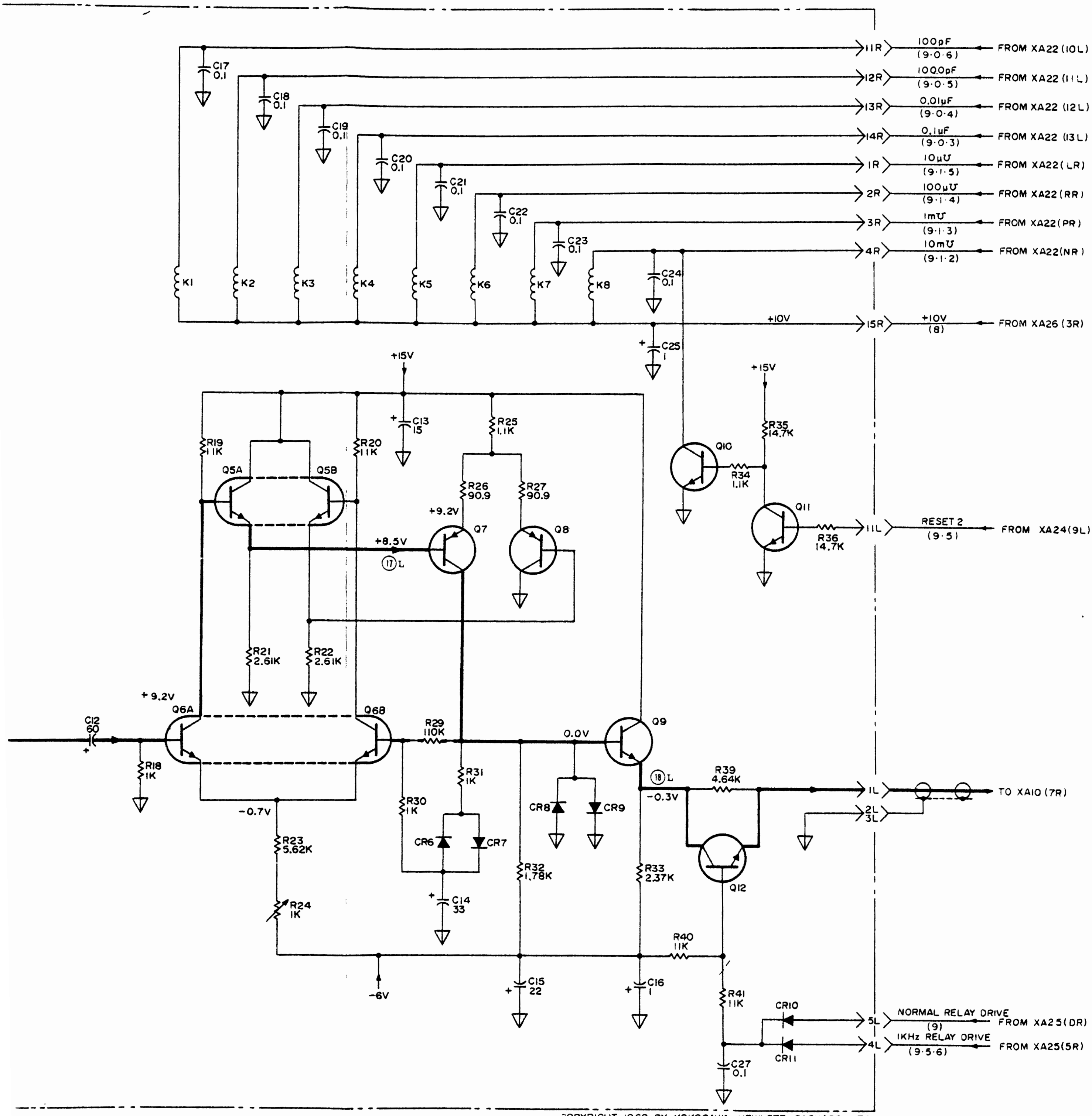
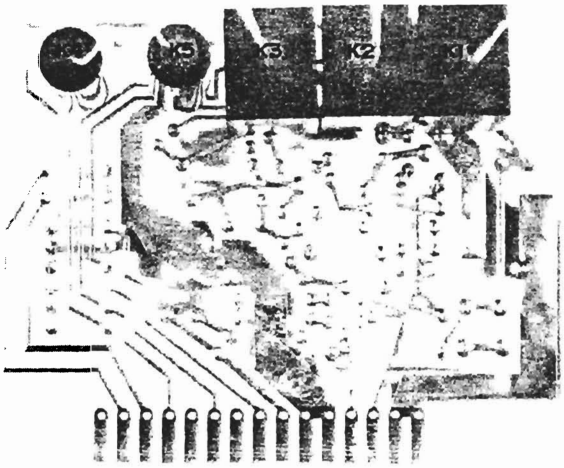
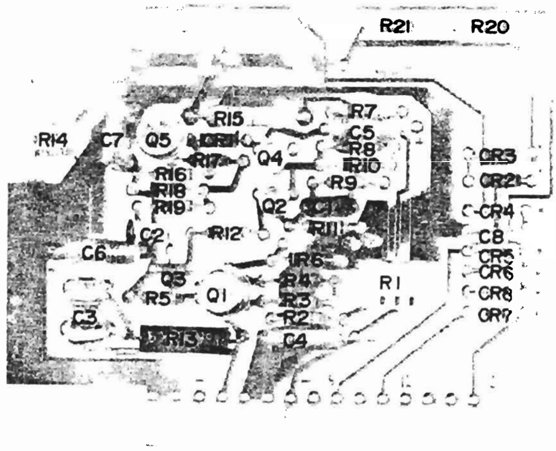


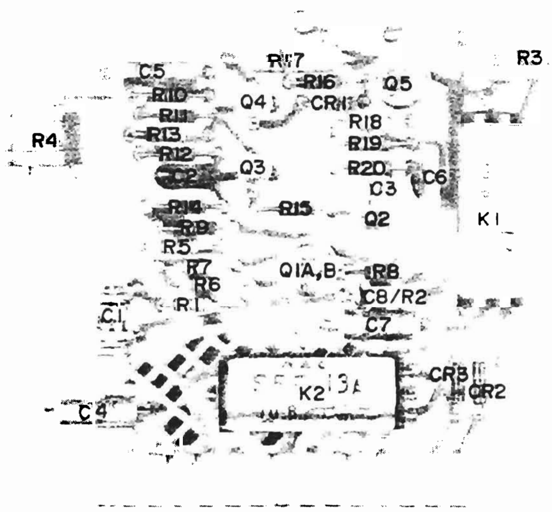
Figure 8-10. Current Detector Ass'y A11



Cs Amplifier Ass'y A7
(04270-7727)



Cs Amplifier Ass'y A7
(04270-7727)



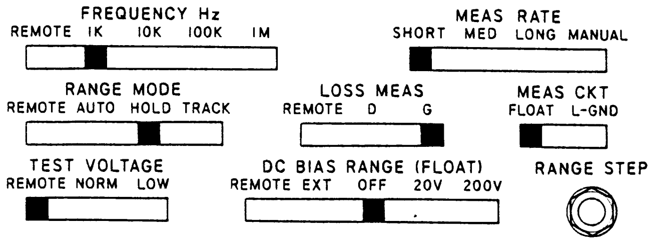
D Amplifier Ass'y A8
(04270-7728)

A12 TROUBLESHOOTING

If a problem exists with a particular conductance range, check the relay driving signal and the transistor switch which correspond to that range. If a problem exists with all the conductance ranges, check all the dc voltages coming into the board (+15Vdc at pin 5-L, +10Vdc at pin 15-R and -6Vdc at pin 10-L). Now make waveform checks described below to determine which stage is not operating.

Waveform check Steps:

a. Set controls as shown below.



b. Disconnect cable from A15J2.

c. Set *external oscillator output to 10mVrms.

d. Connect oscillator to P2 of cable.

e. Connect *oscilloscope input to Test Point.

*AN external test oscillator and oscilloscope such as listed in Table 5-1 should be used.

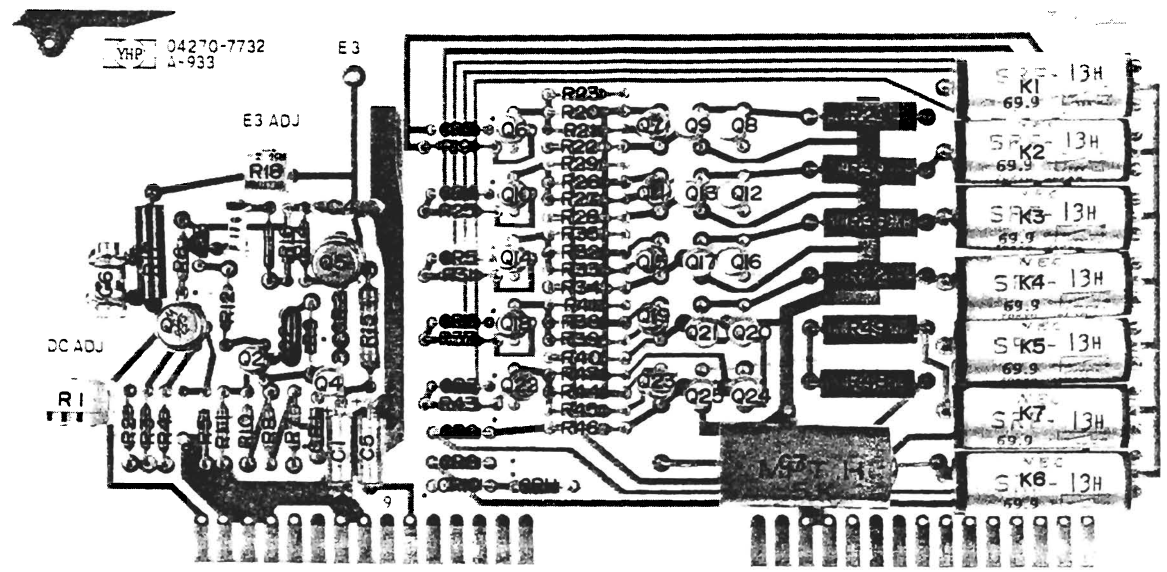
Table 8-9. Energized Relays

FREQ	Selected Capacitance Range					
	10pF	100pF	1000pF	10nF	100nF	1μF
1kHz	—	K1	K2	K3	K4	K5
10kHz	K1	K2	K3	K4	K5	—
100kHz	K2	K3	K4	K5	—	—
1MHz	K3	K4	K5	—	—	—

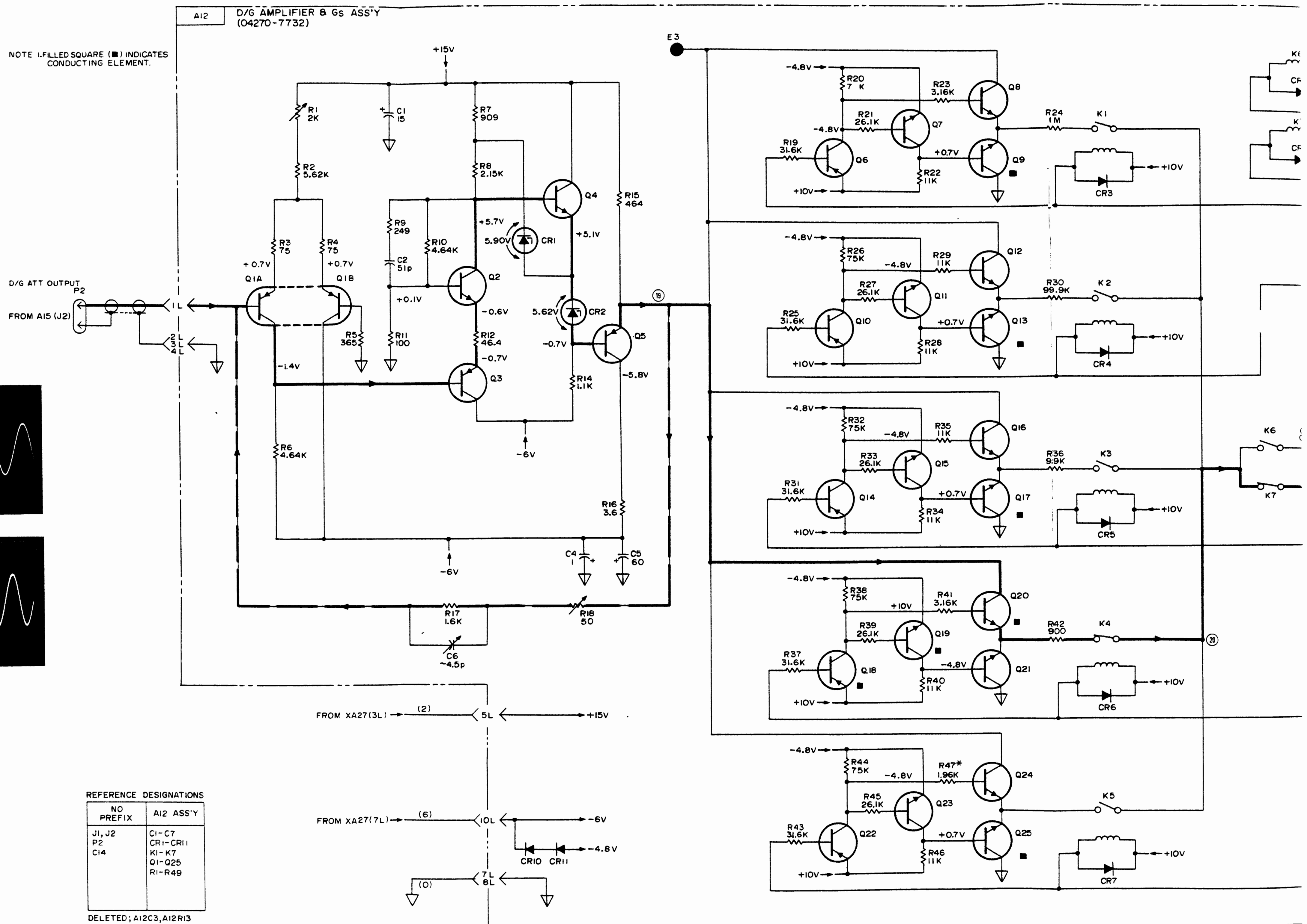
SEE INSIDE

Figure 8-10

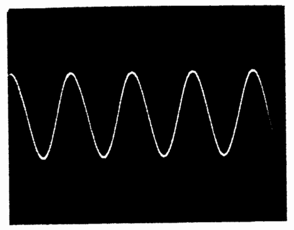
CURRENT DETECTOR ASS'Y A11



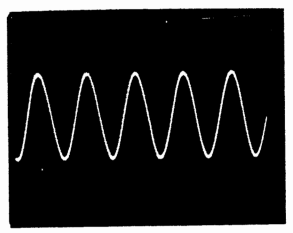
D/G Amplifier & Gs Ass'y A12
(04270-7732)



19



20



REFERENCE DESIGNATIONS

NO PREFIX	A12 ASS'Y
J1, J2 P2 C14	C1-C7 CR1-CR11 K1-K7 Q1-Q25 R1-R49

DELETED; A12C3, A12R13

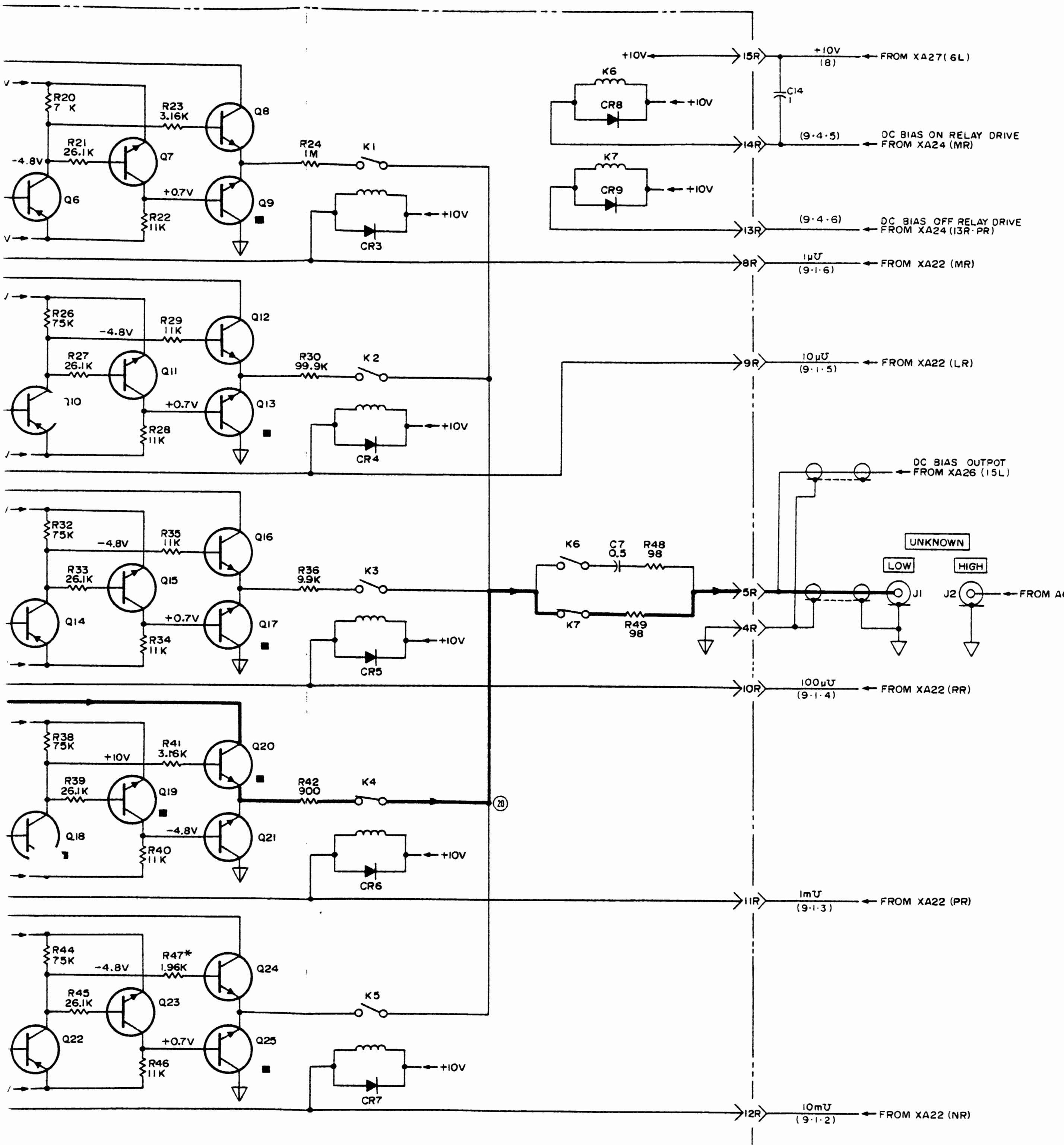
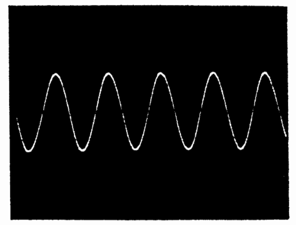
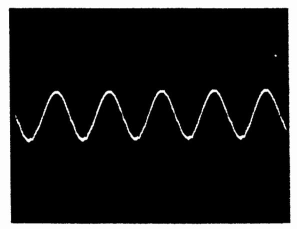


Figure 8-11. D/G Amp & Gs Ass'y A12

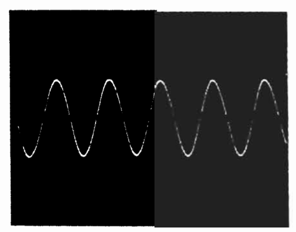
(21)

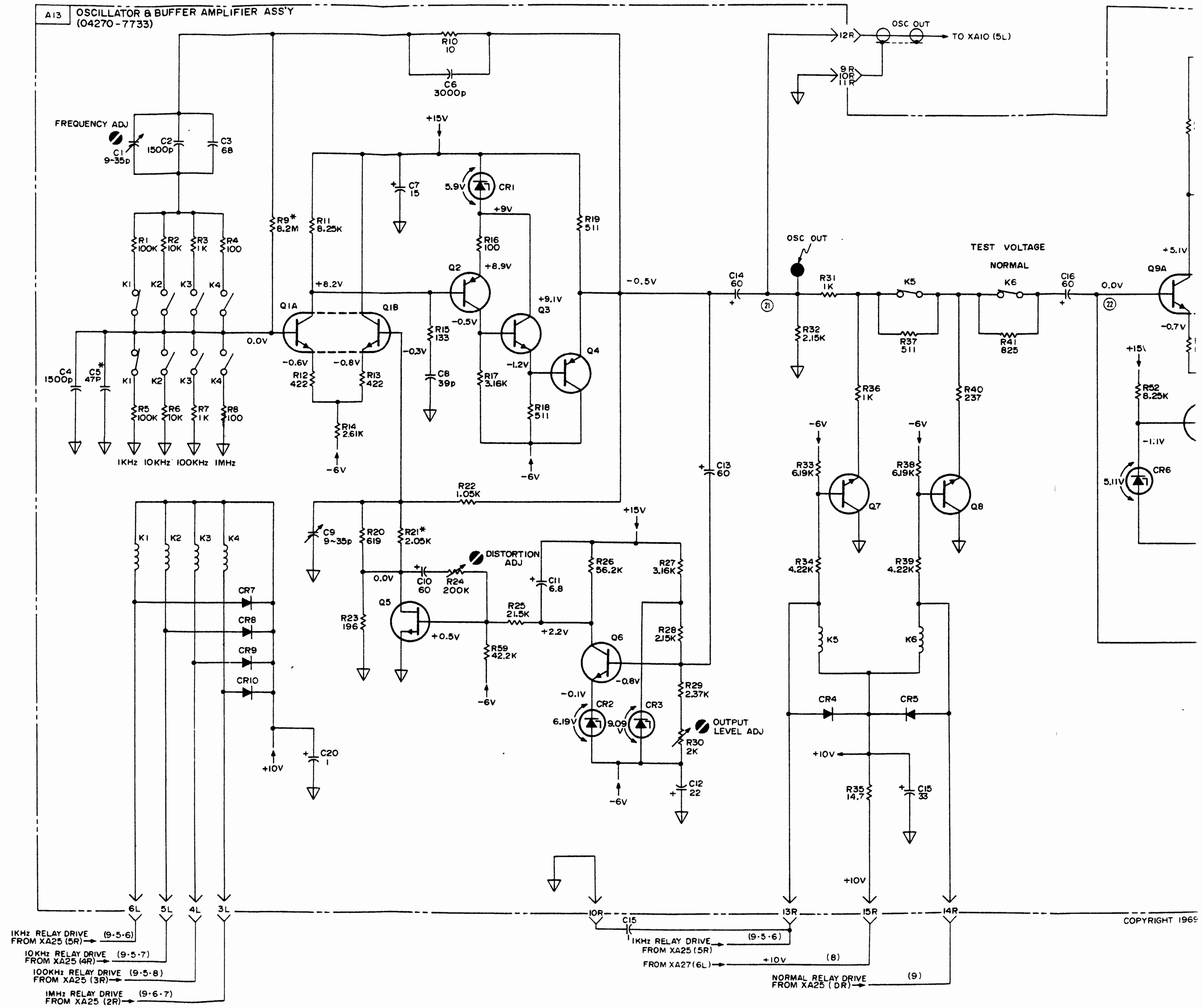


(22)



(23)





A13
OSCILLATOR & BUFFER AMPLIFIER ASS'Y
(04270-7733)
FREQUENCY ADJ
C1 9-35p
C2 1500p
C3 68
R10 10
C6 3000p
+15V
C7 15
5.9V CR1
+9V
R16 100
+8.9V
R9* 8.2M
R11 8.25K
R19 511
R1 100K
R2 10K
R3 1K
R4 100
K1 K2 K3 K4
+8.2V
Q1A Q1B Q2 Q3 Q4
+9.1V
-0.5V
-1.2V
0.0V
-0.6V
-0.8V
-0.3V
R12 422
R13 422
R15 133
C8 39p
R17 3.16K
R18 511
C4 1500p
C5* 47P
R5 100K
R6 10K
R7 1K
R8 100
1KHz 10KHz 100KHz 1MHz
R14 2.61K
-6V
R22 1.05K
C9 9~35p
R20 619
R21* 2.05K
DISTORTION ADJ
C10 60
R24 200K
C11 6.8
R26 56.2K
R27 3.16K
Q5
R23 196
+0.5V
R25 21.5K
+2.2V
R59 42.2K
R28 2.15K
Q6
-0.8V
-0.1V
CR2 CR3
6.19V
9.09V
R29 2.37K
OUTPUT LEVEL ADJ
R30 2K
C12 22
CR7 CR8 CR9 CR10
C20 1
+10V
-0.5V
C14 60
C13 60
(21)
OSC OUT
R31 1K
R32 2.15K
K5
R37 511
TEST VOLTAGE
NORMAL
K6
R41 825
C16 60
0.0V
(22)
Q9A
+5.1V
-0.7V
12R
9R 10R 11R
OSC OUT
TO XA10 (5L)
R36 1K
R40 237
-6V
R33 6.19K
R38 6.19K
Q7 Q8
R34 4.22K
R39 4.22K
K5 K6
CR4 CR5
+10V
R35 14.7
C15 33
+15V
R52 8.25K
-1.1V
5.11V
CR6
6L 5L 4L 3L
10R 13R 15R 14R
C15
1KHz RELAY DRIVE FROM XA25 (5R) (9-5-6)
10KHz RELAY DRIVE FROM XA25 (4R) (9-5-7)
100KHz RELAY DRIVE FROM XA25 (3R) (9-5-8)
1MHz RELAY DRIVE FROM XA25 (2R) (9-6-7)
1KHz RELAY DRIVE FROM XA25 (5R) (9-5-6)
FROM XA27 (6L) +10V (8)
NORMAL RELAY DRIVE FROM XA25 (DR) (9)
COPYRIGHT 1969

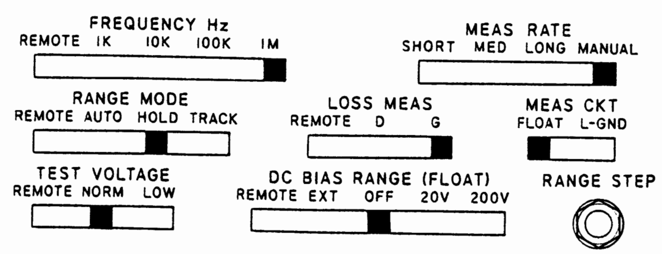
A13 TROUBLESHOOTING

If assembly is not working, check other positions of FREQUENCY and TEST VOLTAGE controls. If it has been determined that a certain position is not operating, the trouble may be traced to the specific relay, diode, resistor or transistor. Check relay control signals according to Table 8-11. If a problem exists in all positions, first check all dc voltages coming into board (+15Vdc at PIN 12-L, +10Vdc at pin 15-R and -6Vdc at pin 11-L). Make waveform checks to determine which stage is not operating. When trouble has been isolated to a stage, make voltage and resistance measurements.

Table 8-11. Relay Control Signals

FREQ	Relay Control Signals					
	Pin6-L for K1	Pin5-L for K2	Pin4-L for K3	Pin3-L for K4	Pin13-R for K5	Pin14-R for K6
1kHz	+0.1V	+10V	+10V	+10V	+0.1V	—
10kHz	+10	+0.1	+10	+10	+10	—
100kHz	+10	+10	+0.1	+10	+10	—
1MHz	+10	+10	+10	+0.1	+10	—
TEST VOLTS						
NORM	—	—	—	—	—	+0.1
LOW	—	—	—	—	—	+10

Set Controls for wavefpr, and DC bias checks as follows: (Capacitance Range 100pF)



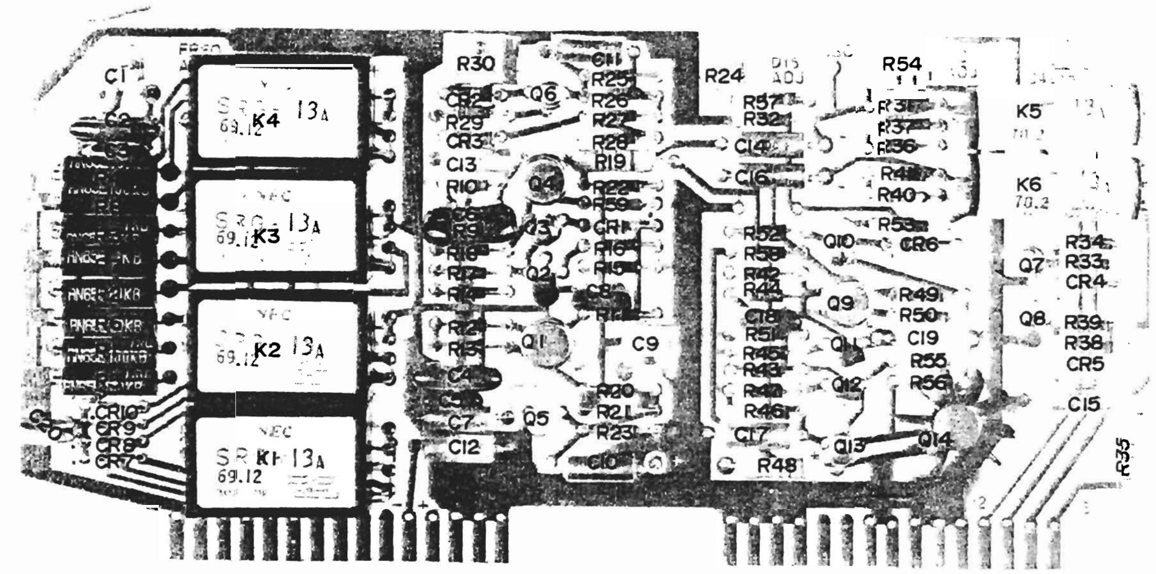
All waveforms are taken with HP 180A Oscilloscope, HP 1801A Vertical Plug-in, HP 1821A Time Base Plug-in, and HP 10004A 10 : 1 Divider Probe.

Table 8-12. OSC & Buffer Waveform Measurement Conditions.

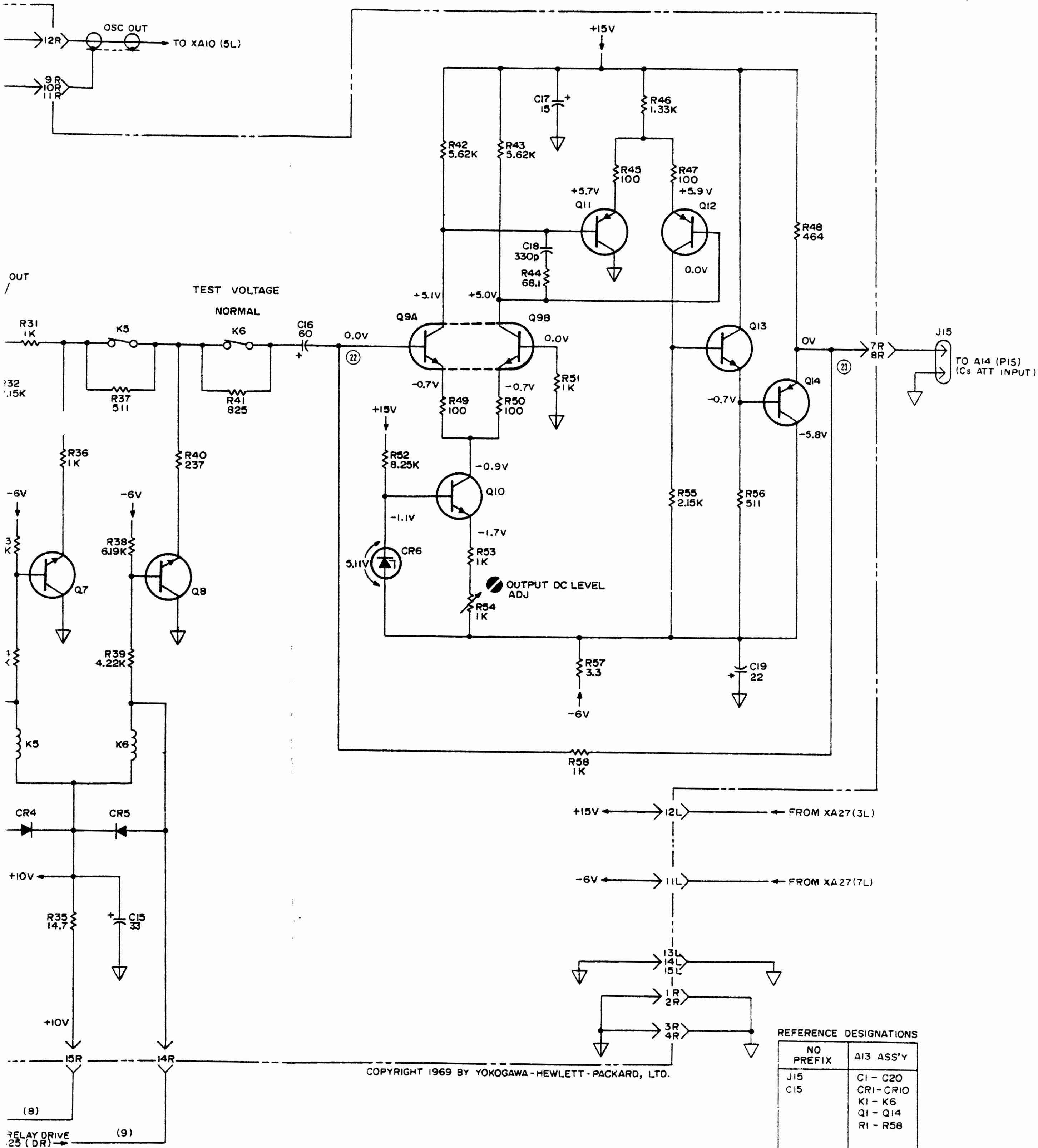
Waveform No.	1801A		1821A			
	V/Cm	Ac/ Dc	Time/ Cm	Main Trigger	Slope	Sweep Mode
21	.1	AC	.5μs	INT	—	Auto
22	.005	AC	.5μs	INT	—	Auto
23	.05	AC	.5μs	INT	—	Auto

SEE INSIDE

Figure 8-11
D/G AMP & GS ASS'Y A12



Oscillator & Buffer Ass'y A13
(04270-7733)

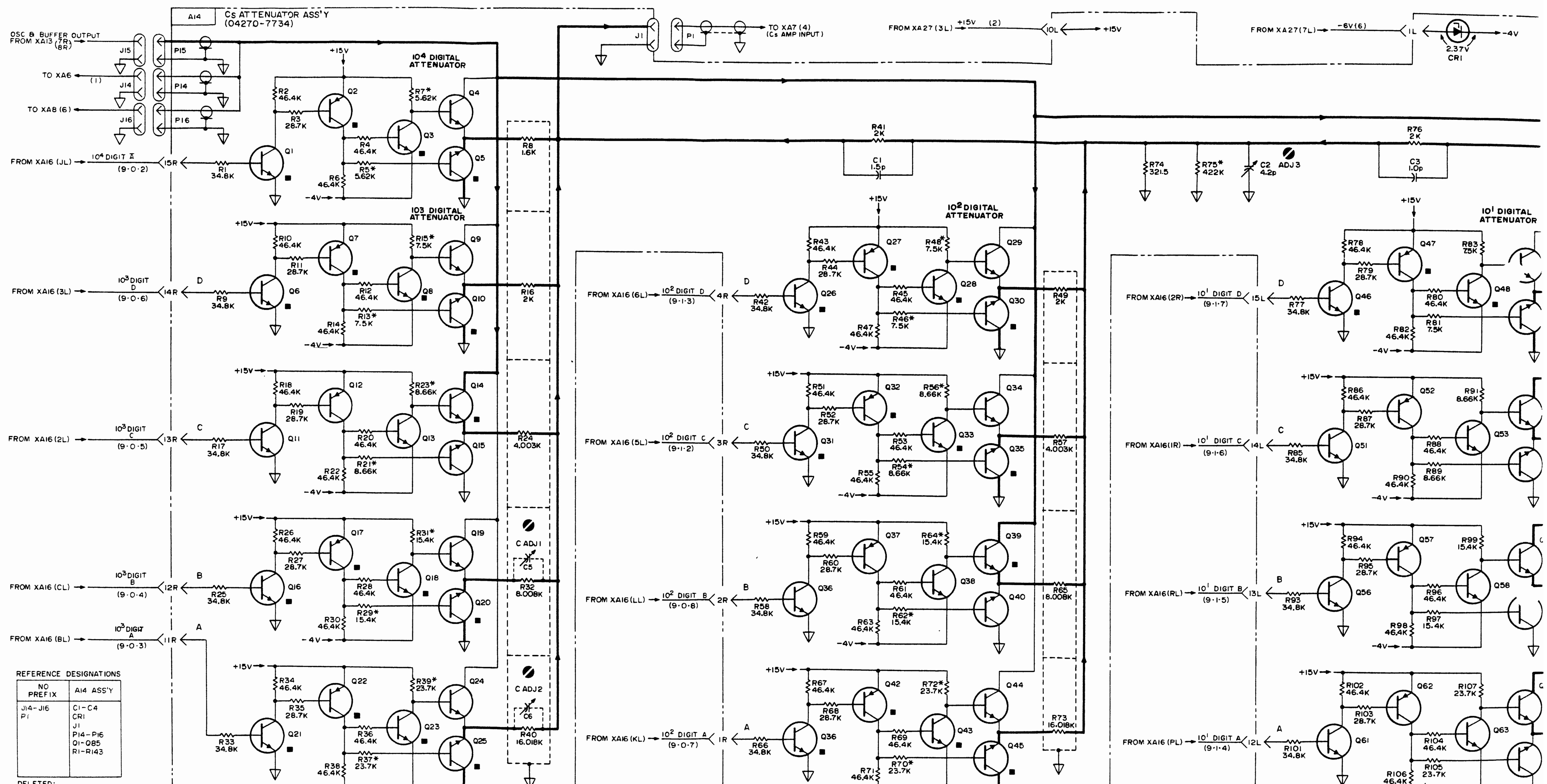


REFERENCE DESIGNATIONS

NO PREFIX	A13 ASS'Y
J15 C15	C1 - C20 CR1 - CR10 K1 - K6 Q1 - Q14 R1 - R58

DELETED;

Figure 8-12. OSC & Buffer Ass'y A13



A14
Cs ATTENUATOR ASS'Y (04270-7734)
OSC & BUFFER OUTPUT FROM XA13 (7R) (8R)
TO XA6 (1)
TO XA8 (6)
J15 P15
J14 P14
J16 P16
10⁴ DIGITAL ATTENUATOR
10³ DIGITAL ATTENUATOR
10² DIGITAL ATTENUATOR
10¹ DIGITAL ATTENUATOR
FROM XA16 (JL) 10⁴ DIGIT Ⅱ (9·0·2) 15R
FROM XA16 (3L) 10³ DIGIT D (9·0·6) 14R
FROM XA16 (2L) 10³ DIGIT C (9·0·5) 13R
FROM XA16 (CL) 10³ DIGIT B (9·0·4) 12R
FROM XA16 (BL) 10³ DIGIT A (9·0·3) 11R
FROM XA16 (6L) 10² DIGIT D (9·1·3) 4R
FROM XA16 (5L) 10² DIGIT C (9·1·2) 3R
FROM XA16 (LL) 10² DIGIT B (9·0·8) 2R
FROM XA16 (KL) 10² DIGIT A (9·0·7) 1R
FROM XA16 (2R) 10¹ DIGIT D (9·1·7) 15L
FROM XA16 (1R) 10¹ DIGIT C (9·1·6) 14L
FROM XA16 (RL) 10¹ DIGIT B (9·1·5) 13L
FROM XA16 (PL) 10¹ DIGIT A (9·1·4) 12L
J1 P1
TO XA7 (4) (Cs AMP INPUT)
FROM XA27 (3L) +15V (2) 10L +15V
FROM XA27 (7L) -6V (6) 1L -4V
2.37V CR1
R41 2K
C1 1.5p
R76 2K
C3 1.0p
R74 321.5
R75* 422K
C2 4.2p ADJ 3
R8 1.6K
R16 2K
R24 4.003K
R32 8.008K
R40 16.018K
C ADJ 1 C5
C ADJ 2 C6
R49 2K
R57 4.003K
R65 8.008K
R73 16.018K
REFERENCE DESIGNATIONS
NO PREFIX | A14 ASS'Y
J14-J16 P1 | C1-C4 CR1 J1 P14-P16 Q1-Q85 R1-R143
DELETED;

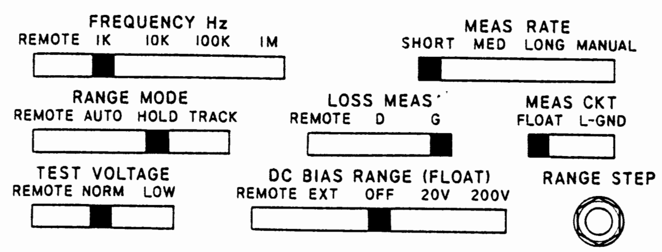
A14 TROUBLESHOOTING

Most troubles in A14 may arise from one of following three causes. 1) A transistor switch which should be open is closed. 2) A transistor switch which should be closed is open. 3) A weighting resistor has changed value. The first step in troubleshooting is to trace which binary is defective according to Table 8-A Troubleshooting Tree. Then make Linearity check or dc voltage measurement.

Linearity Check :

The following steps are to determine if weighting resistors have changed value. If the 4270A reading is out of specification, check the switching transistor and suspect the weighting resistor.

a. Set controls as follows:



Select 100nF Range by depressing RESET button, then set RANGE MODE control to TRACK.

b. Connect a Decade Capacitor (HP MODEL 4440B) to UNKNOWN and set 4440B to 40pF on the vernier. The 4270A should balance and the reading should be 00.04 nF ±0.01nF.

c. Increase the capacitance setting of the 4440B up to 140pF on the vernier by 10pF steps. The 4270A reading should increase to 00.14nF ±0.01nF in 0.01nF steps corresponding to 4440B settings.

d. Increase the capacitance setting of the 4440B up to 1040pF in 100pF steps. The 4270A reading should increase to 01.04nF ±0.01nF in 0.1nF steps.

e. Increase the capacitance setting of the 4440B up to 0.01004μF in 0.001μF steps. The reading should increase to 10.04nF ±0.02nF. If not, adjust the 4440B setting for a 9.99nF reading on the 4270A. Note the 4440B setting. Increase the 4440B setting by 20pF. The 4270A reading should be 10.01nF ±0.01nF.

f. Adjust the 4440B setting for 19.99nF reading on the 4270A. Note the 4440B setting. Increase the 4440B setting by 20pF. The 4270A reading should be 20.01nF.

g. Repeat the same procedures at 39.99nF, 79.99nF and 99.99nF.

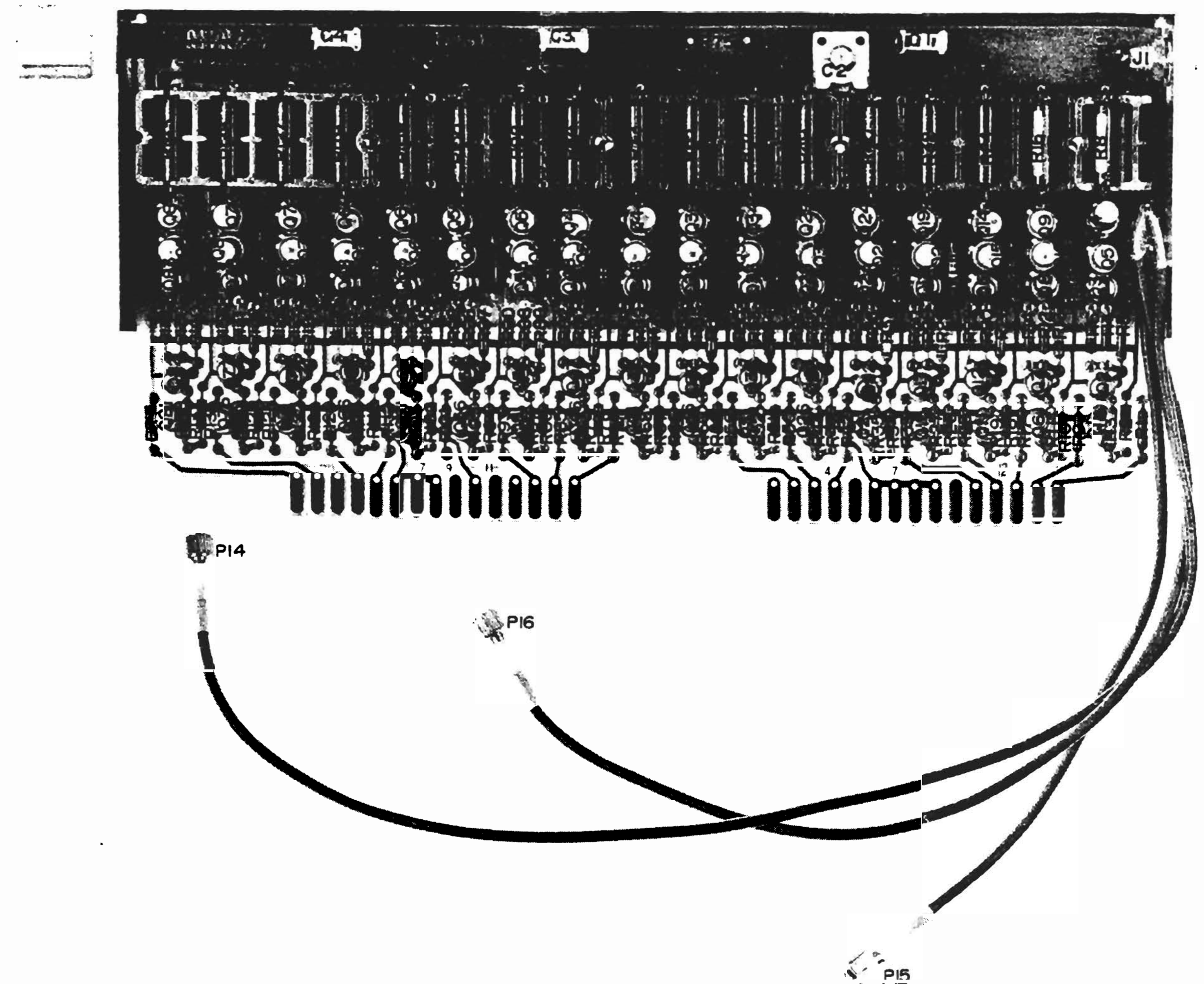
DC Voltage Measurement :

Disconnect coaxial cable from J1. Disconnect the three coaxial cables from J14, J15 and J16. To check the first two stages of the defective binary for dc bias, set A14 in an extender board (HP Part No. 04270-7737) without removing the shield cover. After verifying that the transistors and resistors of the first two stages are normal, remove the shield cover and make made voltage measurements of the other transistors.

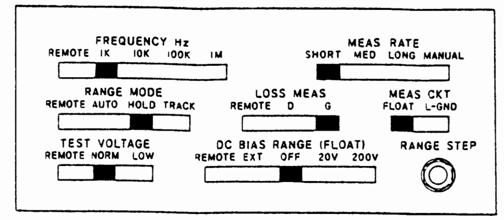
SEE INSIDE

Figure 8-12

OSC & BUFFER ASS'Y A13



Cs Attenuator Ass'y A14
(04270-7734)



Set controls as shown above and select 1 μF Range by depressing RANGE STEP button. Connect hp Model 4440B to UNKNOWN and set 4440B to .0009(the vernier should always be set to 40 pF throughout this troubleshooting procedure). The 4270A should balance.

- **YES** — The readings are .0000 μF and 0.000 m℧.
  - **YES** — Set the 4440B to .0091 μF. The 4270A should balance and the readings should be .0000 μF and 0.000 m℧.
    - **YES** — Set the 4440B to .0910 μF. The 4270A should balance and the readings should be .0000 μF and 0.000 m℧.
      - **YES** — Set the 4440B to .9010 μF. The 4270A should balance and the readings should be .0000 μF and 0.0000 m℧.
        - **YES** — The Over-Flow Binary may be defective. The transistor switch may be shorted. Make dc voltage measurements to isolate a defective transistor or a resistor.
        - **NO** — Decrease the 4440B capacitance settings in 0.1 μF steps until the 4270A balances and the readings are .0000 μF and 0.000 m℧. The defective binary may be the one just before the readings of .0000 μF and 0.000 m℧.
      - **NO** — Decrease the capacitance settings of the 4440B in 0.01 μF steps until the 4270A balances and the readings are .0000 μF and 0.000 m℧. The defective binary may be the one just before the readings of .0000 μF and 0.000 m℧.
    - **NO** — Decrease capacitance settings of 4440B in 0.001 μF steps until 4270A balances and readings are .0000 μF and 0.000 m℧. The defective binary may be the one just befor the readings of .0000 μF and 0.000 m℧ are reached. For example; assume that the 4270A has been balanced and readings after balance are .0000 μF and 0.000 m℧. When the 4440B is set to .0310 μF, the defective binary may be "4" on 2nd digit.
  - **NO** — Decrease capacitance settings of the 4440B in 0.0001 μF steps. The 4270A readings after balance should be .0000 μF and 0.000 m℧.
    - **YES** — The defective binary may be the one just before the readings are .0000 μF and 0.000 m℧. Make dc voltage measurements to isolate a defective transistor or a resistor.
    - **NO** — Set RANGE MODE control to TRACK and set the 4440B to .000X where X is 1 through 9. Depress RESET button. The reading after balance should be within ±1 count of the setting of 4440B.
      - **YES** — Set the 4440B to .00x0 where x is 1 through 9. Depress RESET button. The reading after balance should be within ±9 counts to the setting of the 4440B.
        - **YES** — Set the 4440B to .0x00 where x is 1 through 9. Depress RESET button. The reading after balancing should be within ±90 counts of setting of 4440B.
          - **YES** — Set the 4440B to .X000 where X is 1 through 10. Depress RESET button. The reading after balance should be within ±900 counts of 4440B setting.
            - **YES** — Proceed to Linearity Check.
            - **NO** — The defective binary may be most significant digit. The transistor switch may be open.
          - **NO** — The defective binary may be 2nd significant digit. The transistor switch may be open.
        - **NO** — The defective binary may be 3rd significant digit. The transistor switch may be open. Trace the defective binary as shown in previous step.
      - **NO** — A binary in the least significant digit may be defective. The transistor switch may be open. If x is 1 and "1" binary is defective, the capacitance reading may be .0002 μF. If x is 2 and "2" binary is defective, the capacitance reading may be .0004 μF. If x is 4 and "4" binary is defective, the capacitance reading may be .0008 μF. If x is 8 and "8" binary is defective, the capacitance reading may be .0010 μF.
- **NO** — If the 4270A does not balance. Check other assemblies.

Table 8-A. A14 Troubleshooting Tree.

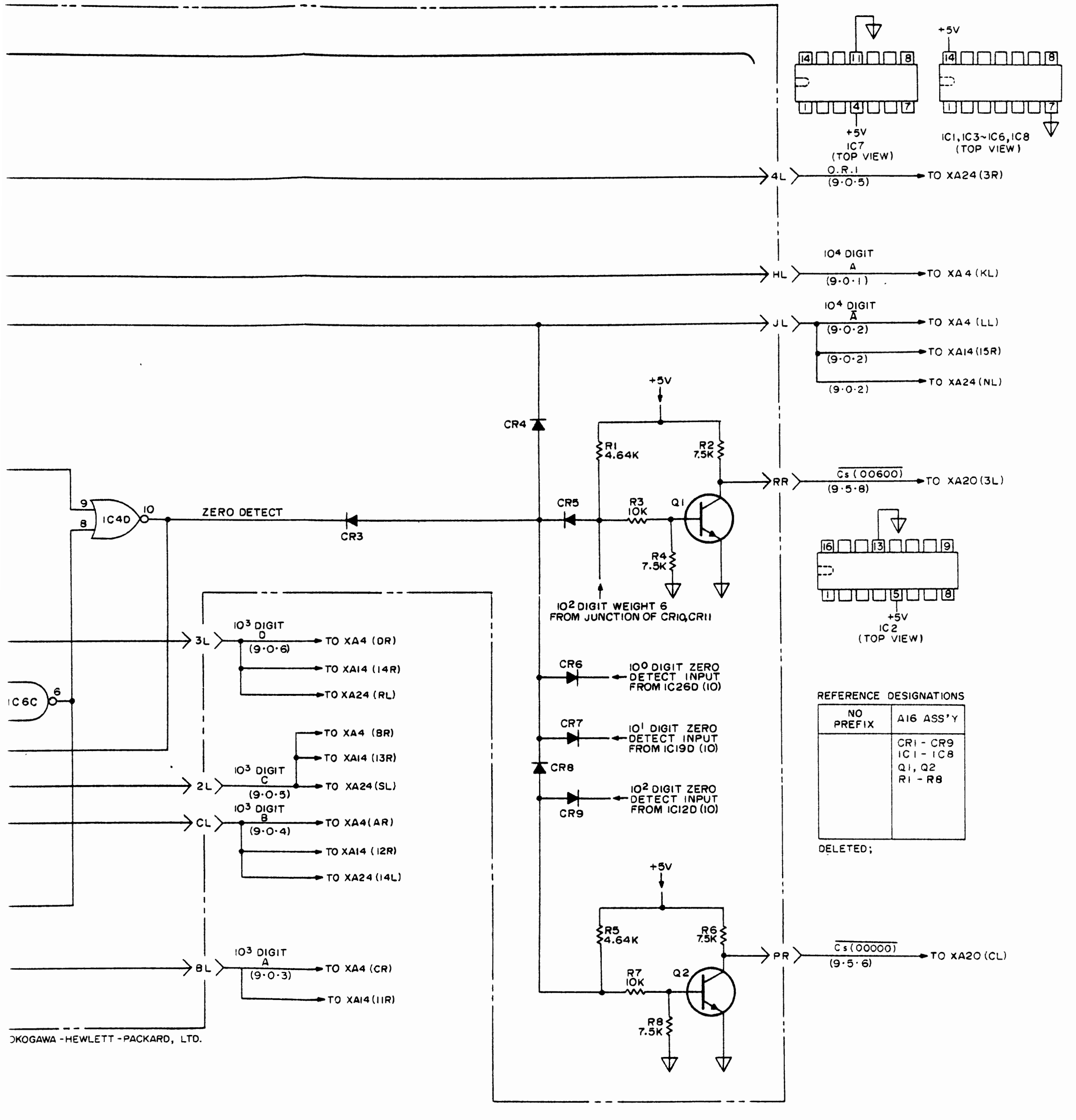


Figure 8-15. Cs Reversible Counter & Driver Ass'y A16
(Sheet 1 of 4)

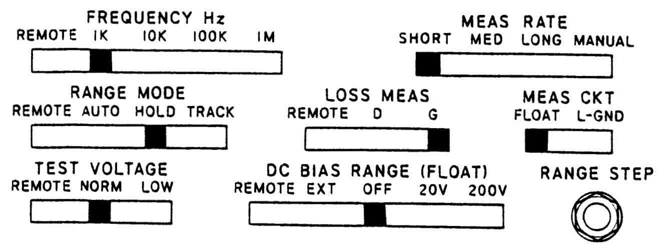
A15 TROUBLESHOOTING

Most of troubles in A15 arise from one of three causes. 1) A transistor switch which should be open is closed. 2) A transistor switch which should be closed is open. 3) A weighting resistor has changed value. The first step in troubleshooting is to trace which binary is defective according to Table 8-B Troubleshooting Tree. Then make Linearity check or dc voltage measurement.

Linearity Check:

The following steps are to determine if weighting resistors have changed value. If the 4270A reading is out of specification, check the switching transistor and suspect the weighting resistor.

a. Set controls as follow:



Select 100nF Range by depressing RESET button, then set RANGE MODE control to TRACK.

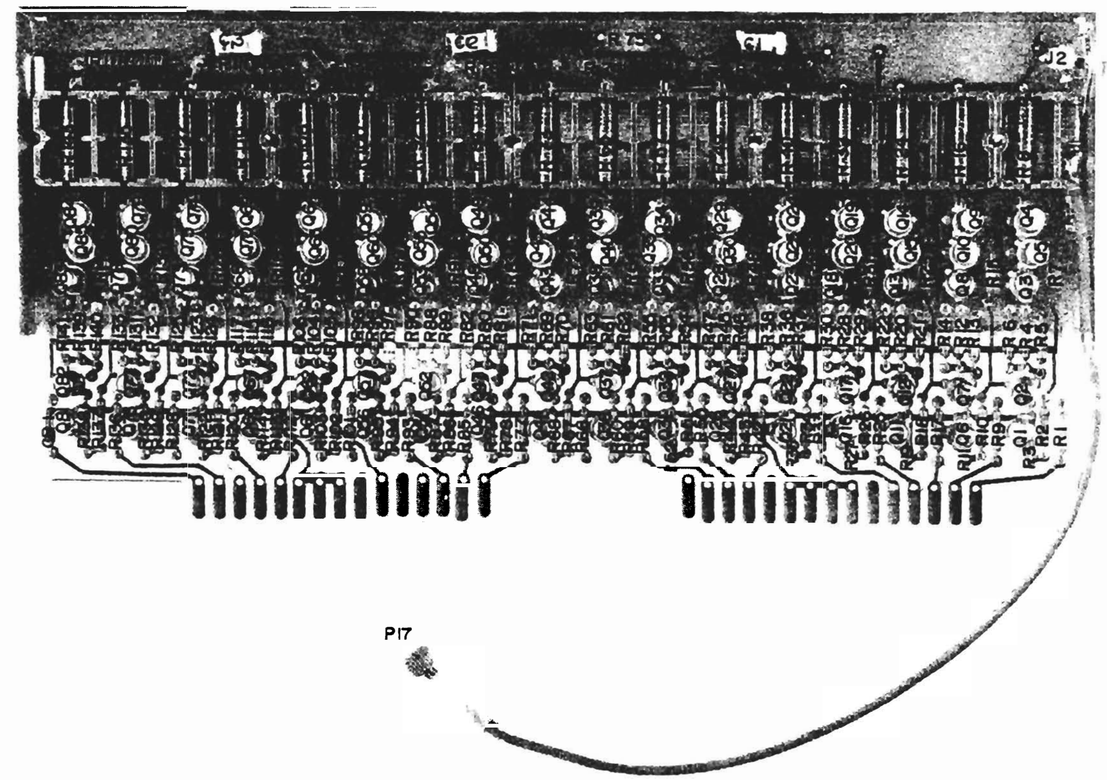
b. Connect a Decade Resistor to UNKNOWN. Set the Decade Resistor for a Conductance reading of 001.9 μ℧. Note the resistance setting.
c. Decrease the resistance setting by 50kΩ. The conductance reading should be 002.1 ± 0.1μ℧.
d. Set the Decade Resistor for 003.9μ℧ of a conductance reading and note the registance setting.
e. Decrease the resistance setting by 12kΩ. The conductance reading should be 004.1 ± 0.1μ℧.
f. Set the Decade a conductance reading of 007.9μ℧. Note the resistance setting.
g. Decrease the resistance setting by 3kΩ. The conductance reading should be 008.1 ± 0.1μ℧.
h. Set the Decade Resistor for a conductance reading of 019.9μ℧. Note the resistance setting.
i. Decrease the resistance setting by 1.23kΩ. The conductance reading should be 020.4 ± 0.4μ℧.
j. Repeat above steps at resistor settings shown in Table 8-13.

Table 8-13. Linearity Check

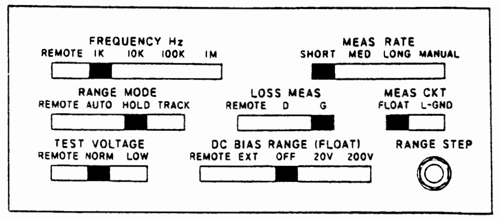
First Conductance Reading (First Resistance Setting)	Decrease Resistance By-	New Conductance Reading
001.9μ℧ (526.3kΩ)	50kΩ	002.1 ± 0.1μ℧
003.9μ℧ (256.4kΩ)	12kΩ	004.1 ± 0.1μ℧
007.9μ℧ (126.5kΩ)	3kΩ	008.1 ± 0.1μ℧
019.9μ℧ (50.25kΩ)	1.23kΩ	020.4 ± 0.4μ℧
039.9μ℧ (25.06kΩ)	0.31kΩ	040.4 ± 0.4μ℧
079.9μ℧ (12.51kΩ)	0.080kΩ	080.4 ± 0.4μ℧
099.9μ℧ (10.010kΩ)	0.070kΩ	100.6 ± 0.6μ℧
199.9μ℧ (5.002kΩ)	0.017kΩ	200.6 ± 0.6μ℧
399.9μ℧ (2.500kΩ)	0.004kΩ	400.6 ± 0.6μ℧
799.9μ℧ (1.250kΩ)	0.001kΩ	800.6 ± 0.6μ℧
009.9μ℧ (101.0kΩ)	4.9kΩ	010.4 ± 0.4μ℧

SEE INSIDE

Figure 8-13
CS ATTENUATOR ASS'Y A14



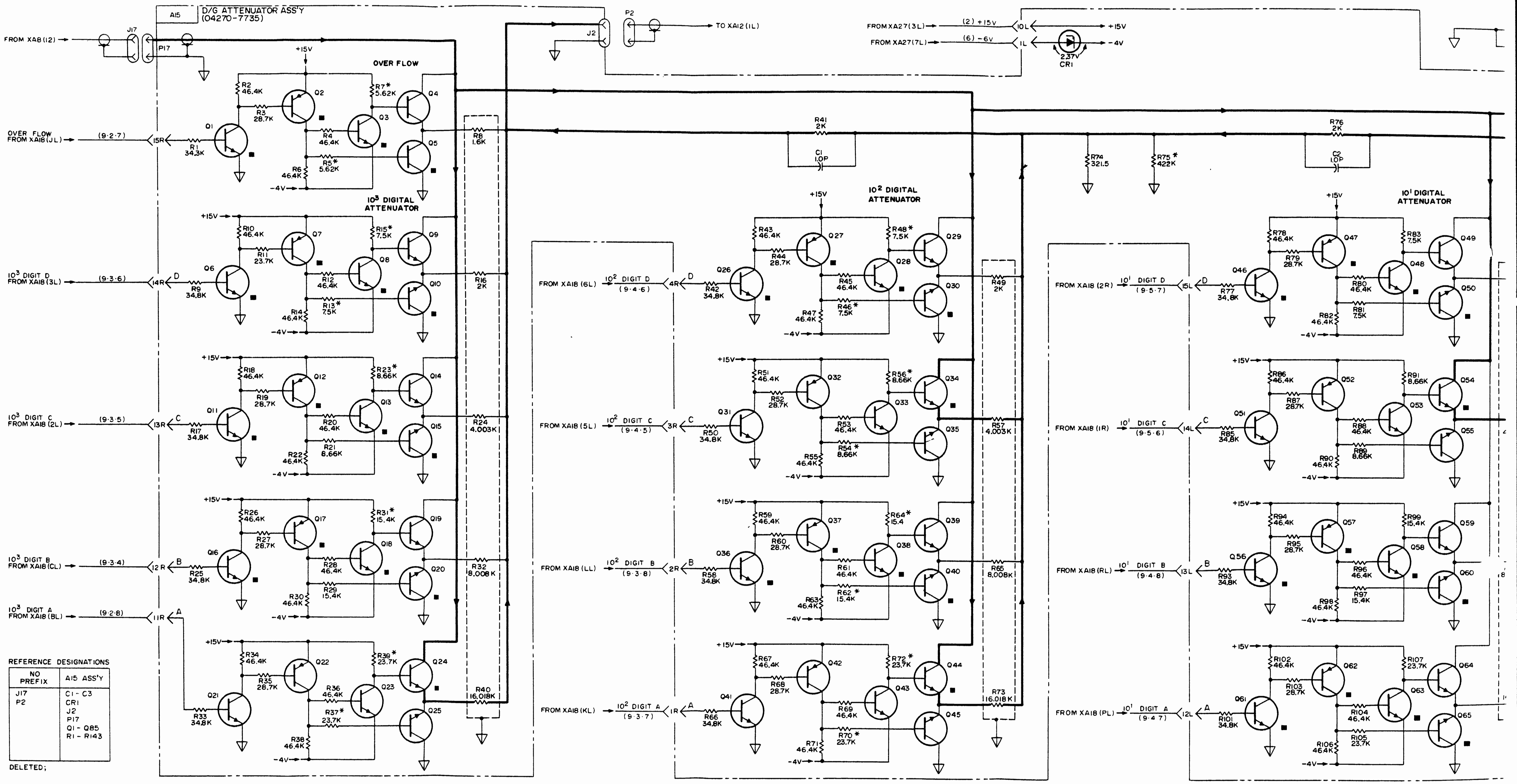
D/G Attenuator Ass'y A15
(04270-7735)



Set controls as shown above and select 1 μF Range by depressing RANGE STEP button. Connect a decade resistor to UNKNOWN and set the decade resistor to 111.1 kΩ. The 4270A should balance.

- **YES** — The readings are .0000 μF and 0.000 m℧.
  - **YES** — Select 100 nF Range by depressing RANGE STEP button. The readings after balance are 00.00 nF and 000.0 μ℧.
    - **YES** — Select 10 nF Range by depressing RANGE STEP button, the readings after balance should be 0.000 nF and 00.00 μ℧.
      - **YES** — Select 1000 pF Range by depressing RANGE STEP button. The readings after balance should be 000.0 pF and 0.000 μ℧.
        - **YES** — The Over-Flow Binary may be defective. The transistor switch may be shorted. Make dc voltage measurement to isolate defective transistor or resistor.
        - **NO** — The defective binary may be the most significant digit. Isolate defective binary as descrebed for 3 rd significant digit.
      - **NO** — The defective binary may be in the 2nd significant digit. Isolate defective binary as described for 3rd significant digit.
    - **NO** — The defective binary may be in the 3 rd significant digit. Set the decade resistor to 220 kΩ. The conductance reading is 000.0 μ℧
      - **YES** — The defective binary is "8" on the 3rd significant digit. The transistor switch may be shorted. Make dc voltage measurements to isolate a defective transistor or resistor.
      - **NO** — Set decade resistor to 400 kΩ. The conductance reading is 000.0 μ℧.
        - **YES** — The defective binary is "4" on the 3rd significant digit. The transistor switch may be shorted. Make dc voltage measurements to isolate a defective transistor or resistor.
        - **NO** — Set decade resistor to 700 kΩ. The conductance reading is 000.0 μ℧.
          - **YES** — The defective binary is "2" on 3rd significant digit.
          - **NO** — The defective binary is "1" on the 3rd significant digit.
  - **NO** — Set the decade resistor to 220 kΩ, 400kΩ, and 700 kΩ. The conductance reading is 0.000 m℧ at one of the above settings.
    - **YES** — The defective binary may be in the least significant digit. The transistor switch may be shorted. Isolate defective binary as described on the 3 rd significant digit.
    - **NO** — Set decade resistor to 125.0 kΩ, 250.0 kΩ, 500.0 kΩ and 1000.0 kΩ. The conductance readings are 0.008, 0.004, 0.002 and 0.001 m℧ ± 1 count, respectively.
      - **YES** — Select 100 nF Range by depressing RANGE STEP button. Set decade resistor to 125.0 kΩ, 250.0 kΩ, 500.0 kΩ and 1000.0 kΩ. The conductance readings are 008.0, 004.0, 002.0 and 001.0 μ℧ ± 10 count, respectively.
        - **YES** — Select 10 nF Range by depressing RANGE STEP button. Set decade resistor to 125.0 kΩ, 250.0 kΩ, 500.0 kΩ and 1000.0 kΩ. The conductance readings are 08.00, 04.00, 02.00 and 01.00 μ℧ ±10 counts, respectively.
          - **YES** — Select 1000 pF Range by depressing RANGE STEP button. Set decade resistor to 125.0 kΩ, 250.0 kΩ, 500.0 kΩ and 1000.0 kΩ. The conductance readings are 8.000, 4.000, 2.000 and 001.0 μ℧ ±10 count, respectively.
            - **YES** — Proceed to Linearity Check.
            - **NO** — A binary of the least significant digit may be defective. A transistor switch may be open. If "1" binary is defective, the conductance reading may be 2.000 μ℧ at 1000.0 kΩ setting. If "2" binary is defective, the conductance reading may be 4.000 μ℧ at 500.0 kΩ setting. If "4" binary is defective, the conductance reading may be 8.000 μ℧ at 250.0 kΩ setting. If "8" binary is defective, the conductance reading may be 0.000 m℧ at 125.0 kΩ setting.
          - **NO** — A binary in the least significant digit may be defective. A transistor switch may be open. If "1" binary is defective, the conductance reading may be 02.00 μ℧ at 1000.0 kΩ setting. If "2" binary is defective, the conductance reading may be 04.00 μ℧ at 500.0 kΩ setting. If "4" binary is defective, the conductance reading may be 08.00 μ℧ at 250.0 kΩ setting. If "8" binary is defective, the conductance reading may be 10.00 μ℧ at 250.0 kΩ setting.
        - **NO** — A binary in the 3rd significant digit may be defective. A transistor switch may be open. If "1" binary is defective, the conductance reading may be 002.0 μ℧ at 1000.0 kΩ setting. If "2" binary is defective, the conductance reading may be 004.0 μ℧ at 500.0 kΩ setting. If "4" binary is defective, the conductance reading may be 008.0 μ℧ at 250.0 kΩ setting. If "8" binary is defective, the conductance reading may be 010.0 μ℧, at 125.0 kΩ setting.
      - **NO** — The conductance readings are 0.x08, 0.x04, 0.x02 and 0.x01 m℧ ±1 count respectively, where x is a figure and may be the most significant digit, the 2nd significant digit or the 3rd significant digit.
        - **YES** — The binary which shows the x is defective. The transistor switch may be open.
        - **NO** — A binary of the least significant digit may be defective. A transistor switch may be open. If "1" binary is defective, the conductance reading may be 0.002m℧ at 1000.0kΩ setting. If "2" binary is defective, the conductance reading may be 0.004m℧ at 500.0kΩ setting. If "4" binary is defective, the conductance raeding may be 0.008m℧ at 250.0kΩ setting. If "8" binary is defective, the conductance raeding may be 0.010m℧ at 125.0kΩ setting.
- **NO** — If the 4270A does not balance, check other assembly.

Table 8-B. A15 Troubleshooting Tree.



REFERENCE DESIGNATIONS

NO PREFIX	A15 ASS'Y
J17 P2	C1 - C3 CR1 J2 P17 Q1 - Q85 R1 - R143

DELETED;

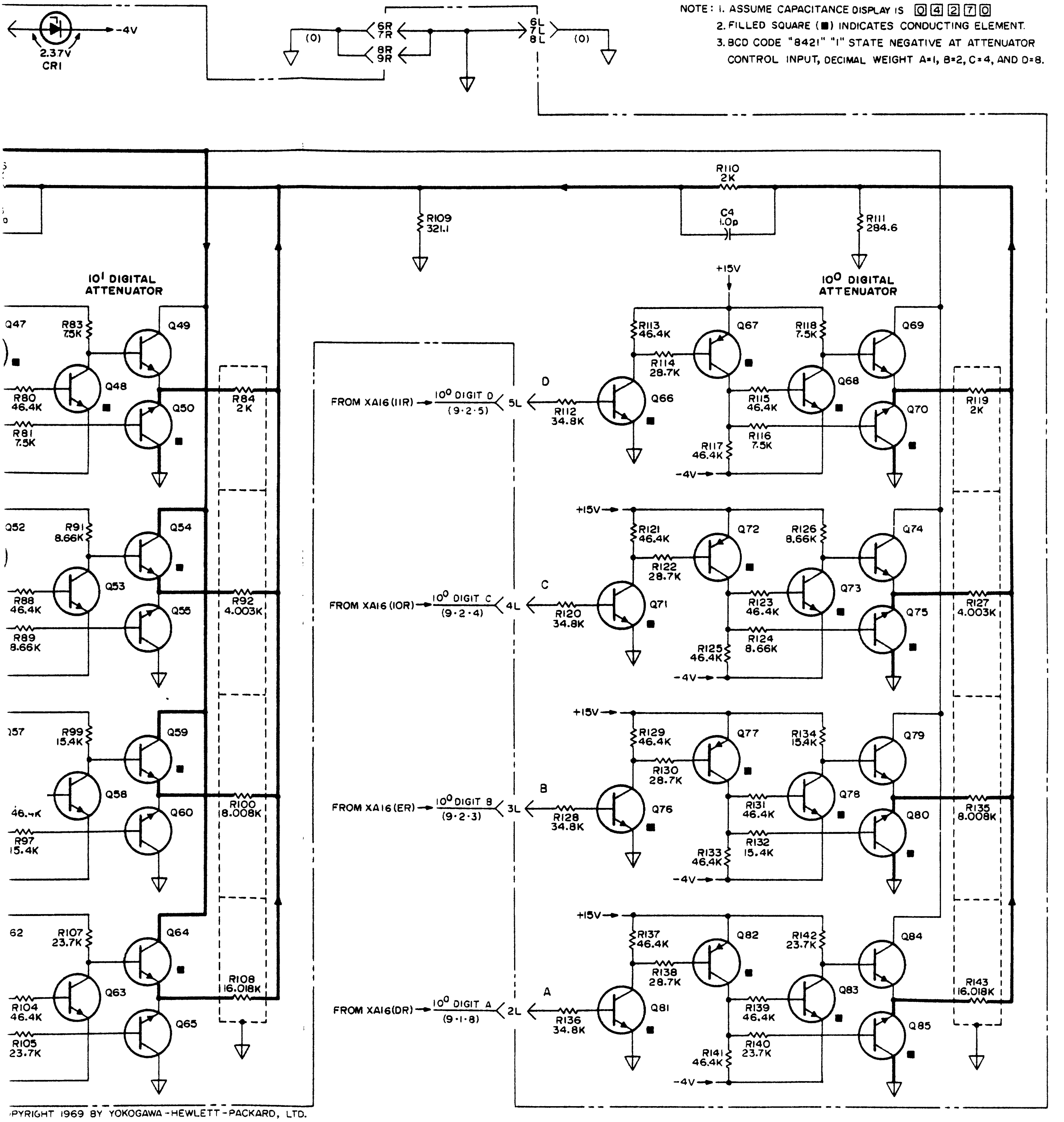
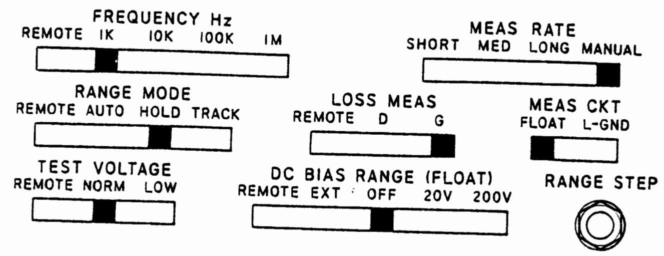


Figure 8-13. Cs Attenuator Ass'y A14

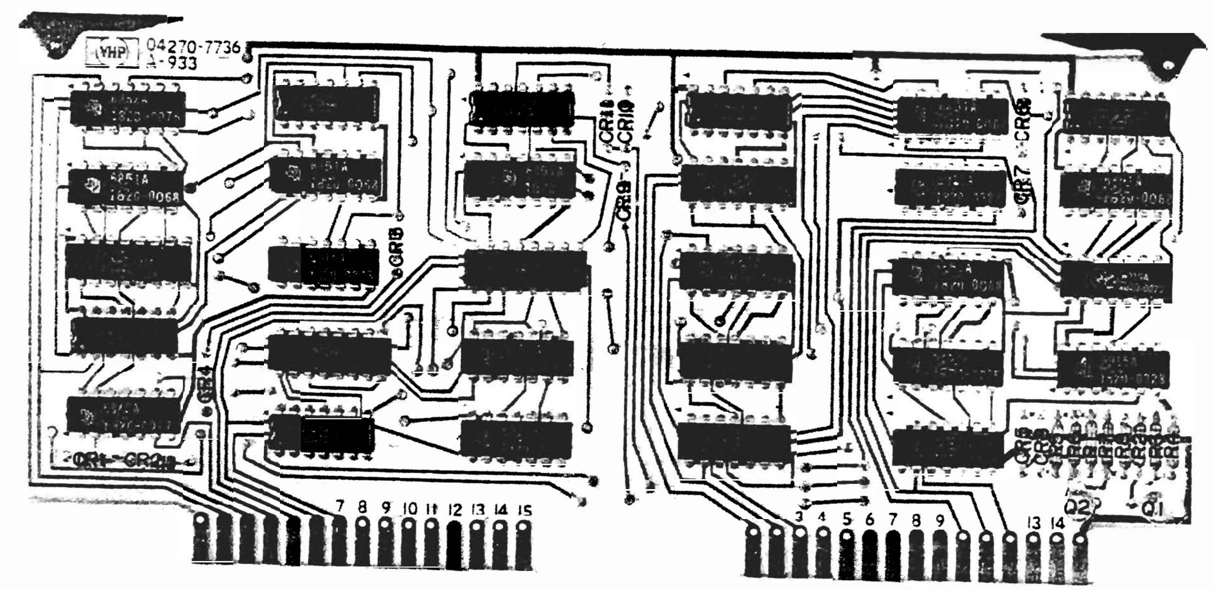
A16 TROUBLESHOOTING

Check the +5Vdc at pins I-L and A-L. Set controls as shown and select 1000pF. Set STORAGE ON/OFF switch on A25 to OFF. Depress and hold RESET button. Verify that the numeric displays are all zero and $\overline{\text{Cs (00000)}}$ is LOW at pin PR using the logic probe. If not, trace back through the logic to isolate a defective gate or flip/flop with the logic probe. To check the count operation (if Special Extenders I and II are available) proceed according to the steps described in paragraph 5-78. If extenders are not available, supply -0.5Vdc through 5kΩ resistor to integrator input at XA19 pin 5-L. While depressing and holding RESET button, set RANGE MODE to TRACK and release RESET button. The Cs counter should start counting up from the least significant digit. If the Cs counter does not start counting up, check UP1, should be HIGH; DOWN 1, should be LOW and DRIVING PULSE at pin 12-R by using a logic probe or oscilloscope. Use oscilloscope to check counting operation of the least significant digit and 3rd significant digit. If miscount is encountered, check the DRIVING PULSE, and J and K inputs that correspond to the flip/flop causing the miscounting. If all input signals are normal, the miscounting may be caused by the defective flip/flop. Before replacing the flip/flop, check the reset signal to the flip/flop by using oscilloscope. The reset signal line is common to all flip/flops and a spike on the reset signal line may cause flip/flop to operate incorrectly. If a spike is discovered on the reset signal line, isolate the flip/flop from which the spike comes and replace the defective component.

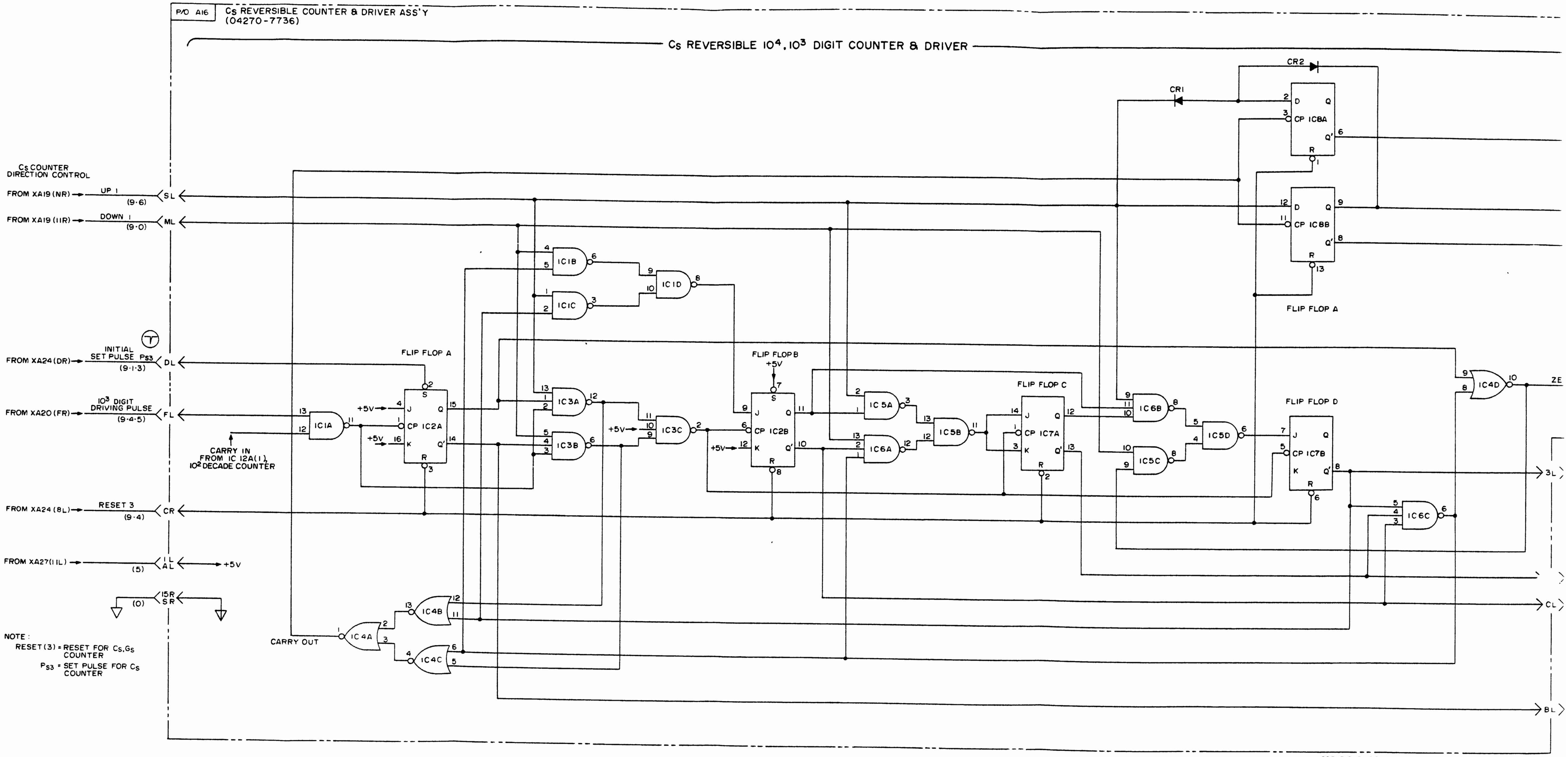


SEE INSIDE

Figure 8-14
D/G ATTENUATOR ASS'Y A15



Cs Reversible Counter & Driver Ass'y A16
(04270-7736)


P/O A16
Cs REVERSIBLE COUNTER & DRIVER ASS'Y
(04270-7736)
Cs REVERSIBLE 10⁴, 10³ DIGIT COUNTER & DRIVER
Cs COUNTER DIRECTION CONTROL
FROM XA19 (NR) UP 1 (9·6) SL
FROM XA19 (11R) DOWN 1 (9·0) ML
INITIAL SET PULSE Ps3
FROM XA24 (DR) (9·1·3) DL
10³ DIGIT DRIVING PULSE
FROM XA20 (FR) (9·4·5) FL
RESET 3
FROM XA24 (8L) (9·4) CR
FROM XA27 (11L) (5) 1L AL +5V
15R SR (0)
NOTE:
RESET (3) = RESET FOR Cs, Gs COUNTER
Ps3 = SET PULSE FOR Cs COUNTER
CARRY IN FROM IC 12A(1), 10² DECADE COUNTER
CARRY OUT
FLIP FLOP A
FLIP FLOP B
FLIP FLOP C
FLIP FLOP D
FLIP FLOP A
IC1A IC1B IC1C IC1D
IC2A IC2B
IC3A IC3B IC3C
IC4A IC4B IC4C IC4D
IC5A IC5B IC5C IC5D
IC6A IC6B IC6C
IC7A IC7B
IC8A IC8B
CR1 CR2
+5V
ZE
3L
CL
BL

NOTE 1. ASSUME D(or G) DISPLAY IS 1 5 4 9
2. FILLED SQUARE(■) INDICATES CONDUCTING ELEMENT.
3. BCD CODE: "8421", "1" STATE NEGATIVE AT ATTENUATOR CONTROL INPUT. DECIMAL WEIGHT A=1, B=2, C=4, AND D=8.

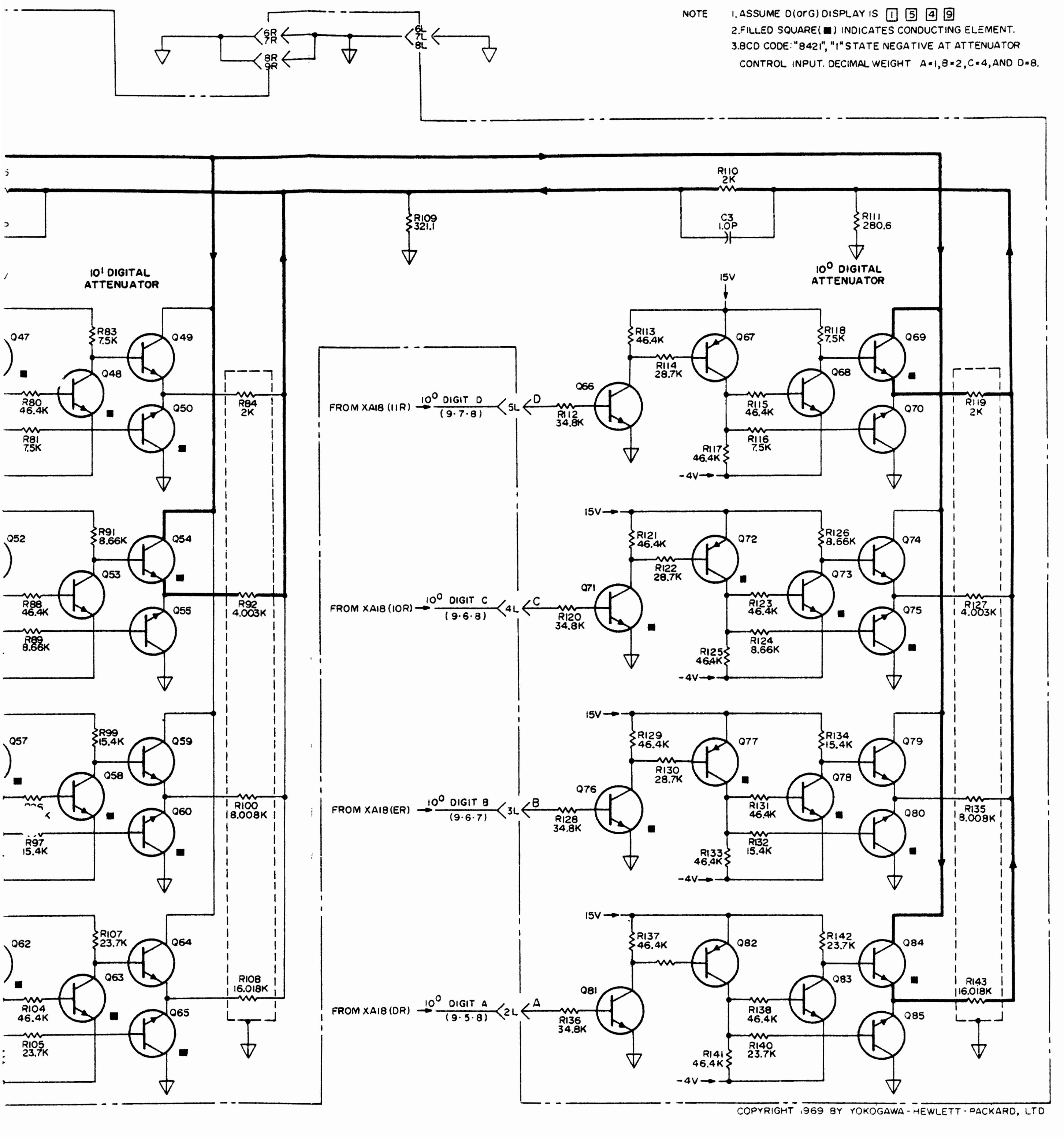
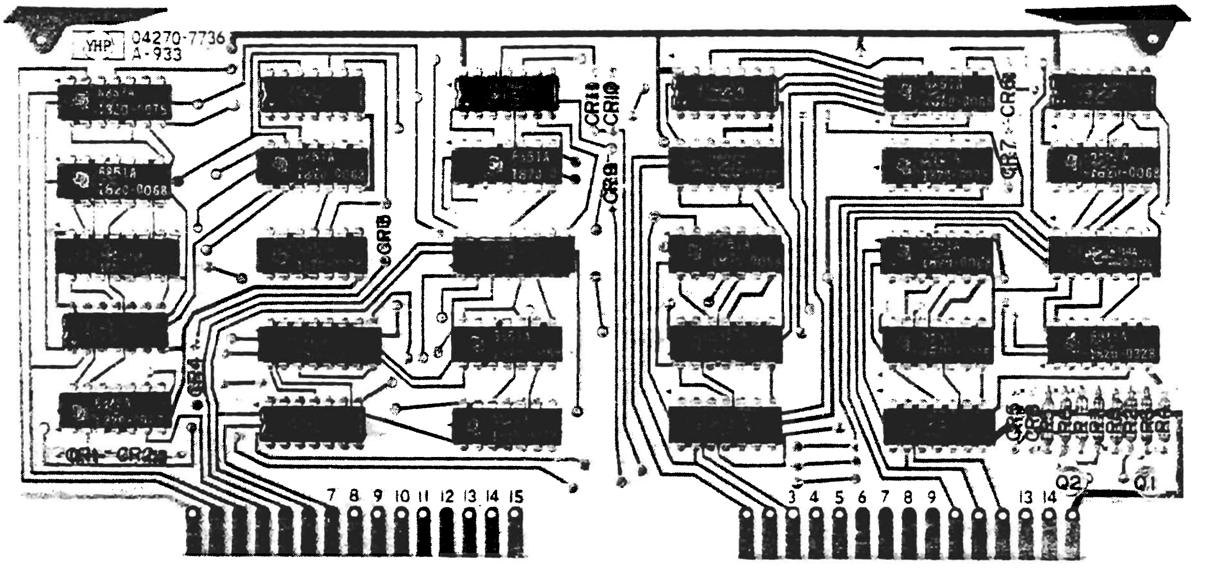
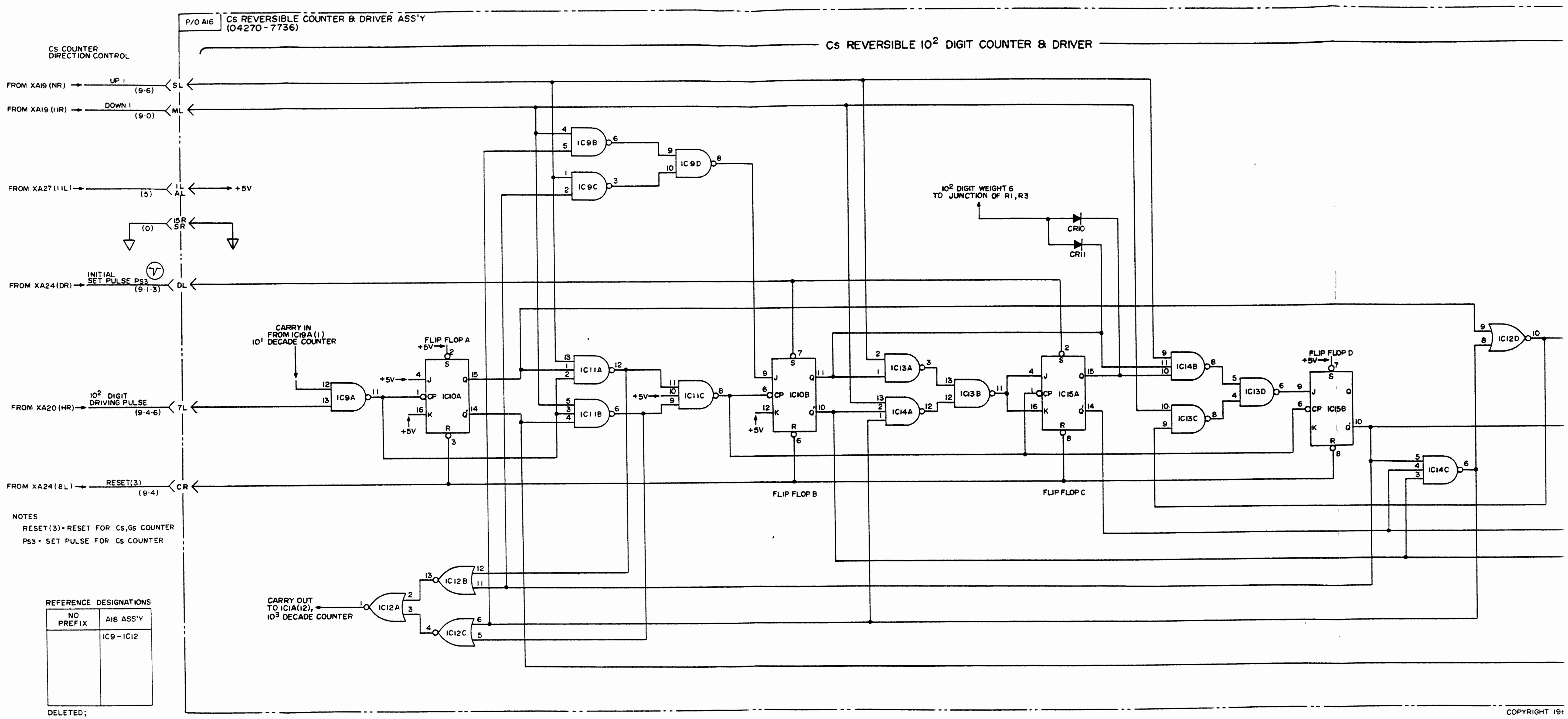


Figure 8-14. D/G Attenuator Ass'y A15



Cs Reversible Counter & Driver Ass'y A16
(04270-7736)


P/O A16
CS REVERSIBLE COUNTER & DRIVER ASS'Y (04270-7736)
Cs REVERSIBLE 10² DIGIT COUNTER & DRIVER
CS COUNTER DIRECTION CONTROL
FROM XA19 (NR)
UP 1
(9·6)
FROM XA19 (11R)
DOWN 1
(9·0)
FROM XA27 (11L)
(5)
+5V
(0)
INITIAL SET PULSE PS3
FROM XA24 (DR)
(9·1·3)
CARRY IN FROM IC19A(1) 10¹ DECADE COUNTER
FLIP FLOP A
10² DIGIT DRIVING PULSE
FROM XA20 (HR)
(9·4·6)
FROM XA24 (8L)
RESET(3)
(9·4)
FLIP FLOP B
FLIP FLOP C
FLIP FLOP D
10² DIGIT WEIGHT 6 TO JUNCTION OF R1, R3
CR10
CR11
NOTES
RESET(3) = RESET FOR CS,GS COUNTER
PS3 = SET PULSE FOR CS COUNTER
CARRY OUT TO IC1A(12), 10³ DECADE COUNTER
REFERENCE DESIGNATIONS
NO PREFIX
A16 ASS'Y
IC9 - IC12
DELETED;
COPYRIGHT 19

Figure

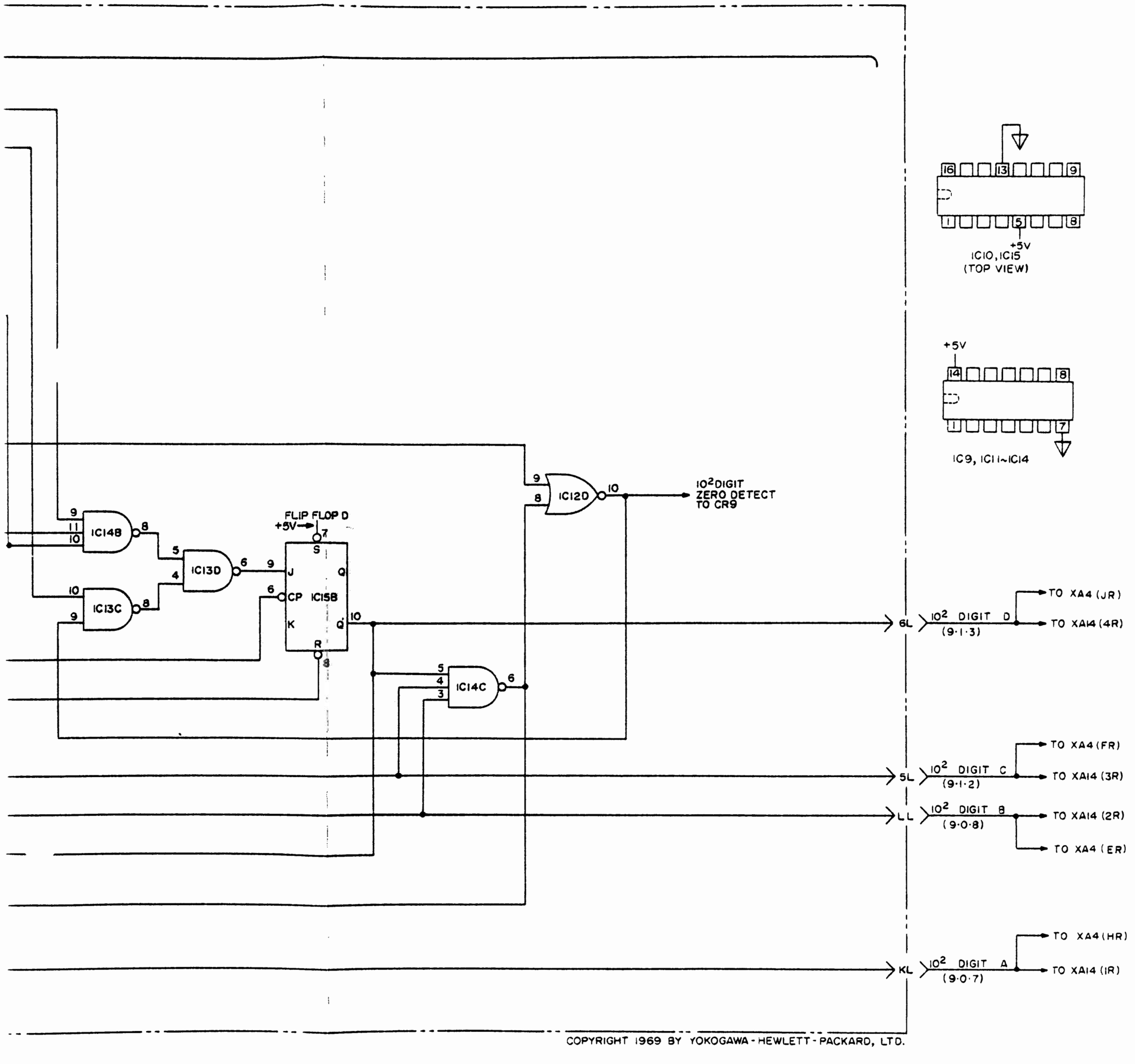
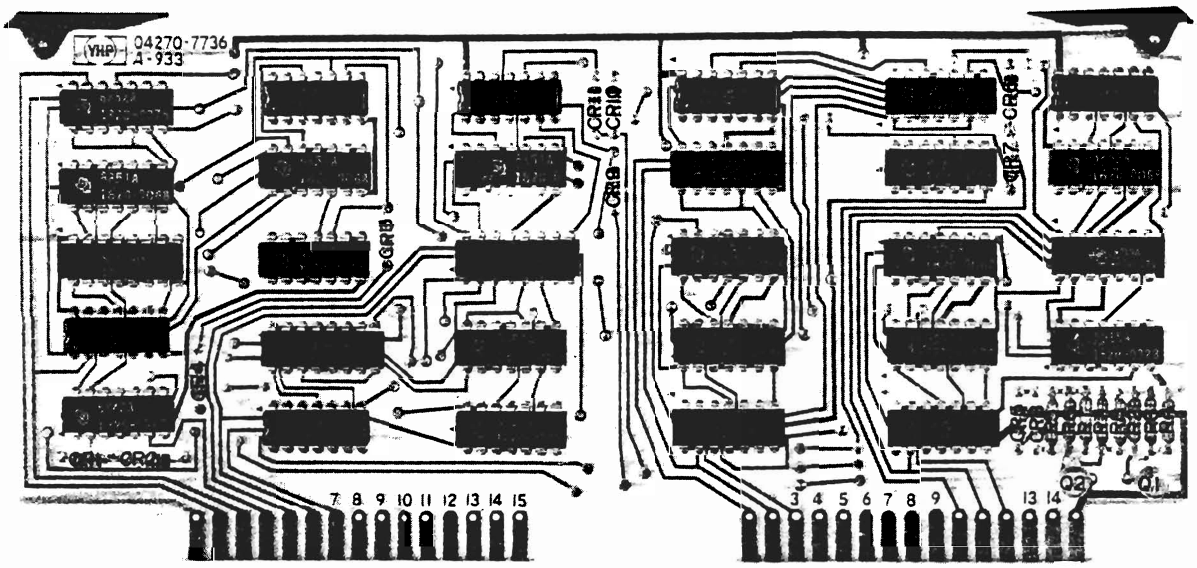
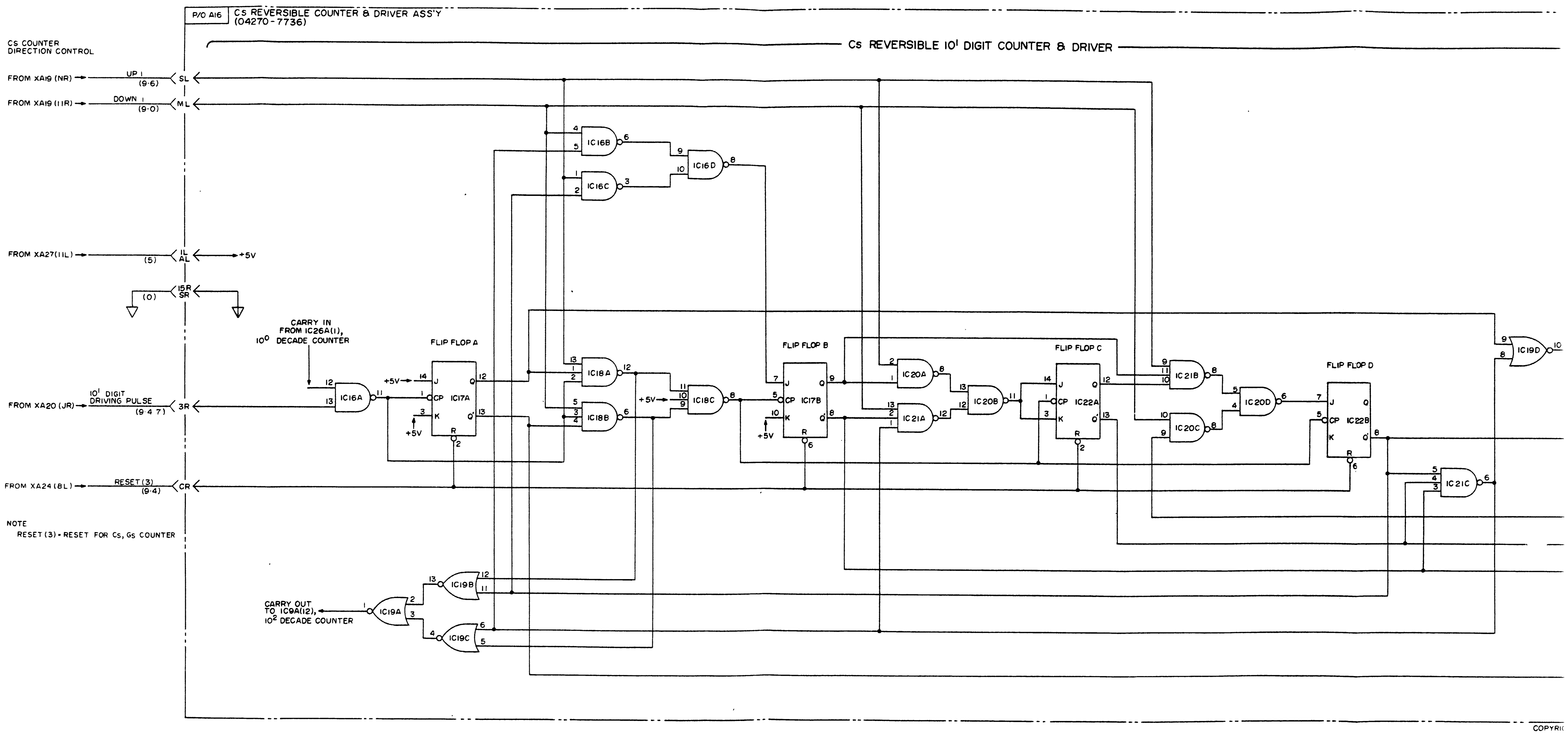


Figure 8-16. Cs Reversible Counter & Driver Ass'y A16
(Sheet 2 of 4)



Cs Reversible Counter & Driver Ass'y A16
(04270-7736)



P/O A16
Cs REVERSIBLE COUNTER & DRIVER ASS'Y (04270-7736)
Cs REVERSIBLE 10¹ DIGIT COUNTER & DRIVER
CS COUNTER DIRECTION CONTROL
FROM XA19 (NR)
UP 1 (9·6)
SL
FROM XA19 (11R)
DOWN 1 (9·0)
ML
FROM XA27(11L)
(5)
IL AL
+5V
15R SR
(0)
CARRY IN FROM IC26A(1), 10⁰ DECADE COUNTER
FROM XA20 (JR)
10¹ DIGIT DRIVING PULSE (9·4 7)
3R
FROM XA24 (8L)
RESET (3) (9·4)
CR
NOTE
RESET (3) = RESET FOR Cs, Gs COUNTER
CARRY OUT TO IC9A(12), 10² DECADE COUNTER
FLIP FLOP A
FLIP FLOP B
FLIP FLOP C
FLIP FLOP D
IC16A
IC16B
IC16C
IC16D
IC17A
IC17B
IC18A
IC18B
IC18C
IC19A
IC19B
IC19C
IC19D
IC20A
IC20B
IC20C
IC20D
IC21A
IC21B
IC21C
IC22A
IC22B
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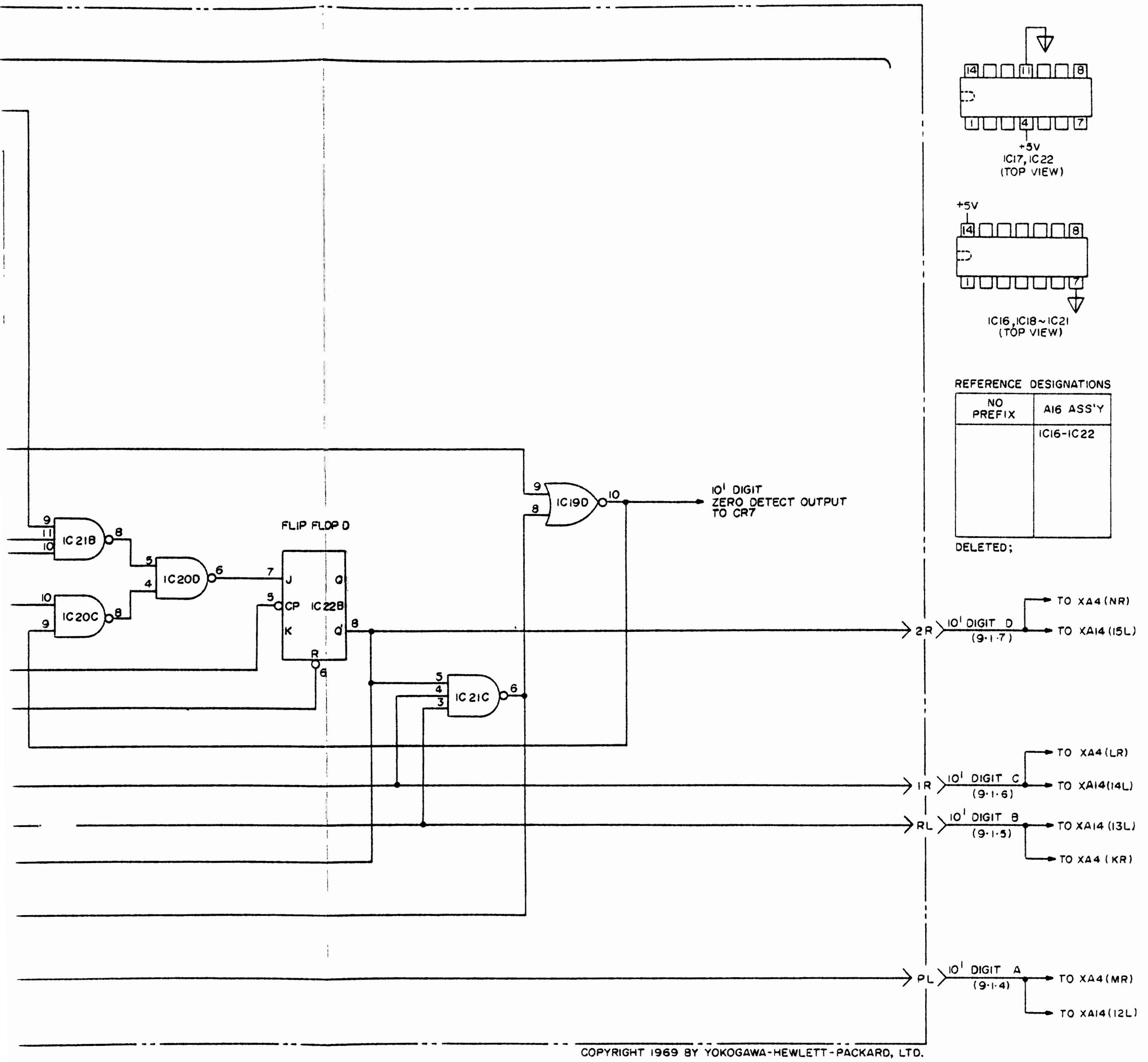
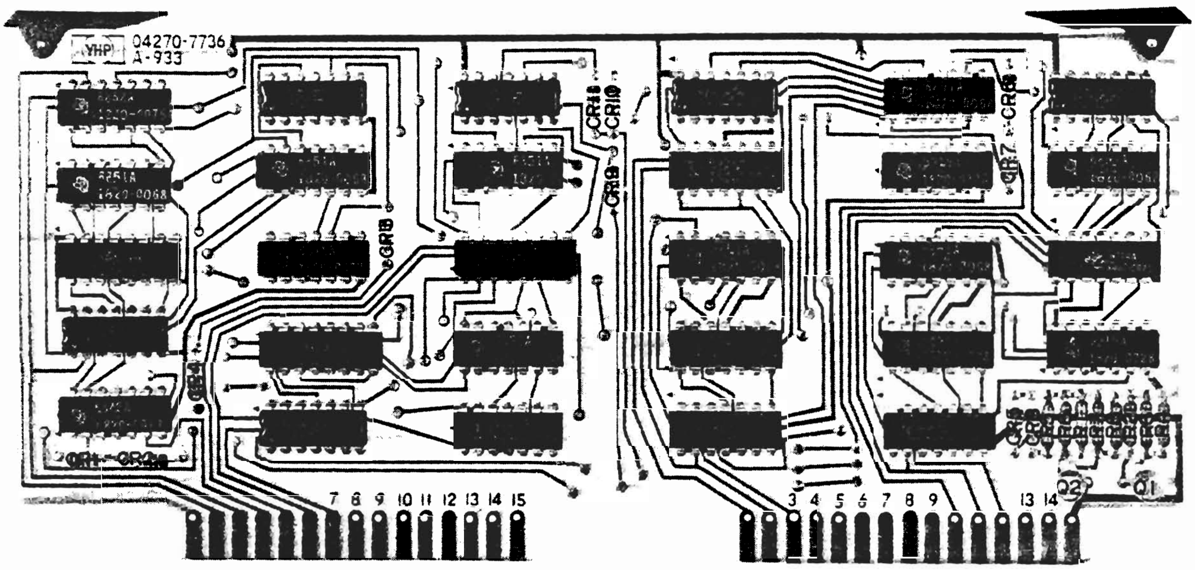
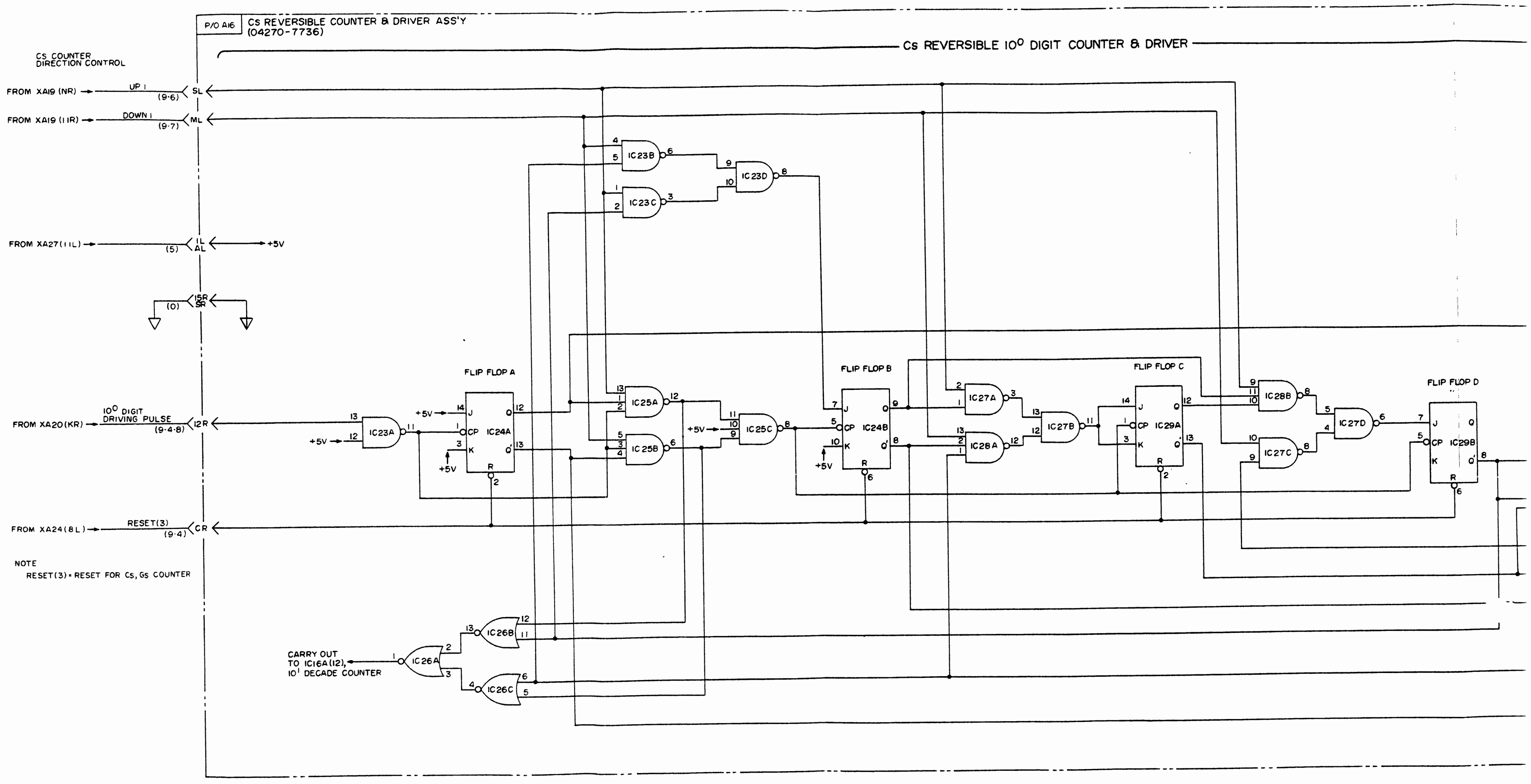


Figure 8-17. Cs Reversible Counter & Driver Ass'y A16
(Sheet 3 of 4)



Cs Reversible Counter & Driver Ass'y A16
(04270-7736)



P/O A16
CS REVERSIBLE COUNTER & DRIVER ASS'Y (04270-7736)
Cs REVERSIBLE 10⁰ DIGIT COUNTER & DRIVER
CS COUNTER DIRECTION CONTROL
FROM XA19 (NR)
UP 1 (9-6)
FROM XA19 (11R)
DOWN 1 (9-7)
FROM XA27(11L)
+5V
10⁰ DIGIT DRIVING PULSE (9-4-8)
FROM XA20 (KR)
FROM XA24(8L)
RESET(3) (9-4)
NOTE
RESET(3) = RESET FOR Cs, Gs COUNTER
CARRY OUT TO IC16A(12), 10¹ DECADE COUNTER
FLIP FLOP A
FLIP FLOP B
FLIP FLOP C
FLIP FLOP D
IC23A
IC23B
IC23C
IC23D
IC24A
IC24B
IC25A
IC25B
IC25C
IC26A
IC26B
IC26C
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IC27B
IC27C
IC27D
IC28A
IC28B
IC29A
IC29B

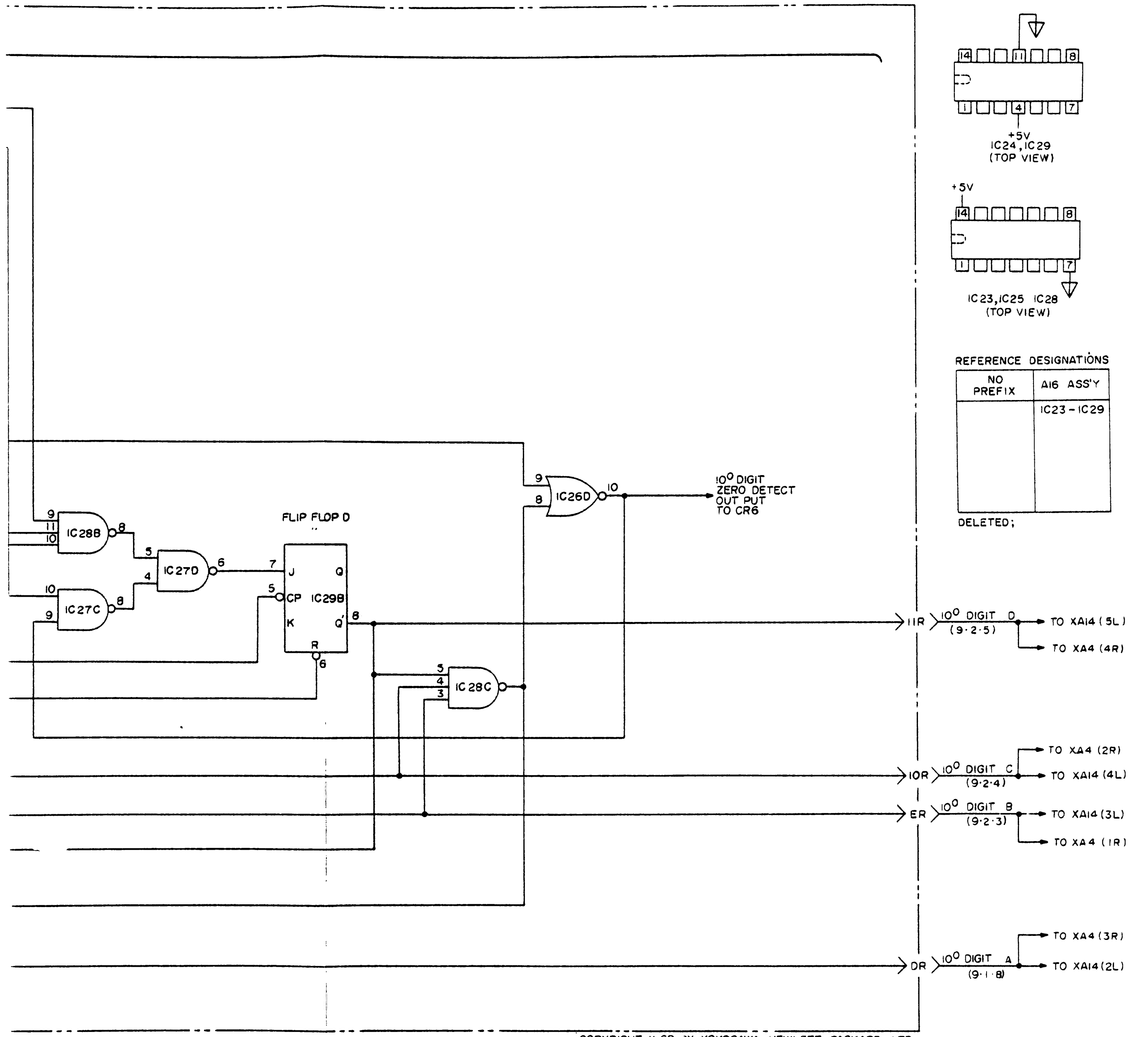
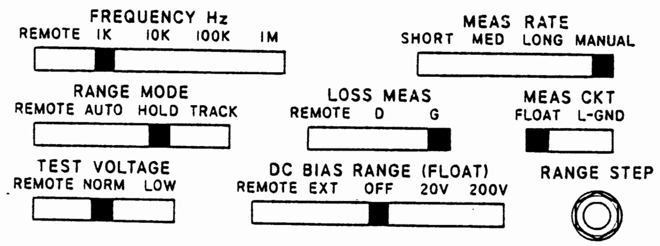
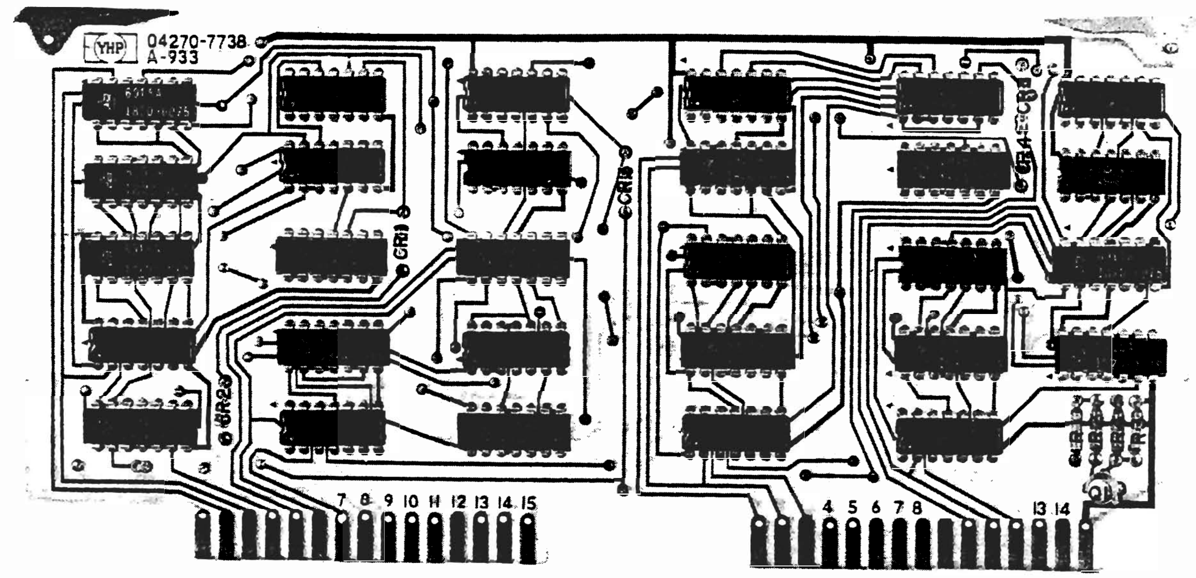


Figure 8-18. Cs Reversible Counter & Driver Ass'y A16
(Sheet 4 of 4)

A18 TROUBLESHOOTING

Check the +5Vdc at pins I-L and A-L. Set controls as shown and select 1000pF. Set STORAGE ON/OFF switch on A25 to OFF. Depress and hold RESET button. Verify that the numeric displays are all zero and Gs(00000) is LOW at pin P-R using the logic probe. If not, trace back through the logic to isolate a defective gate or flip/flop with the logic probe. To check the count operation (if Special Extenders I and II are available) proceed with the steps described in paragraph (5-78). If they are not available, supply -0.5V through 5kΩ resistor to integrator input at XA19 pin 10-L. While depressing and holding RESET button, Set RANGE MODE to TRACK and release RESET button. The D/G counter should start counting up from least significant digit. If the D/G counter does not start counting, check the following:UP 2, should be HIGH; DOWN 2, should be LOW; and DRIVING PULSE at PIN 12-R by using a logic probe or oscilloscope. Use oscilloscope to check counting operation of the least significant digit and of the 3rd significant digit. If miscount is encountered, check the DRIVING PULSE and J and K inputs to the flip/flop corresponding to the mis-counting. If all input signals are normal, the miscounting may be caused by the defective flip/flop. But before replacing the flip/flop, check the reset signal to the flip/flop by using oscilloscope because the reset signal line is common to all flip/flops and a spike on the reset signal line may cause the flip/flop to operate incorrectly. If a spike is discovered on the reset signal line, isolate a flip/flop from which the spike comes and replace the defective component.

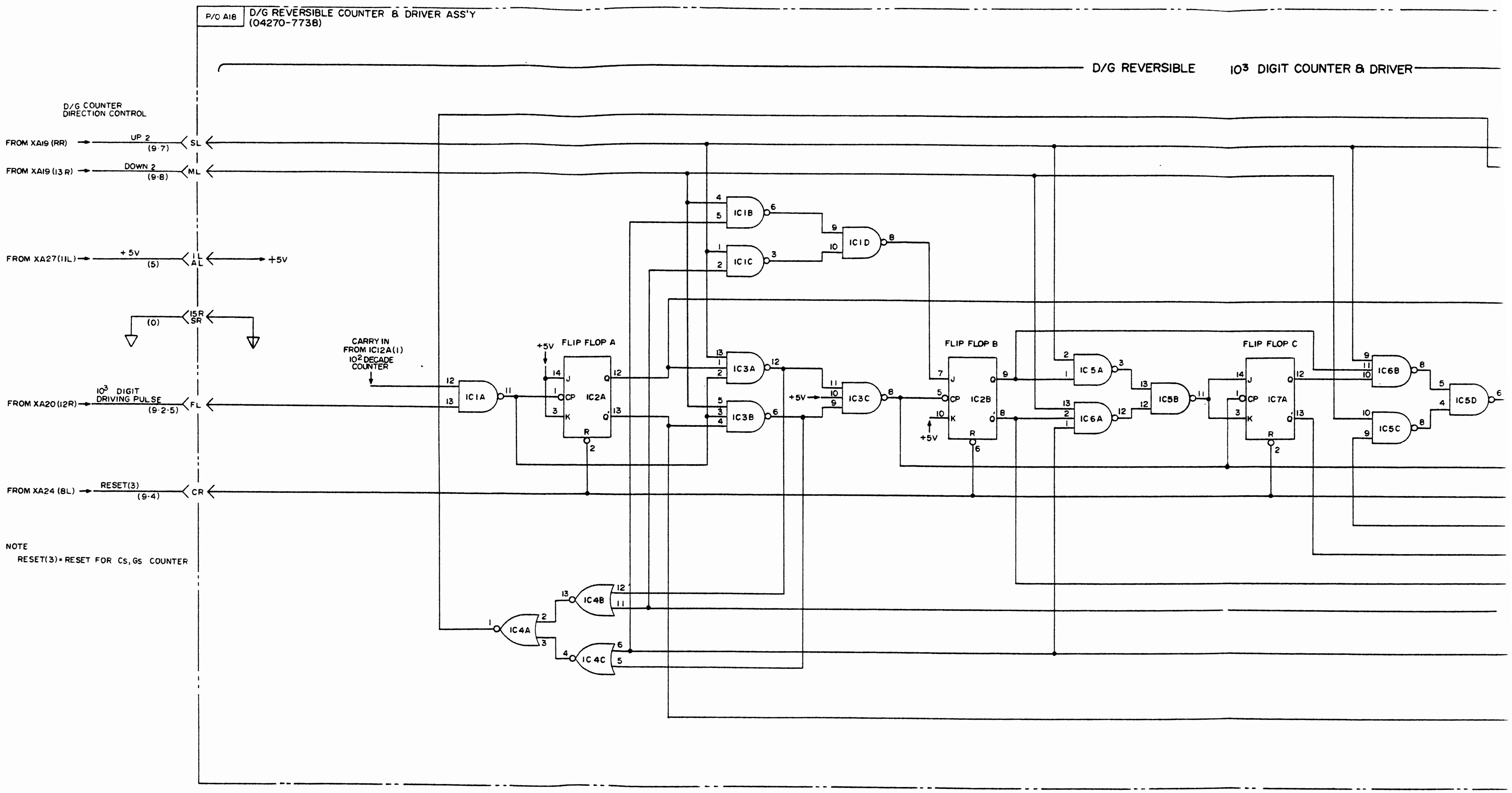




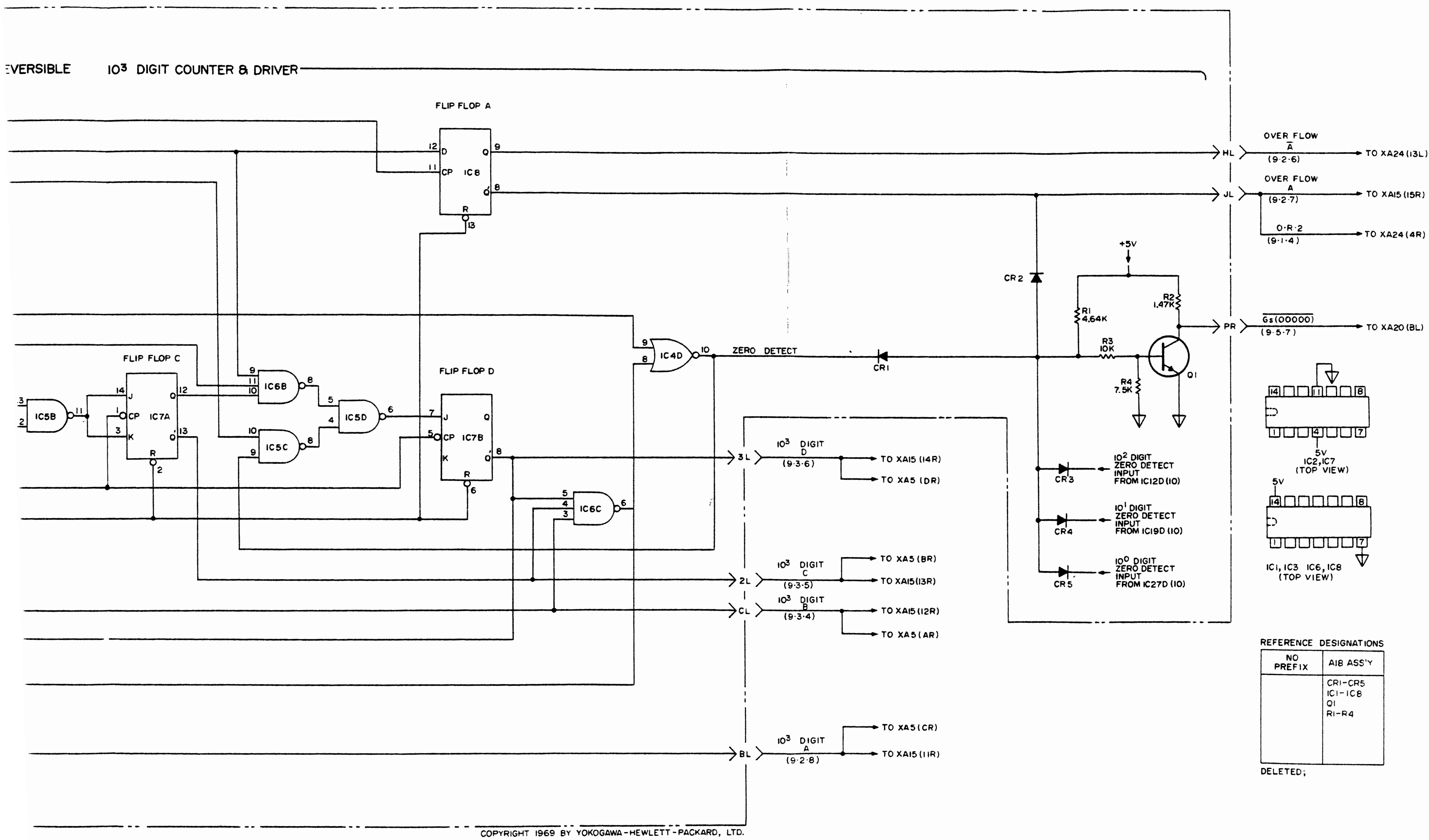
D/G Reversible Counter & Driver Ass'y A18
(04270-7738)

SEE INSIDE

Figure 8-18
CS REVERSIBLE COUNTER & DRIVER ASS'Y A16
(SHEET 4 OF 4)


P/O A18
D/G REVERSIBLE COUNTER & DRIVER ASS'Y (04270-7738)
D/G REVERSIBLE 10³ DIGIT COUNTER & DRIVER
D/G COUNTER DIRECTION CONTROL
FROM XA19 (RR)
UP 2 (9·7)
FROM XA19 (13 R)
DOWN 2 (9·8)
FROM XA27(11L)
+5V (5)
+5V
(0)
CARRY IN FROM IC12A(1) 10² DECADE COUNTER
FROM XA20(12R)
10³ DIGIT DRIVING PULSE (9·2·5)
FROM XA24 (8L)
RESET(3) (9·4)
NOTE
RESET(3)=RESET FOR CS, GS COUNTER
FLIP FLOP A
FLIP FLOP B
FLIP FLOP C
IC1A
IC1B
IC1C
IC1D
IC2A
IC2B
IC3A
IC3B
IC3C
IC4A
IC4B
IC4C
IC5A
IC5B
IC5C
IC5D
IC6A
IC6B
IC7A

79

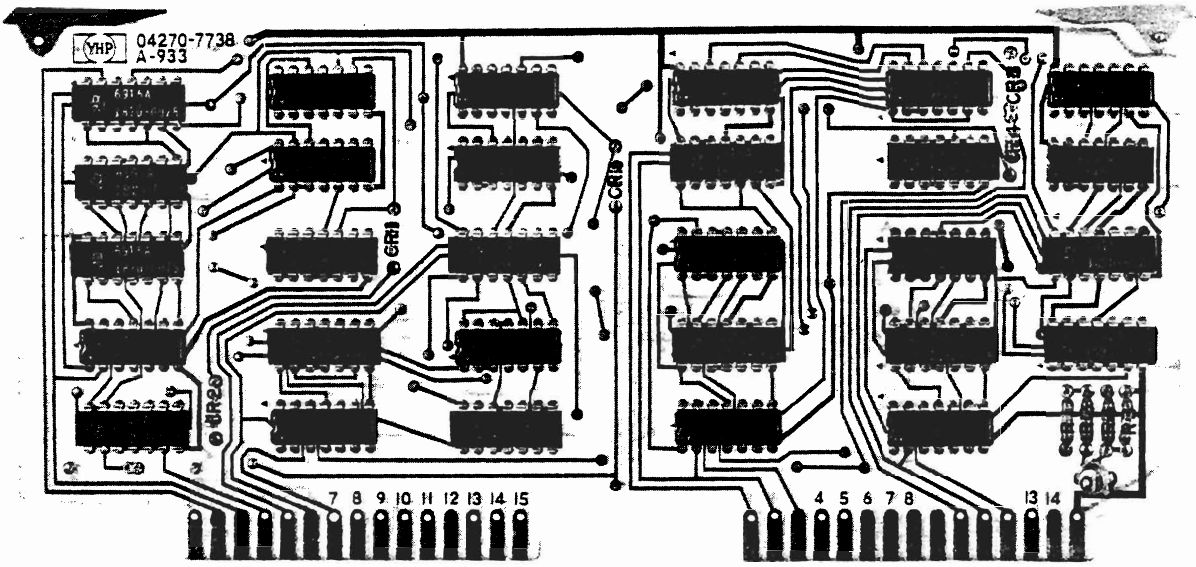


REFERENCE DESIGNATIONS

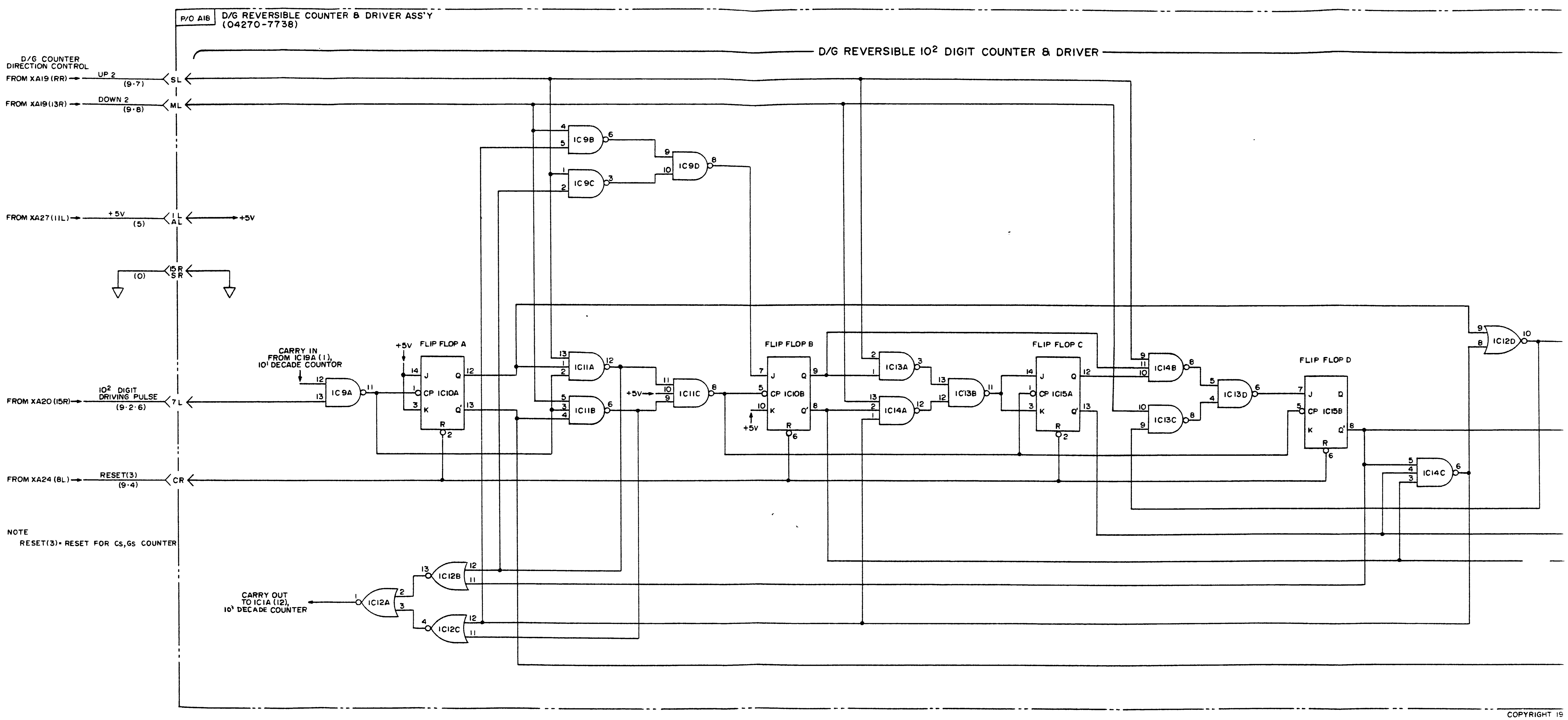
NO PREFIX	A18 ASS'Y
	CR1-CR5 IC1-IC8 Q1 R1-R4

DELETED;

Figure 8-19. D/G Reversible Counter & Driver Ass'y A18
(Sheet 1 of 4)



D/G Reversible Counter & Driver Ass'y A18
(04270-7738)



P/O A18
D/G REVERSIBLE COUNTER & DRIVER ASS'Y
(04270-7738)
D/G REVERSIBLE 10² DIGIT COUNTER & DRIVER
D/G COUNTER
DIRECTION CONTROL
FROM XA19 (RR)
UP 2
(9·7)
FROM XA19 (13R)
DOWN 2
(9·8)
FROM XA27 (11L)
+5V
(5)
+5V
(0)
CARRY IN
FROM IC19A (1),
10¹ DECADE COUNTOR
10² DIGIT
DRIVING PULSE
(9·2·6)
FROM XA20 (15R)
FROM XA24 (8L)
RESET(3)
(9·4)
NOTE
RESET(3)= RESET FOR CS,GS COUNTER
CARRY OUT
TO IC1A (12),
10¹ DECADE COUNTER
FLIP FLOP A
FLIP FLOP B
FLIP FLOP C
FLIP FLOP D
IC9A
IC9B
IC9C
IC9D
IC10A
IC10B
IC11A
IC11B
IC11C
IC12A
IC12B
IC12C
IC12D
IC13A
IC13B
IC13C
IC13D
IC14A
IC14B
IC14C
IC15A
IC15B

Figure 8·

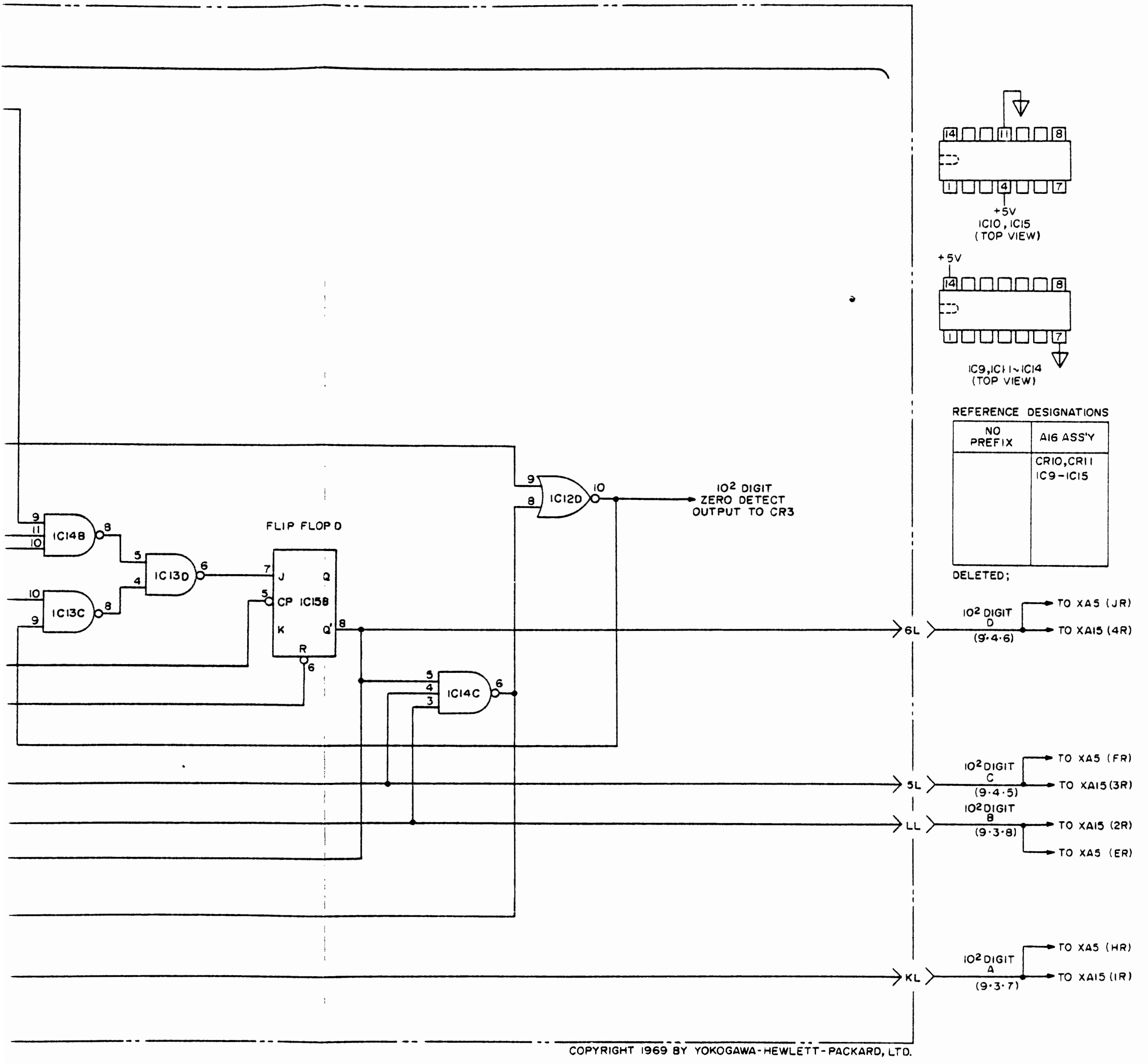
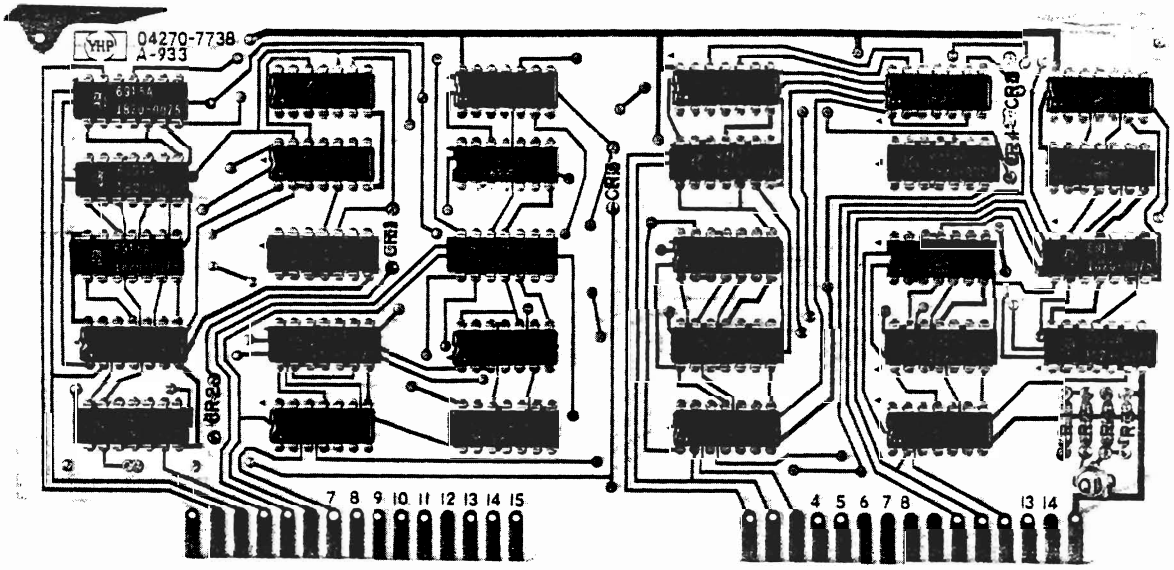
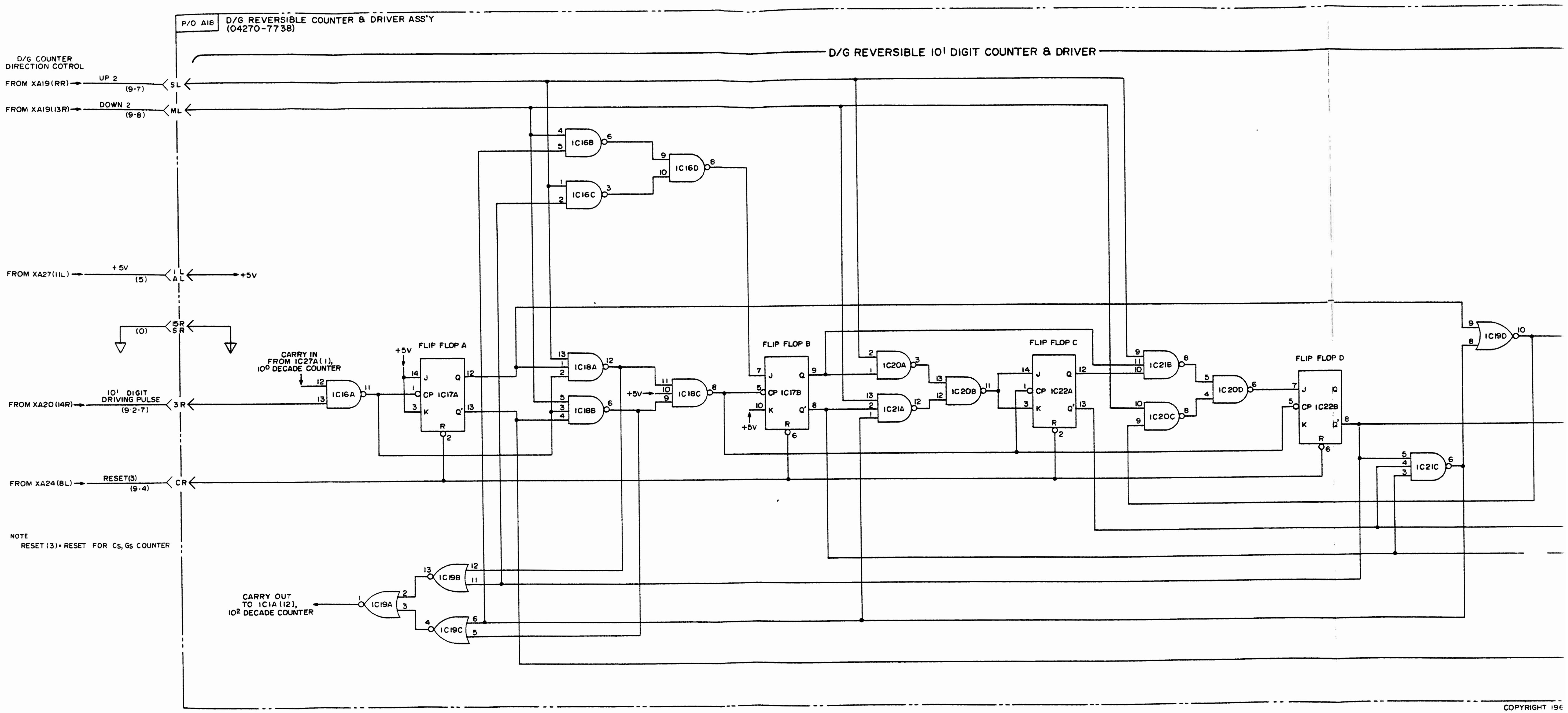


Figure 8-20. D/G Reversible Counter & Driver Ass'y A18
(Sheet 2 of 4)

23



D/G Reversible Counter & Driver Ass'y A18
(04270-7738)



P/O A18
D/G REVERSIBLE COUNTER & DRIVER ASS'Y (04270-7738)
D/G REVERSIBLE 10¹ DIGIT COUNTER & DRIVER
D/G COUNTER DIRECTION COTROL
FROM XA19(RR)
UP 2
(9·7)
FROM XA19(13R)
DOWN 2
(9·8)
FROM XA27(11L)
+5V
(5)
+5V
(0)
CARRY IN FROM IC27A(1), 10⁰ DECADE COUNTER
FROM XA20(14R)
10¹ DIGIT DRIVING PULSE
(9·2·7)
FROM XA24(8L)
RESET(3)
(9·4)
NOTE
RESET (3) = RESET FOR CS, GS COUNTER
CARRY OUT TO IC1A(12), 10² DECADE COUNTER
FLIP FLOP A
FLIP FLOP B
FLIP FLOP C
FLIP FLOP D
IC16A
IC16B
IC16C
IC16D
IC17A
IC17B
IC18A
IC18B
IC18C
IC19A
IC19B
IC19C
IC19D
IC20A
IC20B
IC20C
IC20D
IC21A
IC21B
IC21C
IC22A
IC22B
COPYRIGHT 196

Figure 8

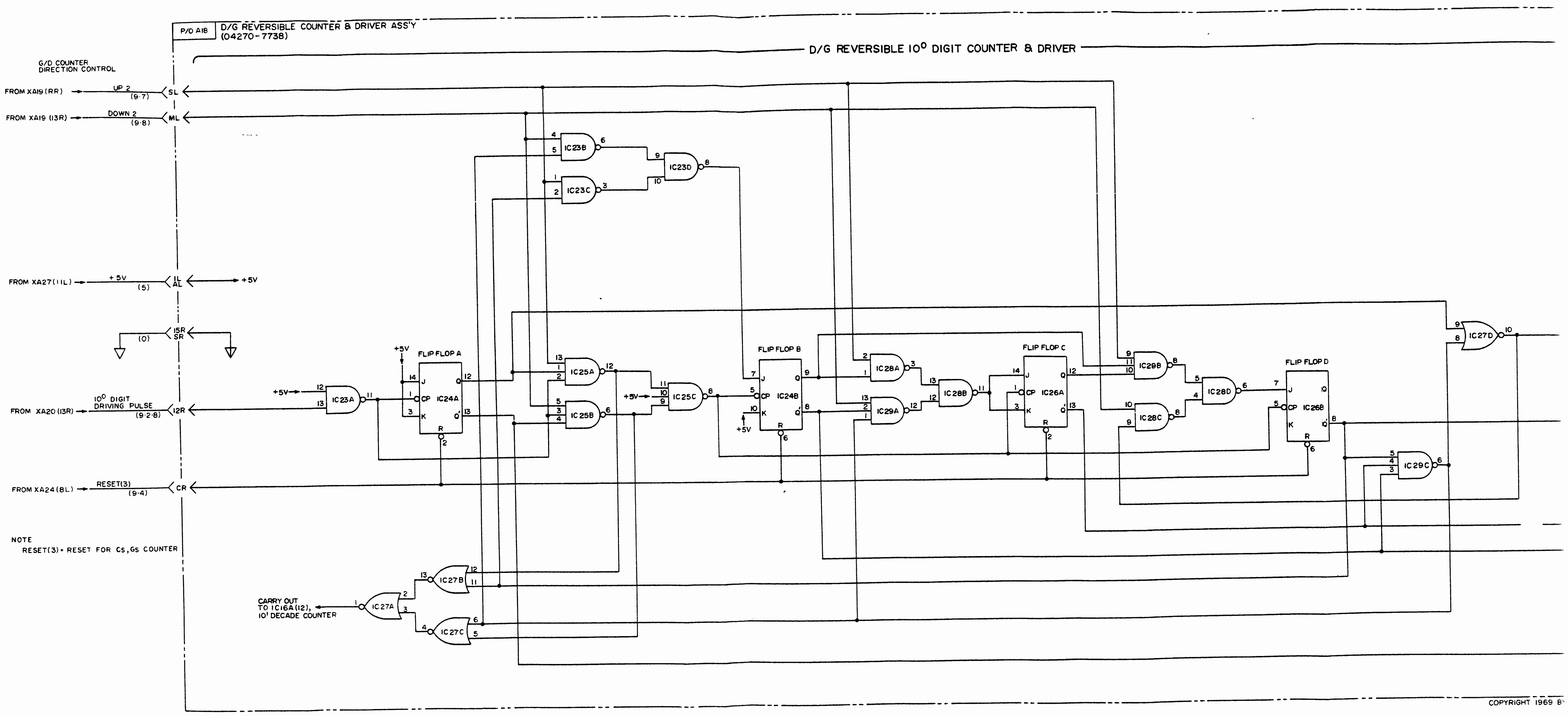
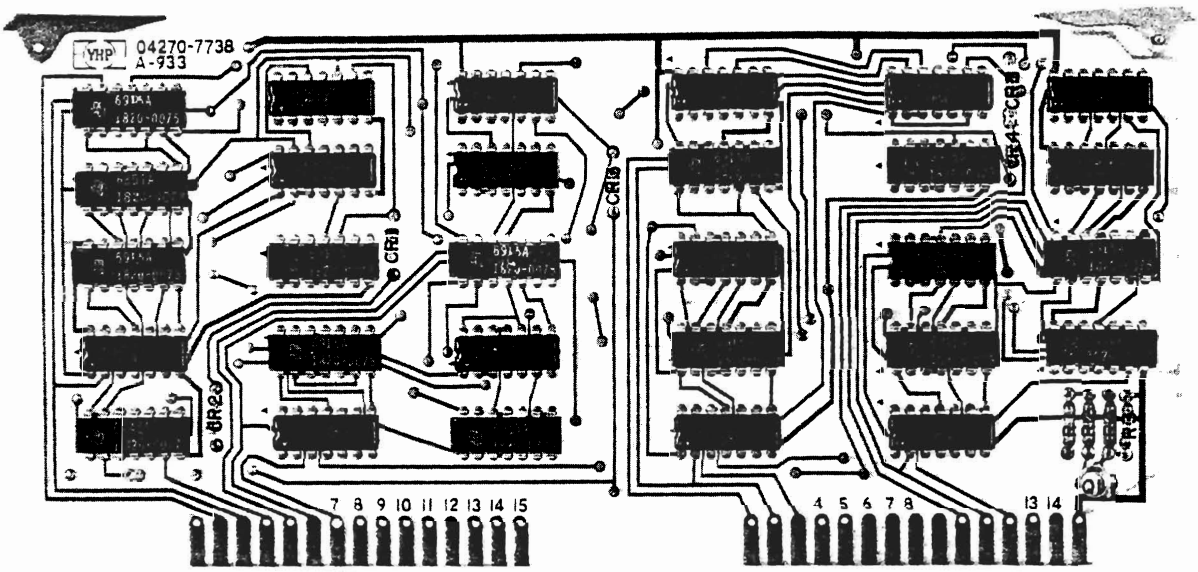
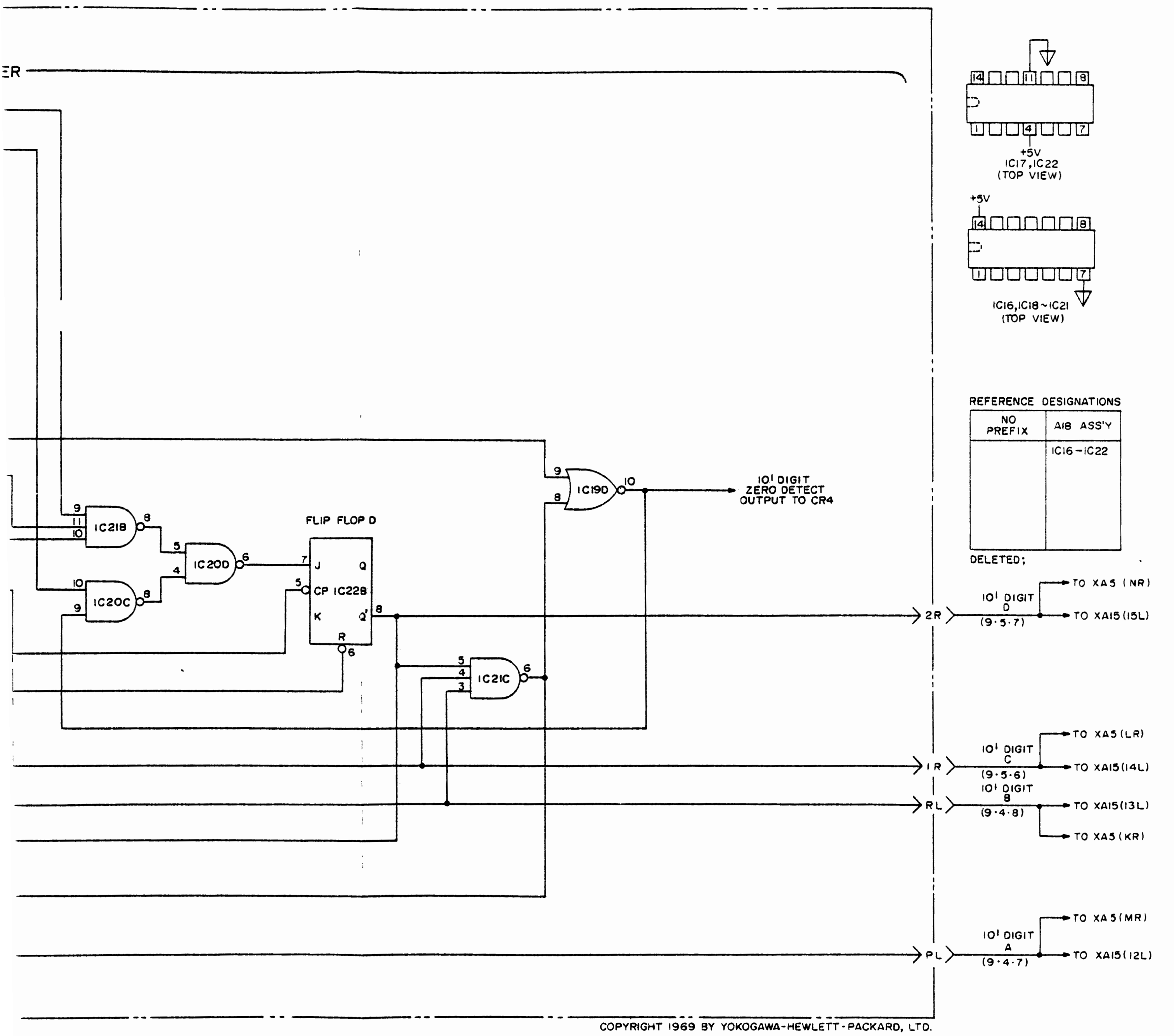

P/O A18
D/G REVERSIBLE COUNTER & DRIVER ASS'Y
(04270-7738)
D/G REVERSIBLE 10° DIGIT COUNTER & DRIVER
G/D COUNTER
DIRECTION CONTROL
FROM XA19 (RR)
UP 2
(9·7)
FROM XA19 (13R)
DOWN 2
(9·8)
FROM XA27 (11L)
+5V
(5)
FROM XA20 (13R)
10° DIGIT
DRIVING PULSE
(9·2·8)
FROM XA24 (BL)
RESET(3)
(9·4)
NOTE
RESET(3) = RESET FOR CS, GS COUNTER
CARRY OUT
TO IC16A (12),
10' DECADE COUNTER
FLIP FLOP A
FLIP FLOP B
FLIP FLOP C
FLIP FLOP D
IC23A
IC23B
IC23C
IC23D
IC24A
IC24B
IC25A
IC25B
IC25C
IC26A
IC26B
IC27A
IC27B
IC27C
IC27D
IC28A
IC28B
IC28C
IC28D
IC29A
IC29B
IC29C
COPYRIGHT 1969 B

Figure 8-22



D/G Reversible Counter & Driver Ass'y A18
(04270-7738)



REFERENCE DESIGNATIONS

NO PREFIX	A18 ASS'Y
	IC16 – IC22

DELETED;

Figure 8-21. D/G Reversible Counter & Driver Ass'y A18 (Sheet 3 of 4)

26

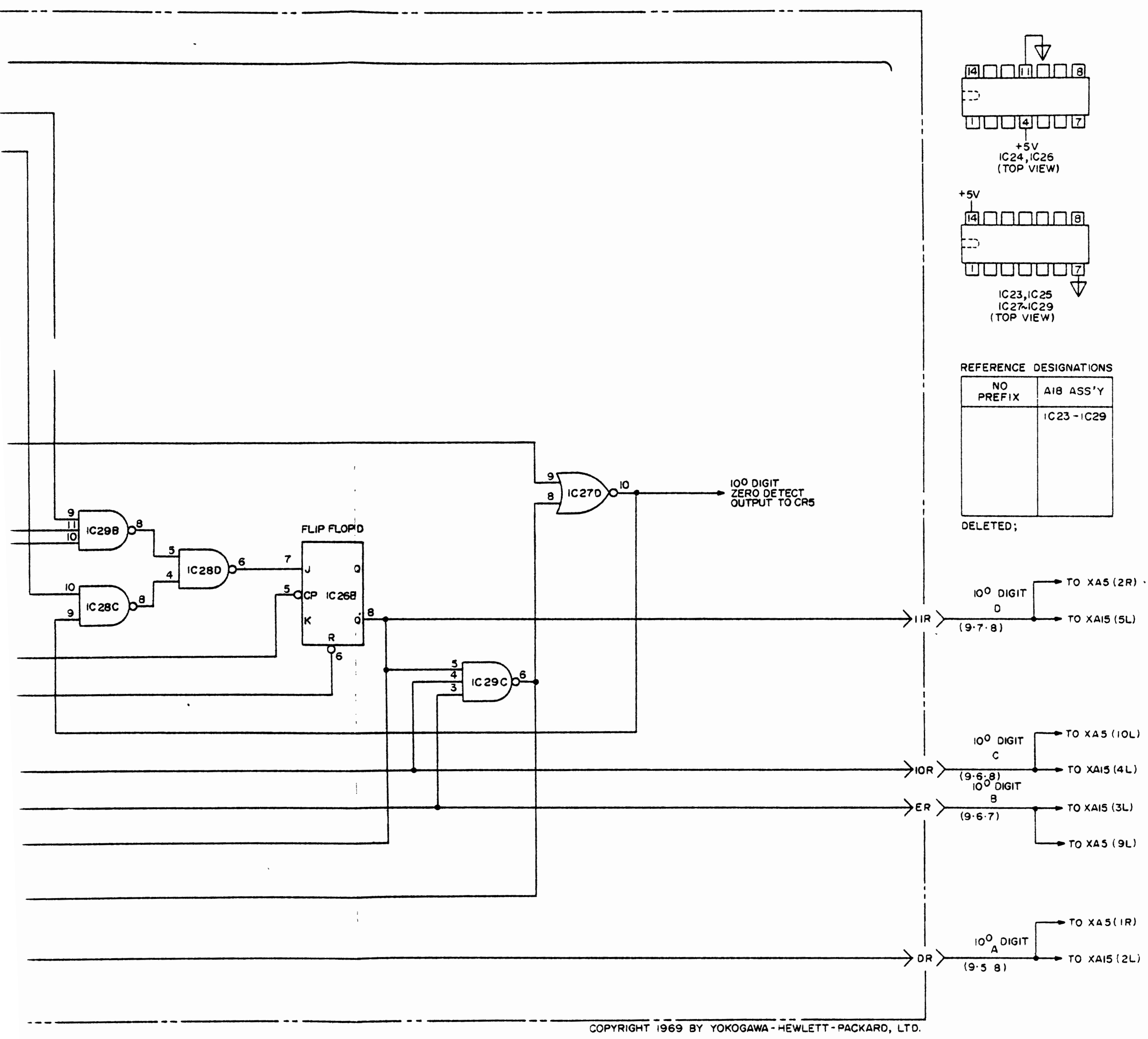


Figure 8-22. D/G Reversible Counter & Driver Ass'y A18 (Sheet 4 of 4)

A19 TROUBLESHOOTING

Check the +12Vdc at pin I-L, the +5Vdc at pin 15-R and the -6Vdc at pin 15-L. Observe the input pulses with oscilloscope; Sampling Pulse 1 at pin B-R; Sampling Pulse 2 at A-R; Timing Pulse PL1 at pin 4-R and PL2 at pin E-R. Using the logic probe, monitor FH at pin 5-R which should go LOW on AUTO RANGE MODE. Using the Special Extender I or externally supplying a dc voltage (±0.5Vdc) through 5kΩ to the integrators is very helpful for troubleshooting A19. Monitor the comparator outputs at Q1, Q2, Q5 and Q6 emitter with the Logic Probe while connecting both Integrator inputs to circuit common. All of them should be LOW. If not, adjust R5 or R8 for minimum output from the Integrators then check the Integrators and the comparators again. If all comparator outputs are LOW, K1 and K2 pulses should be observed at pins 8-R and 7-R for a positive pulse 37μs wide. Verify that H-L SWITCHING SIGNAL does not occur (no output pulse from pin K-R) and that it stays HIGH. Supply +0.5Vdc through 5kΩ to both integrators. Monitor DOWN 1 at pin 11-R and DOWN 2 at pin 13-R which should be HIGH, and D1 at pin C-R and D2 at pin D-R should be seen. Supply -0.5Vdc through 5kΩ to the both integrators. Monitor UP1 at pin N-R and UP2 at pin R-R1 should be HIGH, and U1 at pin 2-R and U2 at pin 3-R should also be seen. Observe C Gate Control Signal at pin 9-R and G Gate Control Signal at pin 10-R while changing the polarity of the voltage supplied to the integrators.

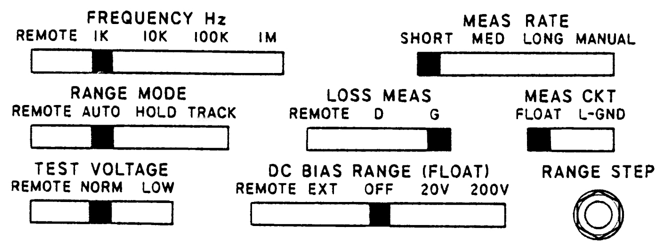
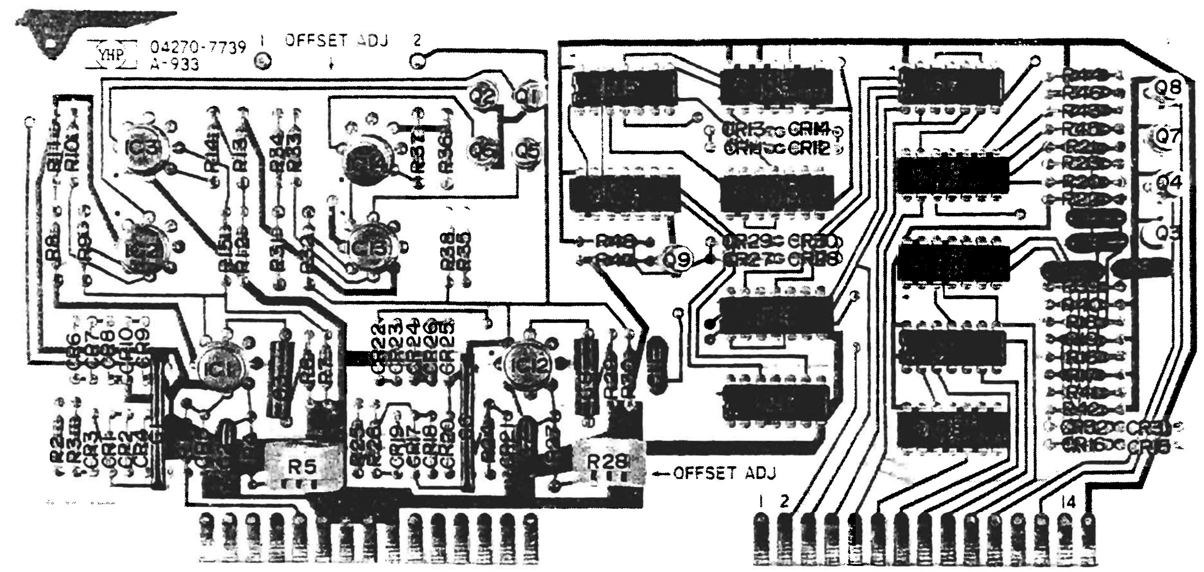
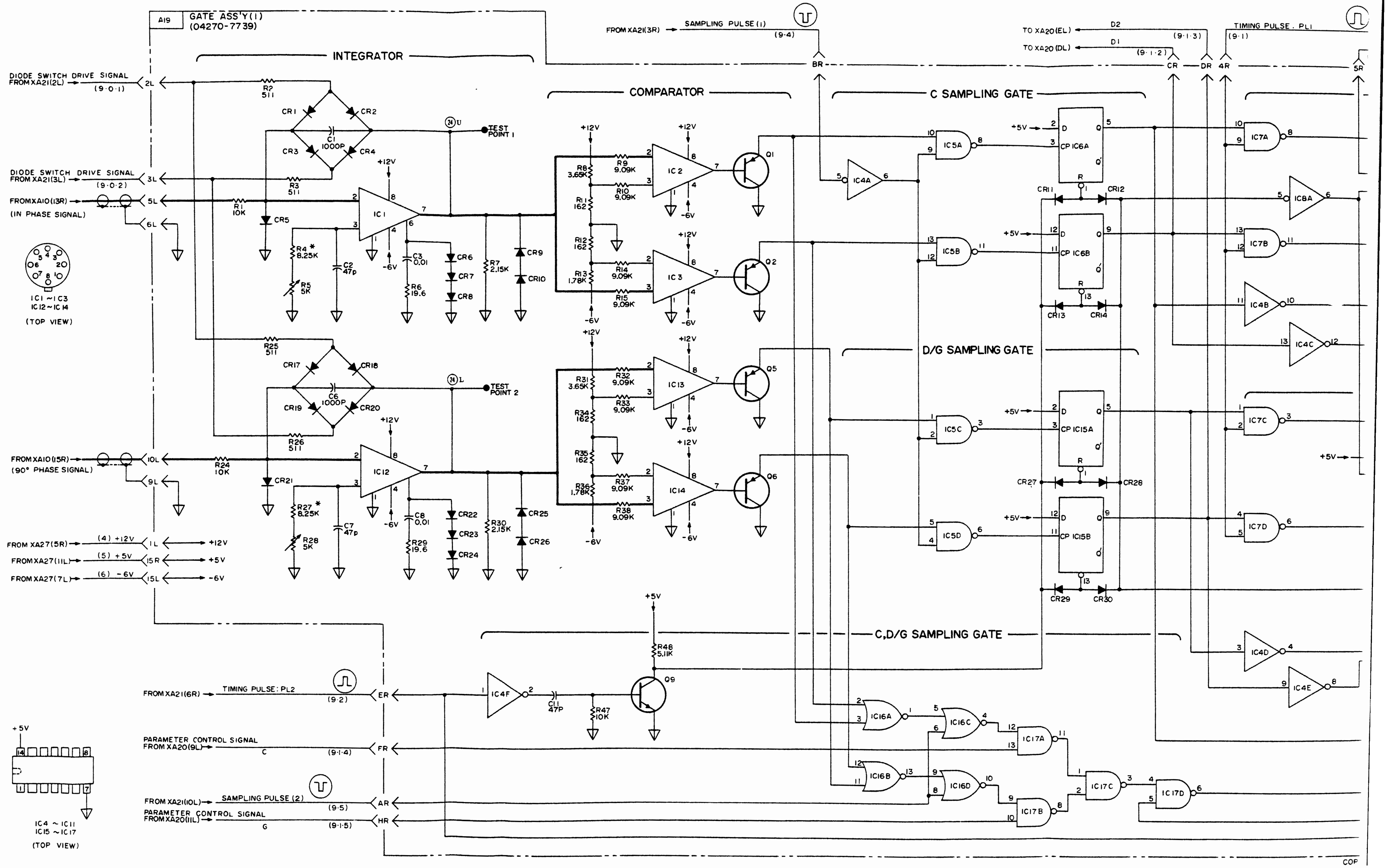


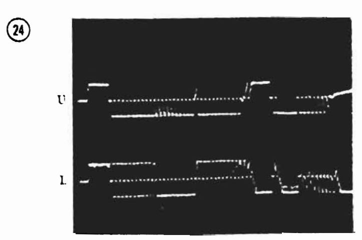
Figure 8-22
D/G REVERSIBLE COUNTER & DRIVER ASS'Y A18
(SHEET 4 OF 4)

SEE INSIDE



Gate Ass'y (1) A19
(04270-7739)


A19
GATE ASS'Y(1)
(04270-7739)
INTEGRATOR
COMPARATOR
C SAMPLING GATE
D/G SAMPLING GATE
C,D/G SAMPLING GATE
DIODE SWITCH DRIVE SIGNAL FROM XA21(2L)
(9·0·1)
DIODE SWITCH DRIVE SIGNAL FROM XA21(3L)
(9·0·2)
FROM XA10(13R)
(IN PHASE SIGNAL)
FROM XA10(15R)
(90° PHASE SIGNAL)
FROM XA27(5R)
(4) +12V
FROM XA27(11L)
(5) +5V
FROM XA27(7L)
(6) -6V
IC1 ~ IC3
IC12 ~ IC14
(TOP VIEW)
TEST POINT 1
TEST POINT 2
FROM XA21(3R)
SAMPLING PULSE (1)
(9·4)
TO XA20(EL)
TO XA20(DL)
D2
D1
(9·1·3)
(9·1·2)
TIMING PULSE . PL1
(9·1)
FROM XA21(6R)
TIMING PULSE: PL2
(9·2)
PARAMETER CONTROL SIGNAL FROM XA20(9L)
C
(9·1·4)
FROM XA21(10L)
SAMPLING PULSE (2)
(9·5)
PARAMETER CONTROL SIGNAL FROM XA20(11L)
G
(9·1·5)
IC4 ~ IC11
IC15 ~ IC17
(TOP VIEW)
COP


24
U
L

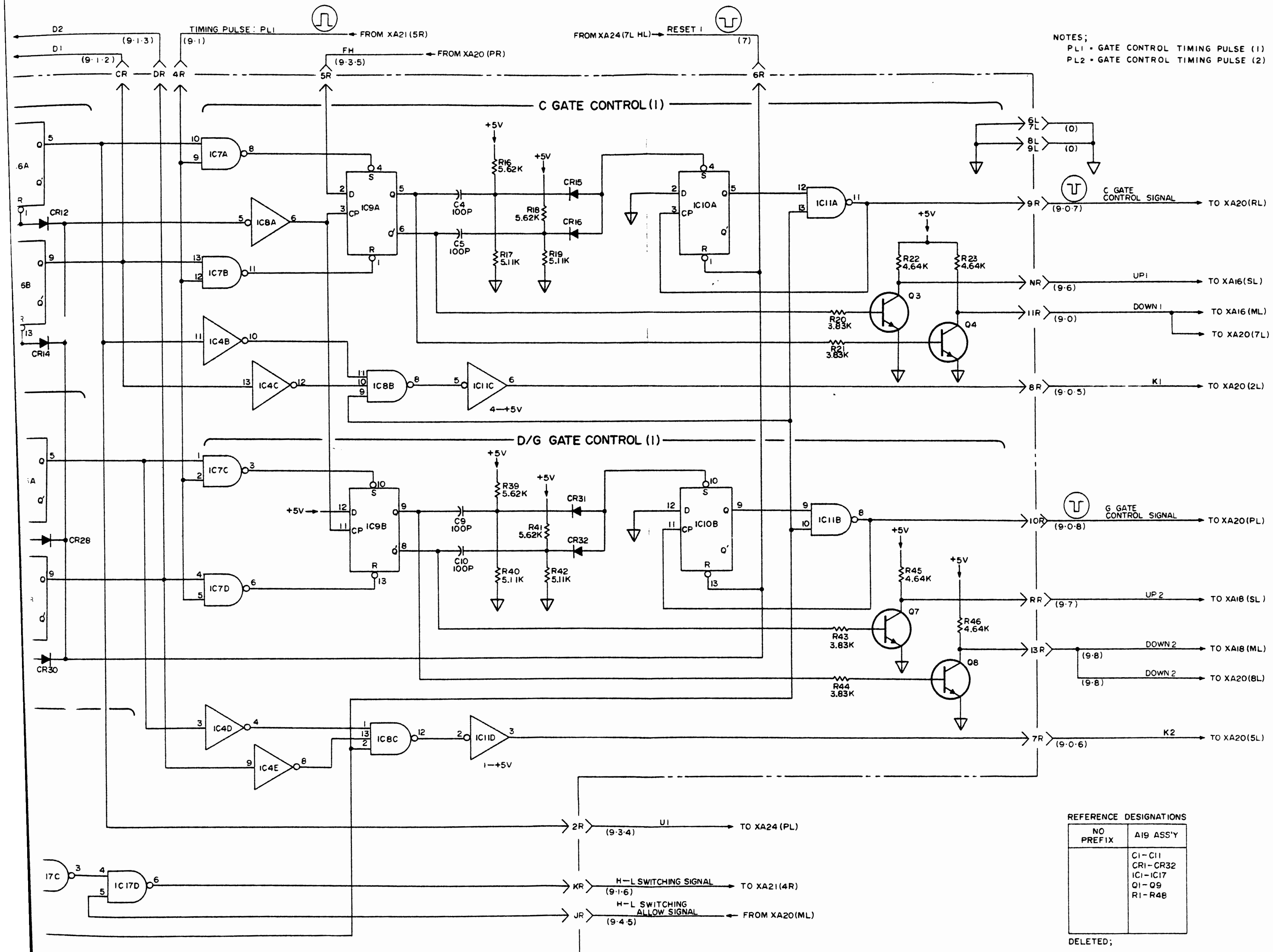


Figure 8-23. Gate Ass'y (1) A19

A20 TROUBLESHOOTING

Measure the +5Vdc at pins 1-L and A-L. Set control as shown and connect oscilloscope to RESET 1 at IC18 pin 8; should go negative while depressing and holding RESET button. Set trigger slope + and adjust the trigger level for stable sweep each time RESET button is released. Connect oscilloscope B channel input to Go at IC18 pin 9; it should go HIGH about 50 ms after RESET 1 pulse. If not, check IC 8A, the set signal and clock input to IC8A.

C Counter Gate Selector:

Set RANGE MODE control to HOLD, Select 100pF Range. Connect 100pF capacitor (HP Part No. 0160-2204) to UNKNOWN. Observe IC18B (11), IC19A (9), IC19B (12) and IC 20A (15) with oscilloscope. For about 55ms, IC18B (11) should be HIGH each time when RESET button is depressed and released, and the other should be LOW. After about 55-ms, IC8B (11) goes LOW and IC19A (9) goes HIGH. Subsequently lower flip-flop goes HIGH every time C Gate Control Signal comes to IC7B (4). Set RANGE MODE control to TRACK and depress RESET button. IC20A (15) should go HIGH and stay HIGH. If incorrect signal is noted, be sure that the set input is correct and the clock input occurs, and then check the resistor flip-flops.

D/G Counter Gato Selector:

Set RANGE MODE control to HOLD. Select 100pF Range. Connect a 100pF capacitor to UNKNOWN. Observe that IC 17B (11), IC22A (12), IC22B (9) and IC20B (11). IC17B (11) goes HIGH when RESET button is depressed and released. Subsequently lower flip-flop goes HIGH when D/G Gate Control Signal comes to IC10A (10). Set RANGE MODE control to TRACK. IC20B (11) goes HIGH and stays HIGH. If incorrect signal is discovered be sure that Set input is correct, that Clock input occurs, and then check the resistor flip-flops.

PARAMETER CONTROL:

Set RANGE MODE control to HOLD and connect 100pF capacitor to UNKNOWN.

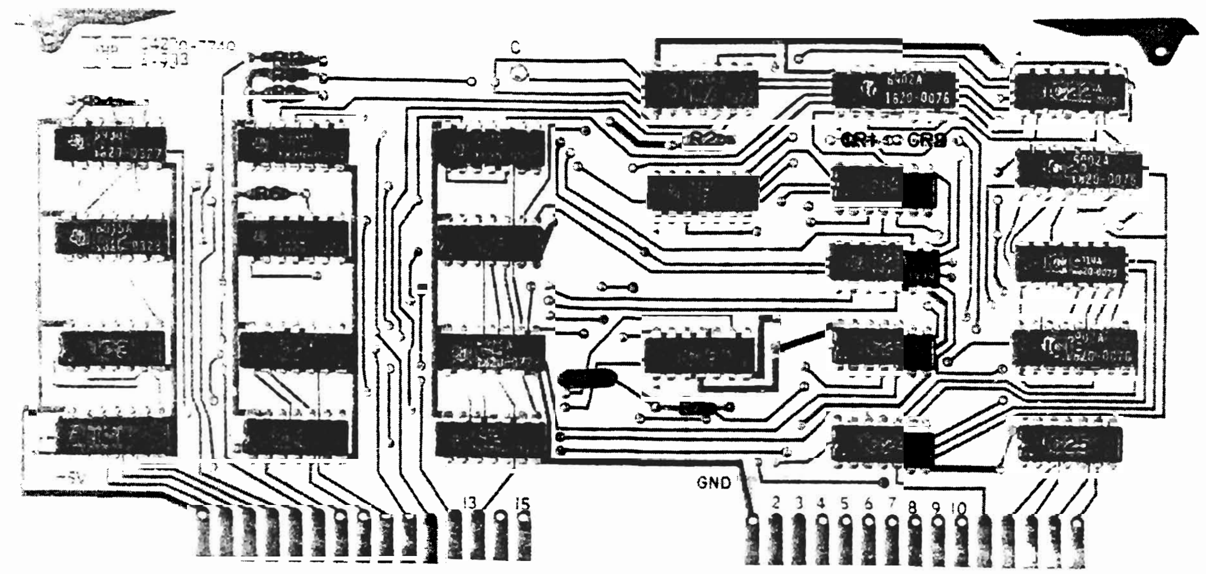
PARAMETER "C" at PIN 9-L may be observed with oscilloscope each time RESET button is depressed and released

NULL DETECTOR:

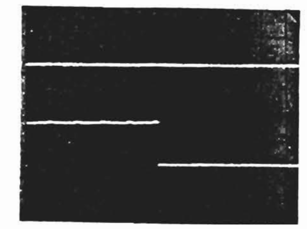
Set RANGE MODE control to HOLD. Connect both integrator inputs on A19 to the circuit common to produce K1 and K2 pulses. Observe IC6B (10) with oscilloscope (see figure (27)) If the negative pulse is absent, observe IC15A (10) and IC15D (13) and trace back through the logic with oscilloscope to isolate a defective gate. If the negative pulse is present, connect both integrator inputs to + 0.5Vdc through 5.1kΩ. Observe IC6B (10) with oscilloscope see figure (28)) If negative pulses are absent, trace back through the logic with oscilloscope to isolate a defective gate. If negative pulses occur, connect both integrator inputs on A19 to the phase detector outputs. Unsolder a wire from pin N-L on XA20. Connect 100pF capacitor to UNKNOWN. Observe IC6B (8) and IC6B (9) at the same time. If negative pulses do not occur at the same time, check IC 16A and IC16B.

SEE INSIDE

Figure 8-23
GATE ASS'Y (1) A19



Gate Ass'y (2) A20
(04270-7740)

(25)


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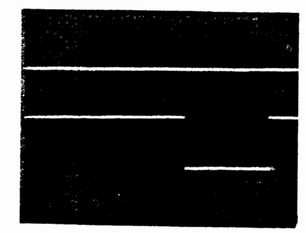
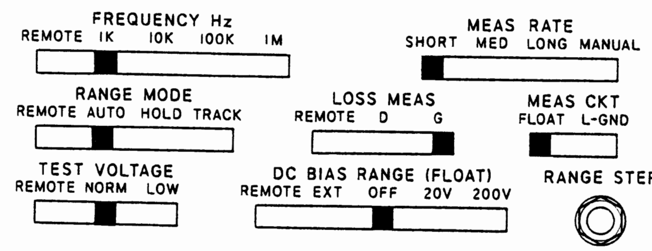


Set Controls for waveform and DC bias checks as follows:



All waveforms are taken with HP 180A Oscilloscope, HP 1801A Vertical Plug-in, HP 1821A Time Base Plug-in, and HP 10004A 10 : 1 Divider Probe.

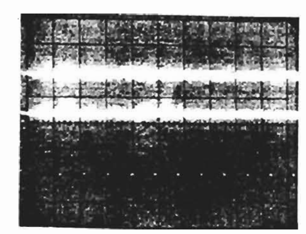
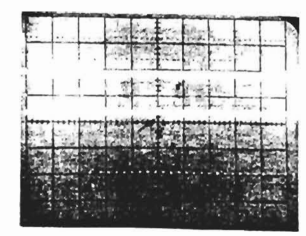
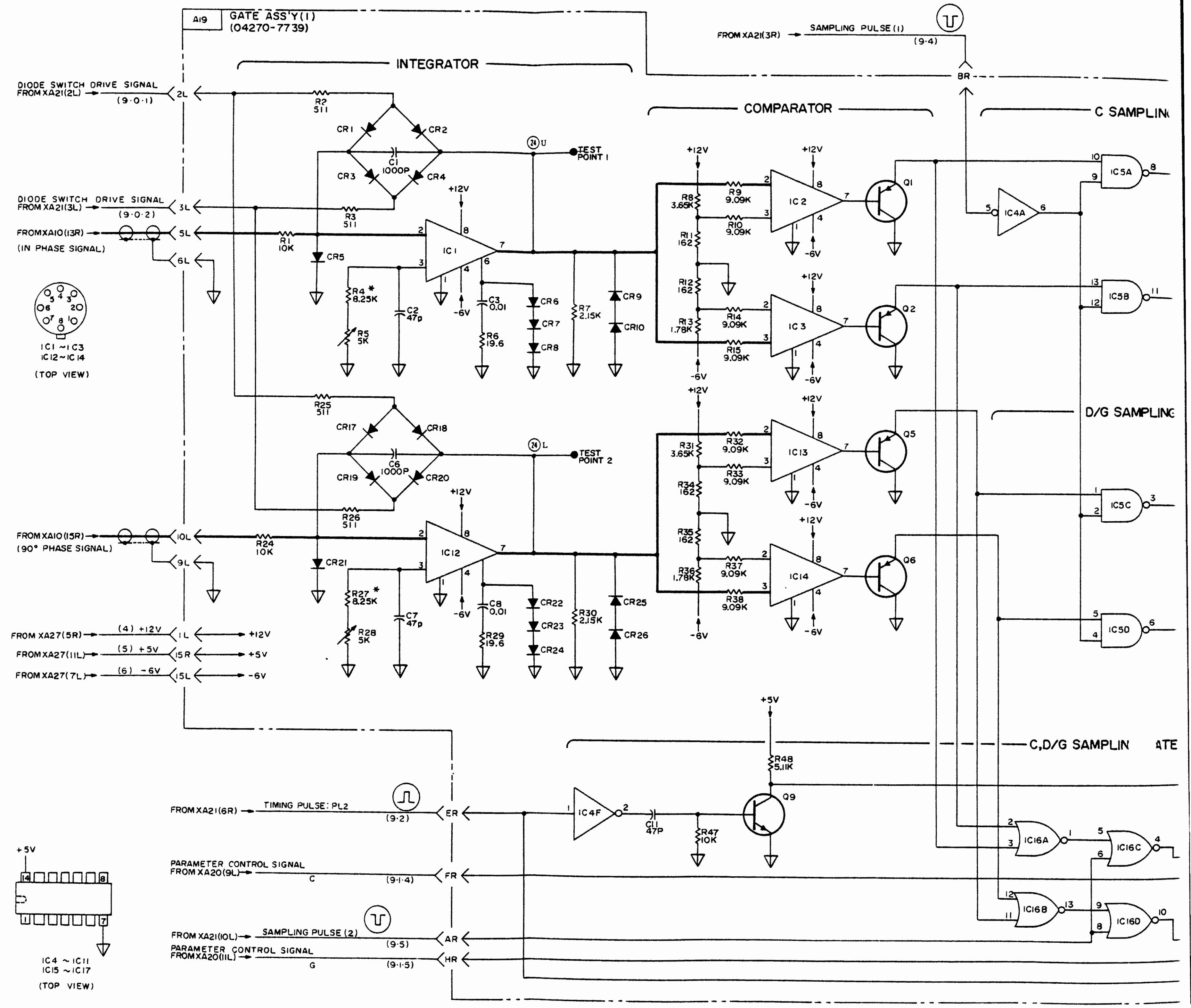
(27)


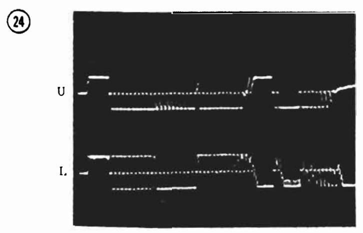
Table 8-15. Gate Ass'y (2) Waveform Measurement Conditions.

Waveform No.	1801A		1821A			
	V/Cm	Ac/ Dc	Time/ Cm	Main Trigger	Slope	Sweep Mode
25 U	.5	DC	10ms	Int(25 μ)	+	Norm
25 L	.2	DC	10ms	Int(25 μ)	+	Norm
26 L	.2	DC	10ms	Int(25 μ)	+	Norm
27 L	.2	DC	20ms	Int(25 μ)	+	Norm
28 L	.2	DC	10ms	Int(25 μ)	+	Norm

(28)



A19
GATE ASS'Y(1)
(04270-7739)
INTEGRATOR
COMPARATOR
C SAMPLIN
D/G SAMPLING
C,D/G SAMPLIN ATE
DIODE SWITCH DRIVE SIGNAL
FROM XA21(2L)
(9·0·1)
DIODE SWITCH DRIVE SIGNAL
FROM XA21(3L)
(9·0·2)
FROM XA10(13R)
(IN PHASE SIGNAL)
FROM XA10(15R)
(90° PHASE SIGNAL)
FROM XA27(5R)
(4) +12V
FROM XA27(11L)
(5) +5V
FROM XA27(7L)
(6) -6V
FROM XA21(3R)
SAMPLING PULSE (1)
(9·4)
TEST POINT 1
TEST POINT 2
IC1 ~ IC3
IC12 ~ IC14
(TOP VIEW)
FROM XA21(6R)
TIMING PULSE: PL2
(9·2)
PARAMETER CONTROL SIGNAL
FROM XA20(9L)
(9·1·4)
FROM XA21(10L)
SAMPLING PULSE (2)
(9·5)
PARAMETER CONTROL SIGNAL
FROM XA20(11L)
(9·1·5)
+5V
IC4 ~ IC11
IC15 ~ IC17
(TOP VIEW)

24


U
L

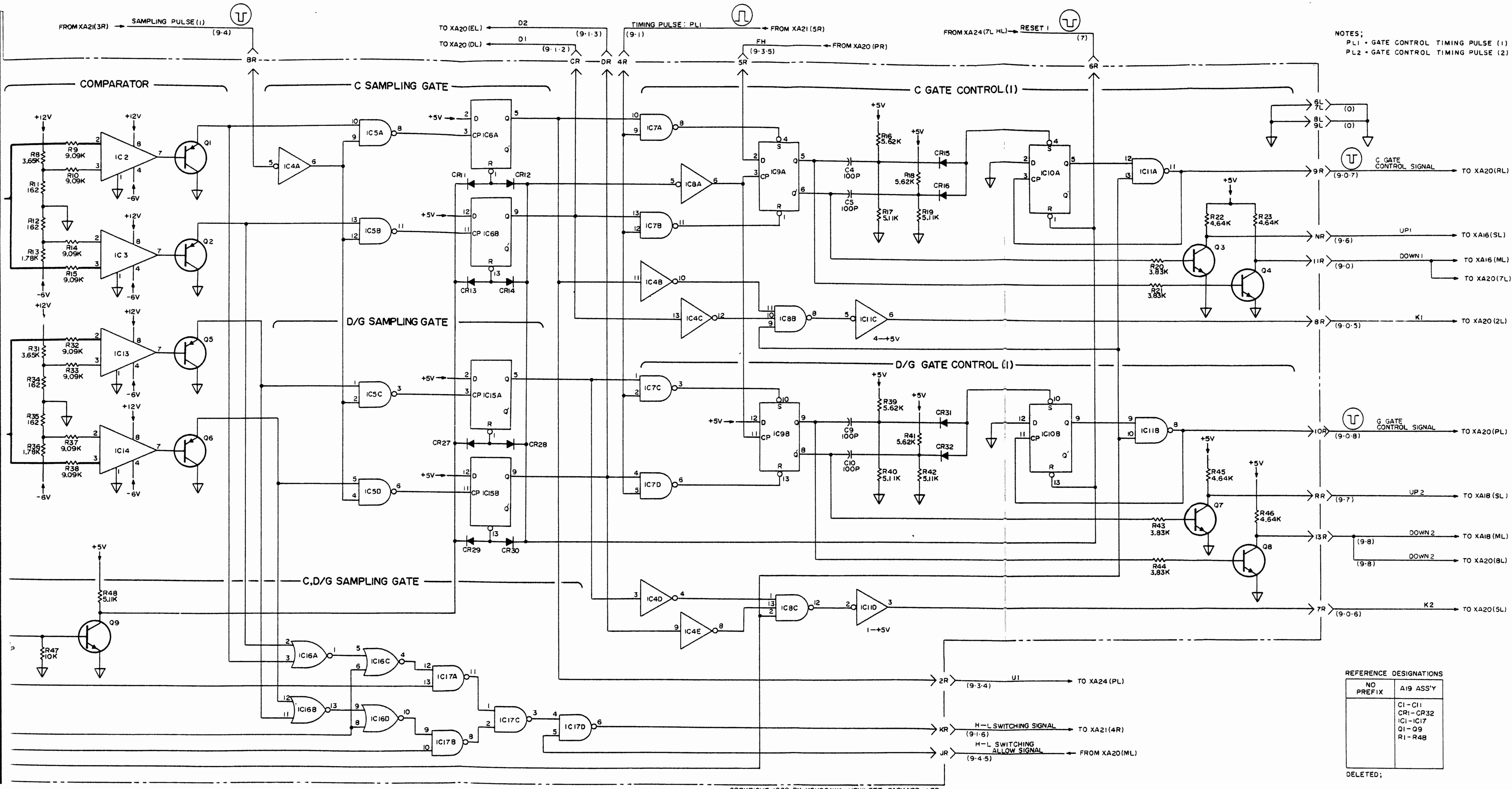


Figure 8-23. Gate Ass'y (1) A19

A20 TROUBLESHOOTING

Measure the +5Vdc at pins 1-L and A-L. Set control as shown and connect oscilloscope to RESET 1 at IC18 pin 8; should go negative while depressing and holding RESET button. Set trigger slope + and adjust the trigger level for stable sweep each time RESET button is released. Connect oscilloscope B channel input to Go at IC18 pin 9; it should go HIGH about 50 ms after RESET 1 pulse. If not, check IC 8A, the set signal and clock input to IC8A.

C Counter Gate Selector:

Set RANGE MODE control to HOLD, Select 100pF Range. Connect 100pF capacitor (HP Part No. 0160-2204) to UNKNOWN. Observe IC18B (11), IC19A (9), IC19B (12) and IC 20A (15) with oscilloscope. For about 55ms, IC18B (11) should be HIGH each time when RESET button is depressed and released, and the other should be LOW. After about 55-ms, IC8B (11) goes LOW and IC19A (9) goes HIGH. Subsequently lower flip-flop goes HIGH every time C Gate Control Signal comes to IC7B (4). Set RANGE MODE control to TRACK and depress RESET button. IC20A (15) should go HIGH and stay HIGH. If incorrect signal is noted, be sure that the set input is correct and the clock input occurs, and then check the resistor flip-flops.

D/G Counter Gato Selector:

Set RANGE MODE control to HOLD. Select 100pF Range. Connect a 100pF capacitor to UNKNOWN. Observe that IC 17B (11), IC22A (12), IC22B (9) and IC20B (11). IC17B (11) goes HIGH when RESET button is depressed and released. Subsequently lower flip-flop goes HIGH when D/G Gate Control Signal comes to IC10A (10). Set RANGE MODE control to TRACK. IC20B (11) goes HIGH and stays HIGH. If incorrect signal is discovered be sure that Set input is correct, that Clock input occurs, and then check the resistor flip-flops.

PARAMETER CONTROL:

Set RANGE MODE control to HOLD and connect 100pF capacitor to UNKNOWN.

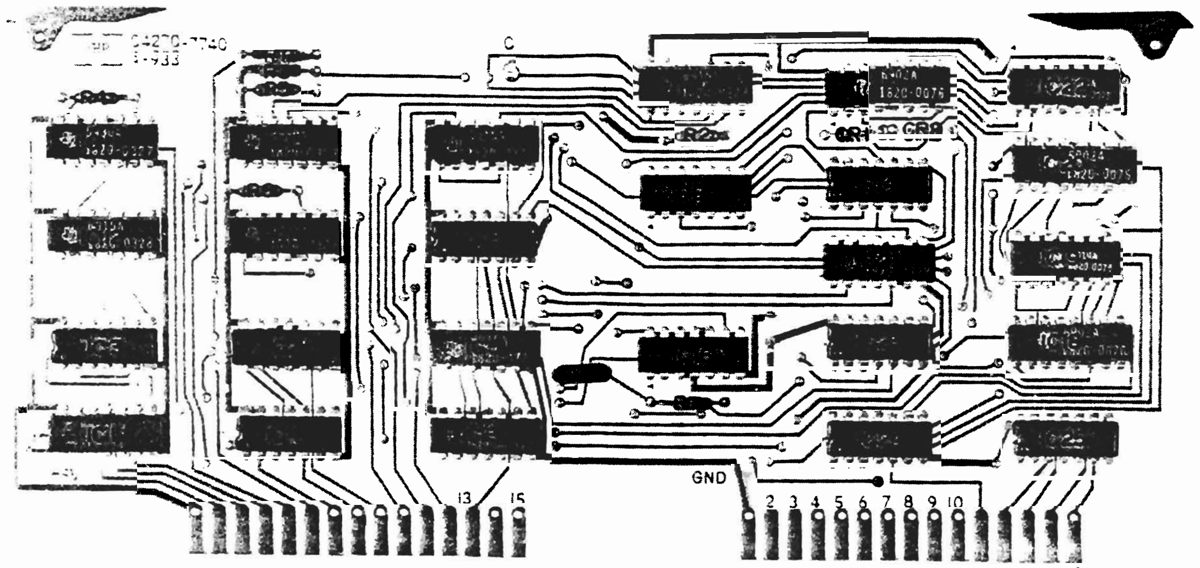
PARAMETER "C" at PIN 9-L may be observed with oscilloscope each time RESET button is depressed and released

NULL DETECTOR:

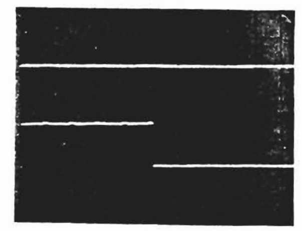
Set RANGE MODE countrol to HOLD. Connect both integrator inputs on A19 to the circuit common to produce K1 and K2 pulses. Observe IC6B (10) with oscilloscope (see figure (27)) If the negative pulse is absent, observe IC15A (10) and IC15D (13) and trace back through the logic with oscilloscope to isolate a defective gate. If the negative pulse is present, connect both integrator inputs to + 0.5Vdc through 5.1kΩ. Observe IC6B (10) with oscilloscope see figure (28)) If negative pulses are absent, trace back through the logic with oscilloscope to isolate a defective gate. If negative pulses occur, connect both integrator inputs on A19 to the phase detector outputs. Unsolder a wire from pin N-L on XA20. Connect 100pF capacitor to UNKNOWN. Observe IC6B (8) and IC6B (9) at the same time. If negative pulses do not occur at the same time, check IC 16A and IC16B.

SEE INSIDE

Figure 8-23
GATE ASS'Y (1) A19



Gate Ass'y (2) A20
(04270-7740)

(25)


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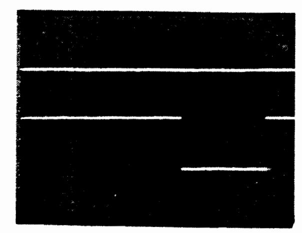
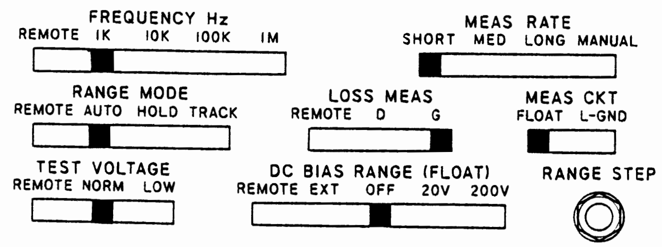


Set Controls for waveform and DC bias checks as follows:



All waveforms are taken with HP 180A Oscilloscope, HP 1801A Vertical Plug-in, HP 1821A Time Base Plug-in, and HP 10004A 10 : 1 Divider Probe.

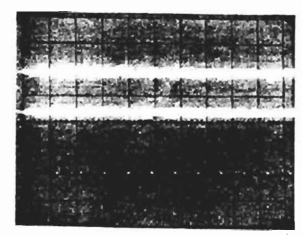
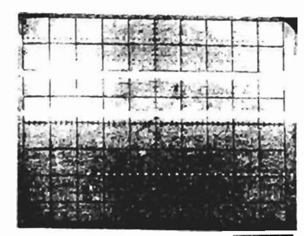
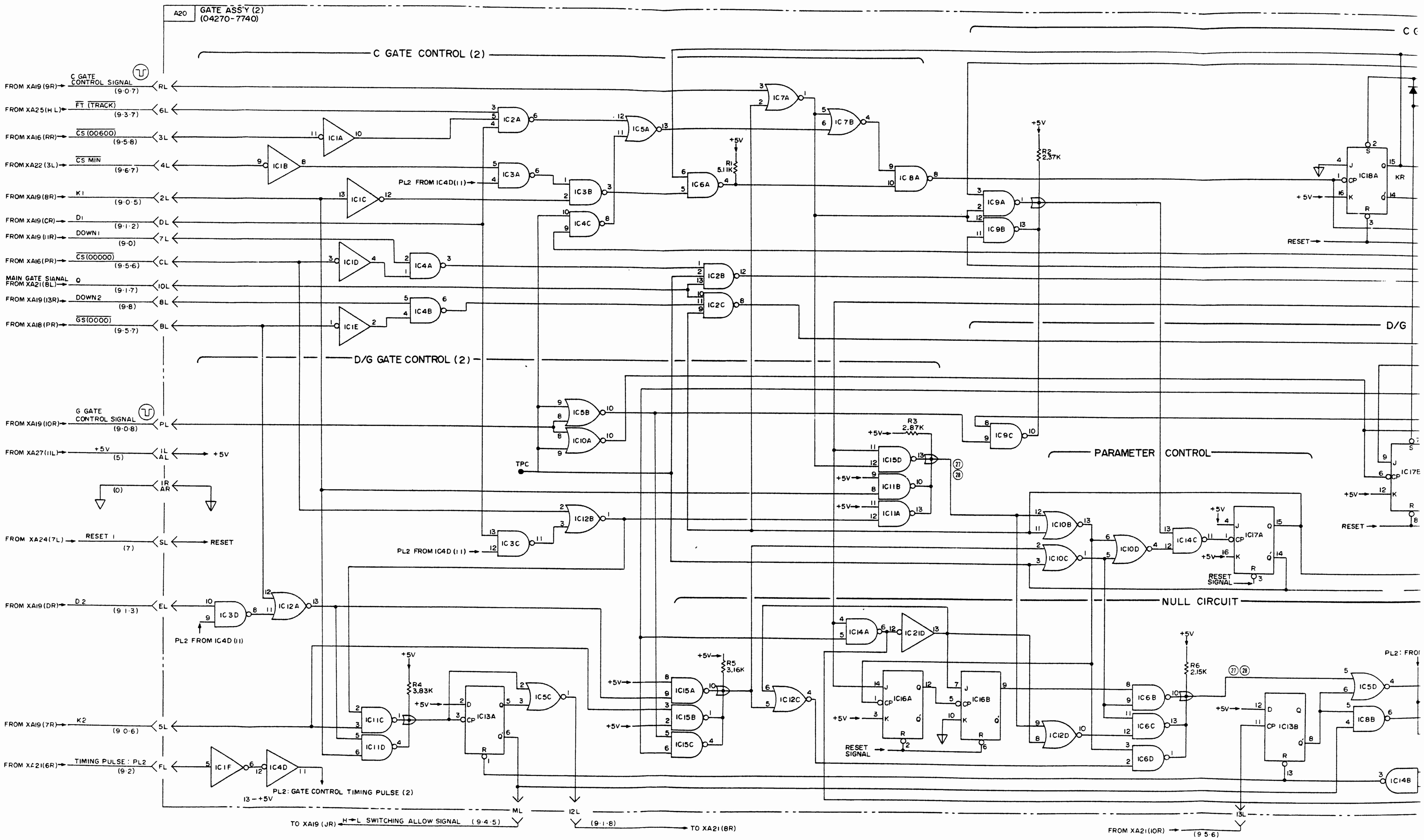
(27)


Table 8-15. Gate Ass'y (2) Waveform Measurement Conditions.

Waveform No.	1801A		1821A			
	V/Cm	Ac/Dc	Time/Cm	Main Trigger	Slope	Sweep Mode
25 U	.5	DC	10ms	Int(25 μ)	+	Norm
25 L	.2	DC	10ms	Int(25 μ)	+	Norm
26 L	.2	DC	10ms	Int(25 μ)	+	Norm
27 L	.2	DC	20ms	Int(25 μ)	+	Norm
28 L	.2	DC	10ms	Int(25 μ)	+	Norm

(28)



A20
GATE ASS'Y (2)
(04270-7740)
C GATE CONTROL (2)
D/G GATE CONTROL (2)
PARAMETER CONTROL
NULL CIRCUIT
FROM XA19 (9R)
C GATE CONTROL SIGNAL
(9·0·7)
FROM XA25(H L)
FT (TRACK)
(9·3·7)
FROM XA16 (RR)
CS (00600)
(9·5·8)
FROM XA22 (3L)
CS MIN
(9·6·7)
FROM XA19 (8R)
K1
(9·0·5)
FROM XA19 (CR)
D1
(9·1·2)
FROM XA19 (11R)
DOWN1
(9·0)
FROM XA16 (PR)
CS (00000)
(9·5·6)
MAIN GATE SIANAL
FROM XA21(8L)
Q
(9·1·7)
FROM XA19 (13R)
DOWN2
(9·8)
FROM XA18 (PR)
GS(0000)
(9·5·7)
FROM XA19 (10R)
G GATE CONTROL SIGNAL
(9·0·8)
FROM XA27(11L)
+5V
(5)
(0)
FROM XA24(7L)
RESET 1
(7)
RESET
FROM XA19 (DR)
D2
(9·1·3)
PL2 FROM IC4D (11)
FROM XA19 (7R)
K2
(9·0·6)
FROM XA21(6R)
TIMING PULSE : PL2
(9·2)
PL2: GATE CONTROL TIMING PULSE (2)
13 — +5V
TO XA19 (JR)
H→L SWITCHING ALLOW SIGNAL (9·4·5)
ML
12L
(9·1·8)
TO XA21(8R)
13L
FROM XA21(10R)
(9·5·6)
TPC
R1 5.11K
R2 2.37K
R3 2.87K
R4 3.83K
R5 3.16K
R6 2.15K
RESET SIGNAL
RESET
D/G
KR
PL2: FRO

A20 TROUBLESHOOTING

Measure the +5Vdc at pins 1-L and A-L. Set control as shown and connect oscilloscope to RESET 1 at IC18 pin 8; should go negative while depressing and holding RESET button. Set trigger slope + and adjust the trigger level for stable sweep each time RESET button is released. Connect oscilloscope B channel input to Go at IC18 pin 9; it should go HIGH about 50 ms after RESET 1 pulse. If not, check IC 8A, the set signal and clock input to IC8A.

C Counter Gate Selector:

Set RANGE MODE control to HOLD, Select 100pF Range. Connect 100pF capacitor (HP Part No. 0160-2204) to UNKNOWN. Observe IC18B (11), IC19A (9), IC19B (12) and IC 20A (15) with oscilloscope. For about 55ms, IC18B (11) should be HIGH each time when RESET button is depressed and released, and the other should be LOW. After about 55-ms, IC8B (11) goes LOW and IC19A (9) goes HIGH. Subsequently lower flip-flop goes HIGH every time C Gate Control Signal comes to IC7B (4). Set RANGE MODE control to TRACK and depress RESET button. IC20A (15) should go HIGH and stay HIGH. If incorrect signal is noted, be sure that the set input is correct and the clock input occurs, and then check the resistor flip-flops.

D/G Counter Gato Selector:

Set RANGE MODE control to HOLD. Select 100pF Range. Connect a 100pF capacitor to UNKNOWN. Observe that IC 17B (11), IC22A (12), IC22B (9) and IC20B (11). IC17B (11) goes HIGH when RESET button is depressed and released. Subsequently lower flip-flop goes HIGH when D/G Gate Control Signal comes to IC10A (10). Set RANGE MODE control to TRACK. IC20B (11) goes HIGH and stays HIGH. If incorrect signal is discovered be sure that Set input is correct, that Clock input occurs, and then check the resistor flip-flops.

PARAMETER CONTROL:

Set RANGE MODE control to HOLD and connect 100pF capacitor to UNKNOWN.

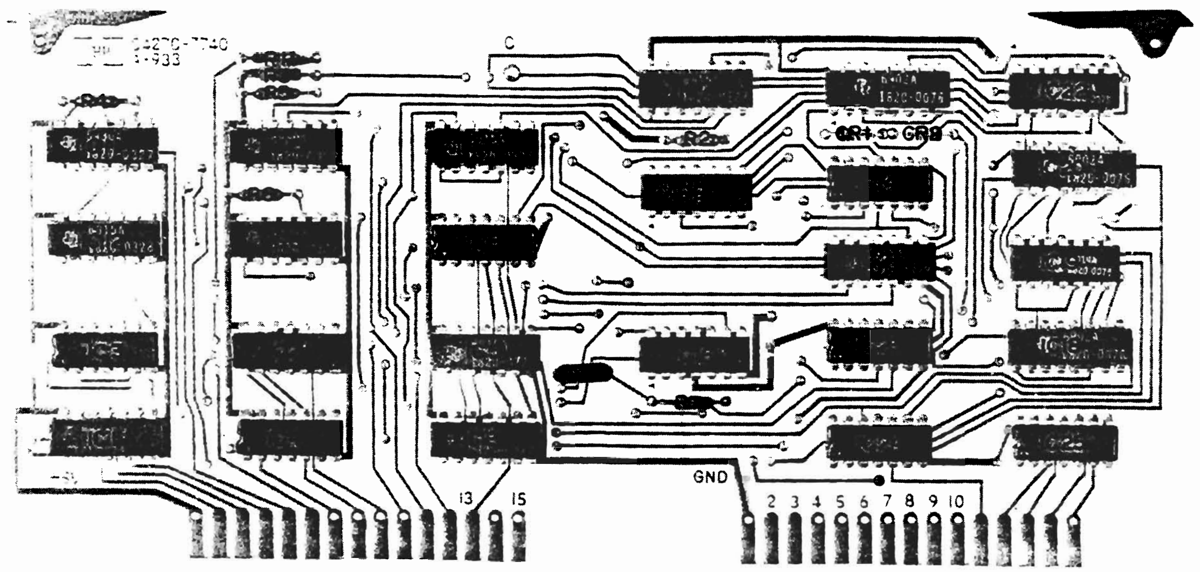
PARAMETER "C" at PIN 9-L may be observed with oscilloscope each time RESET button is depressed and released

NULL DETECTOR:

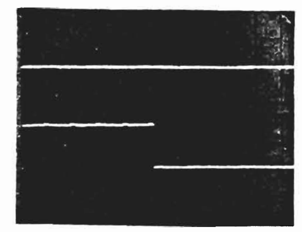
Set RANGE MODE control to HOLD. Connect both integrator inputs on A19 to the circuit common to produce K1 and K2 pulses. Observe IC6B (10) with oscilloscope (see figure (27)) If the negative pulse is absent, observe IC15A (10) and IC15D (13) and trace back through the logic with oscilloscope to isolate a defective gate. If the negative pulse is present, connect both integrator inputs to +0.5Vdc through 5.1kΩ. Observe IC6B (10) with oscilloscope see figure (28)) If negative pulses are absent, trace back through the logic with oscilloscope to isolate a defective gate. If negative pulses occur, connect both integrator inputs on A19 to the phase detector outputs. Unsolder a wire from pin N-L on XA20. Connect 100pF capacitor to UNKNOWN. Observe IC6B (8) and IC6B (9) at the same time. If negative pulses do not occur at the same time, check IC 16A and IC16B.

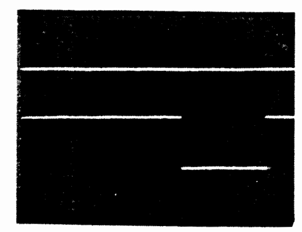
SEE INSIDE

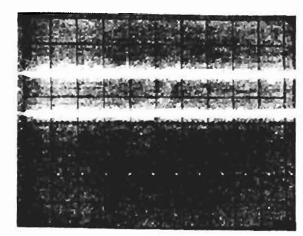
Figure 8-23
GATE ASS'Y (1) A19

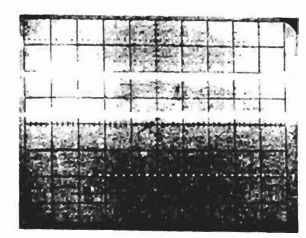


Gate Ass'y (2) A20
(04270-7740)

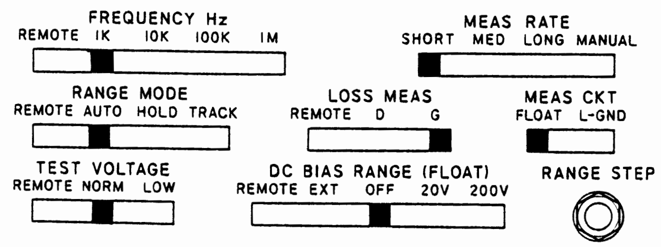
25


26


27


28


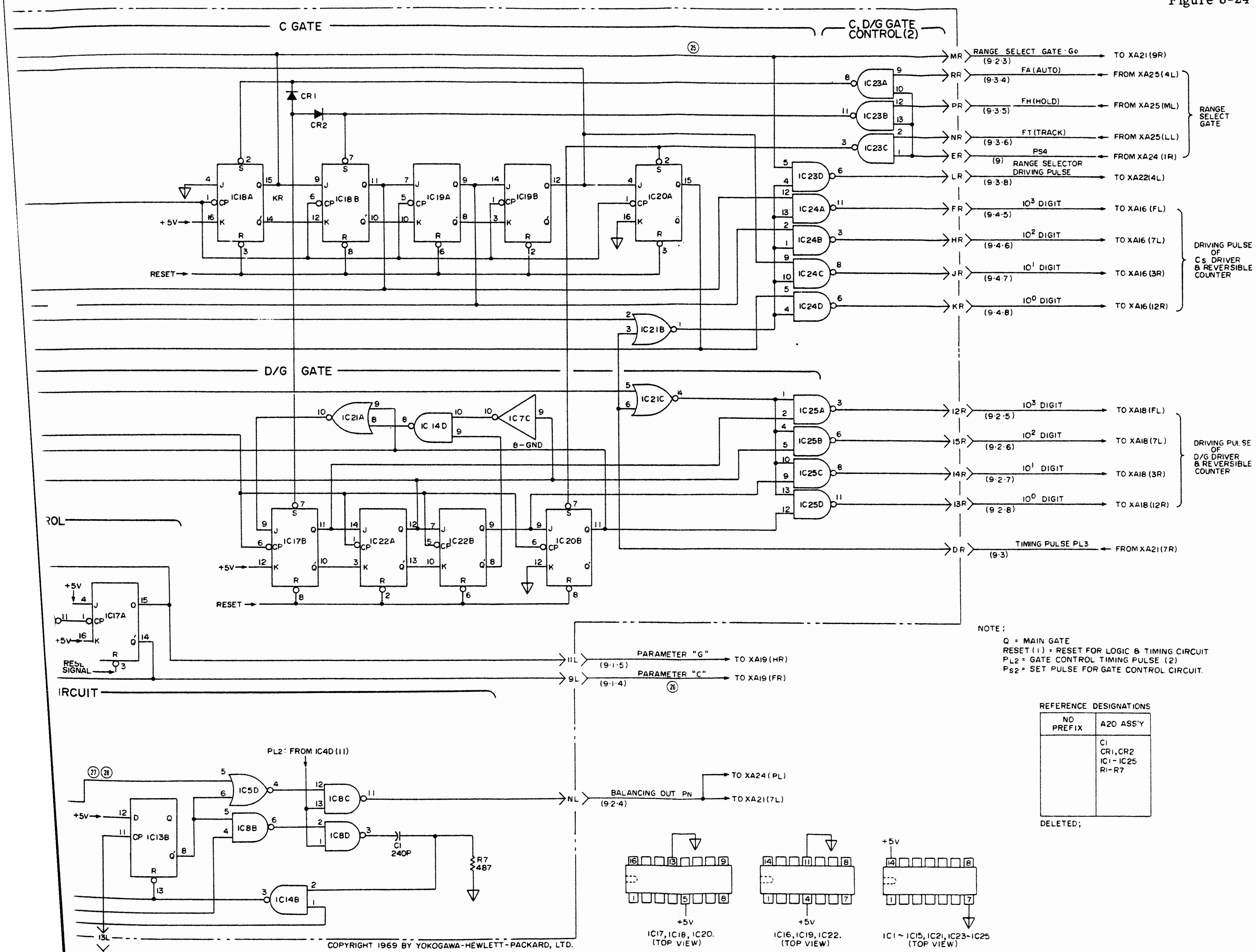
Set Controls for waveform and DC bias checks as follows:



All waveforms are taken with HP 180A Oscilloscope, HP 1801A Vertical Plug-in, HP 1821A Time Base Plug-in, and HP 10004A 10 : 1 Divider Probe.

Table 8-15. Gate Ass'y (2) Waveform Measurement Conditions.

Waveform No.	1801A		1821A			
	V/Cm	Ac/Dc	Time/Cm	Main Trigger	Slope	Sweep Mode
25 U	.5	DC	10ms	Int(25 μ)	+	Norm
25 L	.2	DC	10ms	Int(25 μ)	+	Norm
26 L	.2	DC	10ms	Int(25 μ)	+	Norm
27 L	.2	DC	20ms	Int(25 μ)	+	Norm
28 L	.2	DC	10ms	Int(25 μ)	+	Norm

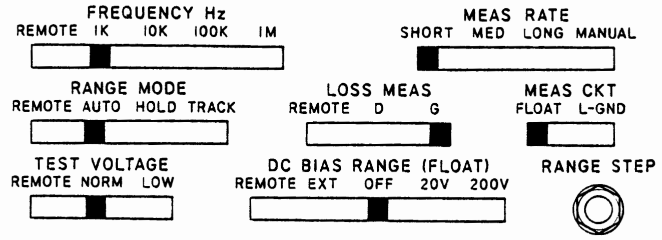

C GATE
C, D/G GATE CONTROL (2)
D/G GATE
IC18A IC18B IC19A IC19B IC20A
IC23A IC23B IC23C IC23D
IC24A IC24B IC24C IC24D
IC21A IC21B IC21C IC14D IC7C
IC25A IC25B IC25C IC25D
IC17A IC17B IC22A IC22B IC20B
IC13B IC5D IC8B IC8C IC8D IC14B
CR1 CR2
RESET
+5V
8-GND
MR RANGE SELECT GATE·Go (9·2·3) TO XA21(9R)
RR FA (AUTO) (9·3·4) FROM XA25(4L)
PR FH (HOLD) (9·3·5) FROM XA25(ML)
NR FT (TRACK) (9·3·6) FROM XA25(LL)
RANGE SELECT GATE
ER PS4 (9) FROM XA24 (1R)
LR RANGE SELECTOR DRIVING PULSE (9·3·8) TO XA22(4L)
FR 10³ DIGIT (9·4·5) TO XA16 (FL)
HR 10² DIGIT (9·4·6) TO XA16 (7L)
JR 10¹ DIGIT (9·4·7) TO XA16 (3R)
KR 10⁰ DIGIT (9·4·8) TO XA16 (12R)
DRIVING PULSE OF Cs DRIVER & REVERSIBLE COUNTER
12R 10³ DIGIT (9·2·5) TO XA18 (FL)
15R 10² DIGIT (9·2·6) TO XA18 (7L)
14R 10¹ DIGIT (9·2·7) TO XA18 (3R)
13R 10⁰ DIGIT (9·2·8) TO XA18 (12R)
DRIVING PULSE OF D/G DRIVER & REVERSIBLE COUNTER
DR TIMING PULSE PL3 (9·3) FROM XA21(7R)
11L PARAMETER "G" (9·1·5) TO XA19 (HR)
9L PARAMETER "C" (9·1·4) TO XA19 (FR)
RESET SIGNAL
IRCUIT
PL2: FROM IC4D (11)
NL BALANCING OUT Pn (9·2·4) TO XA24 (PL) TO XA21 (7L)
C1 240P
R7 487
13L
NOTE;
Q = MAIN GATE
RESET (1) = RESET FOR LOGIC & TIMING CIRCUIT
PL2 = GATE CONTROL TIMING PULSE (2)
PS2 = SET PULSE FOR GATE CONTROL CIRCUIT.
REFERENCE DESIGNATIONS
NO PREFIX | A20 ASS'Y
C1 CR1, CR2 IC1 – IC25 R1 – R7
DELETED;
IC17, IC18, IC20. (TOP VIEW)
IC16, IC19, IC22. (TOP VIEW)
IC1 ~ IC15, IC21, IC23 ~ IC25 (TOP VIEW)

A21 TROUBLESHOOTING

Check +5Vdc at PIN 14-R and +6Vdc at Test Point 1. Check SYNCHRONIZING SIGNAL a PIN 13-L which should be a 3.5Vp-p rectangular signal at the measurment frequency. When RESET button is depressed. MAIN GATE SIGNAL Q (IC1A ⑤) should go HIGH, the initial set signal should go HIGH at pin 11-R and a pulse train of SAMPLING PULSE 1 (width 50μs) may be observed at pin 3-R with the oscilloscope. Refer to waveforms for the initial set pulse and the SAMPLING PULSE 1. If both of them do not occur, check the oneshot or the pulsed oscillator. If only the initial set pulse is absent, check IC17. If only the SAMPLING PULSE 1 is absent, check Gated Output from IC15 which is shown in waveform No. ㉜. Then check IC5B ⑥, IC5A ⑧ and IC8A ⑤. If an incorrect signal is discovered, check the input signal to the IC, then trace back through the logic to isolate a defective gate.

Signals TIMING PULSE PL1, TIMING PULSE PL2 and TIMING PULSE PL3 may be observed with an oscilloscope. Sampling Pulse 2 may also be observed with an oscilloscope. These pulses are negative and have a width of 3μs. If Sampling Pulse 2 does not occur, check IC17B, IC13C, IC 14D, IC16C or IC16D. Diode Switch Drive signal may be observed at pin 2-L and pin 3-L; they are 180° out of phase. Unsolder a wire from XA21 pin 7-L and observe the AUTOMATIC RESET SIGNAL; a negative pulse of 10μs width should occur about every 1.5 sec. If this pulse is not generated, check the Time Limit Pulse Generator circuit.

Set Controls for waveform and DC bias checks as follows:



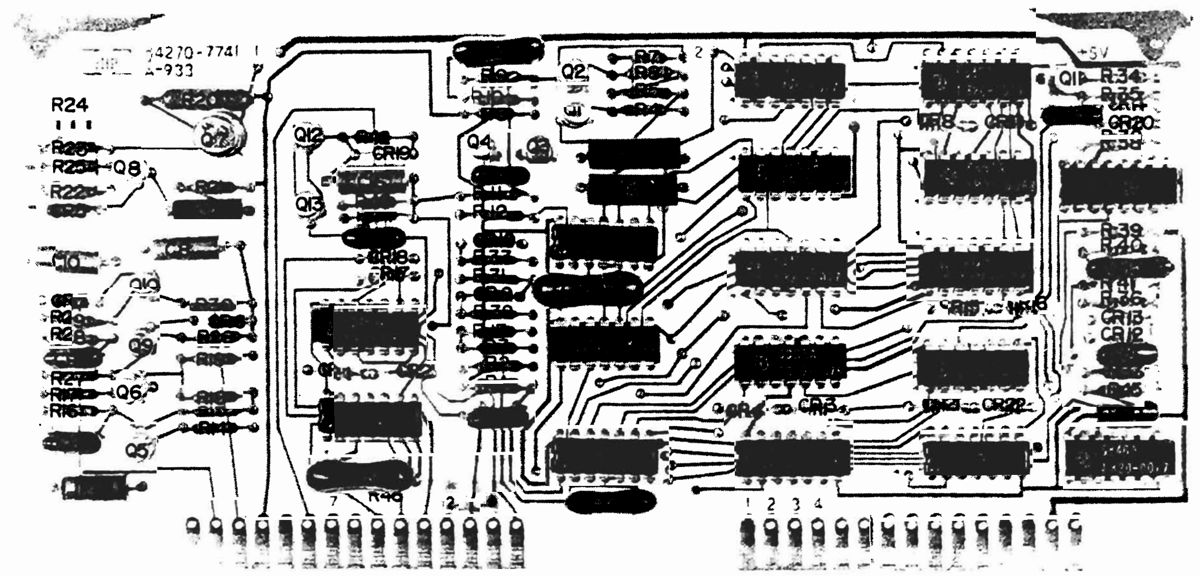
All waveforms are taken with HP 181A Oscilloscope, HP 1801A Vertical Plug-in, HP 1821A Time Base Plug-in, and HP 10004A 10 : 1 Divider Probe.

Table 8-16. Timing Circuit Waveform Measurement Conditions.

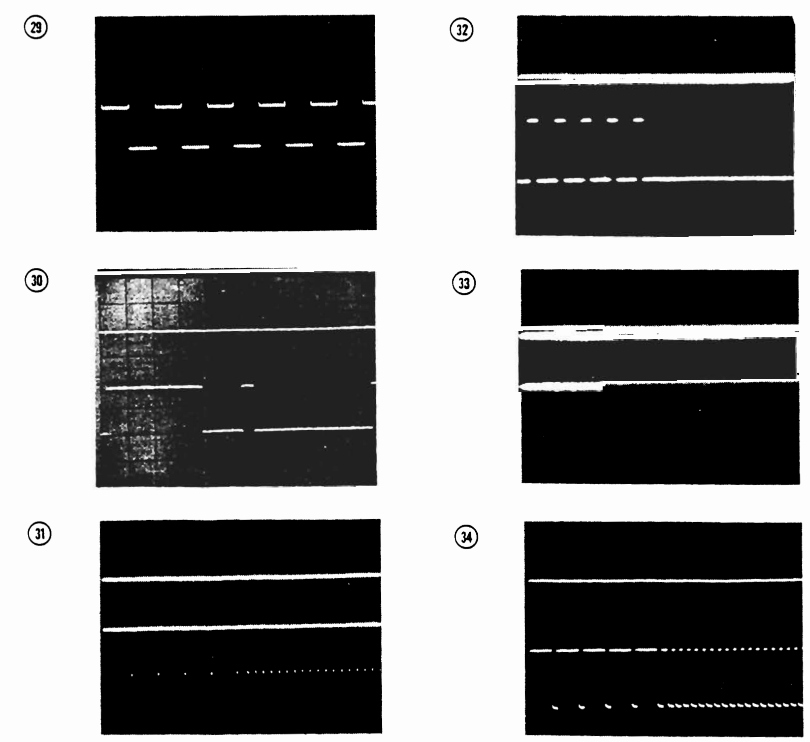
Weveform No.	1801A		1821A			
	V/Cm	Ac/Dc	Time/Cm	Main Trigger	Slope	Sweep Mode
29	.2	DC	.5ms	Int	+	Auto
30 U	.2	DC	2ms	Int(30μ)	+	Norm
30 L	.2	DC	2ms	Int(30μ)	+	Norm
31 L*	.2	DC	10ms	Int(30μ)	+	Norm
32 L*	.2	DC	10ms	Int(30μ)	+	Norm
33 L*	.2	DC	10ms	Int(30μ)	+	Norm
34 L*	.5	DC	10ms	Int(30μ)	+	Norm

SEE INSIDE

Figure 8-24
GATE ASS'Y (2) A20



Timing Circuit Ass'y A21
(04270-7741)



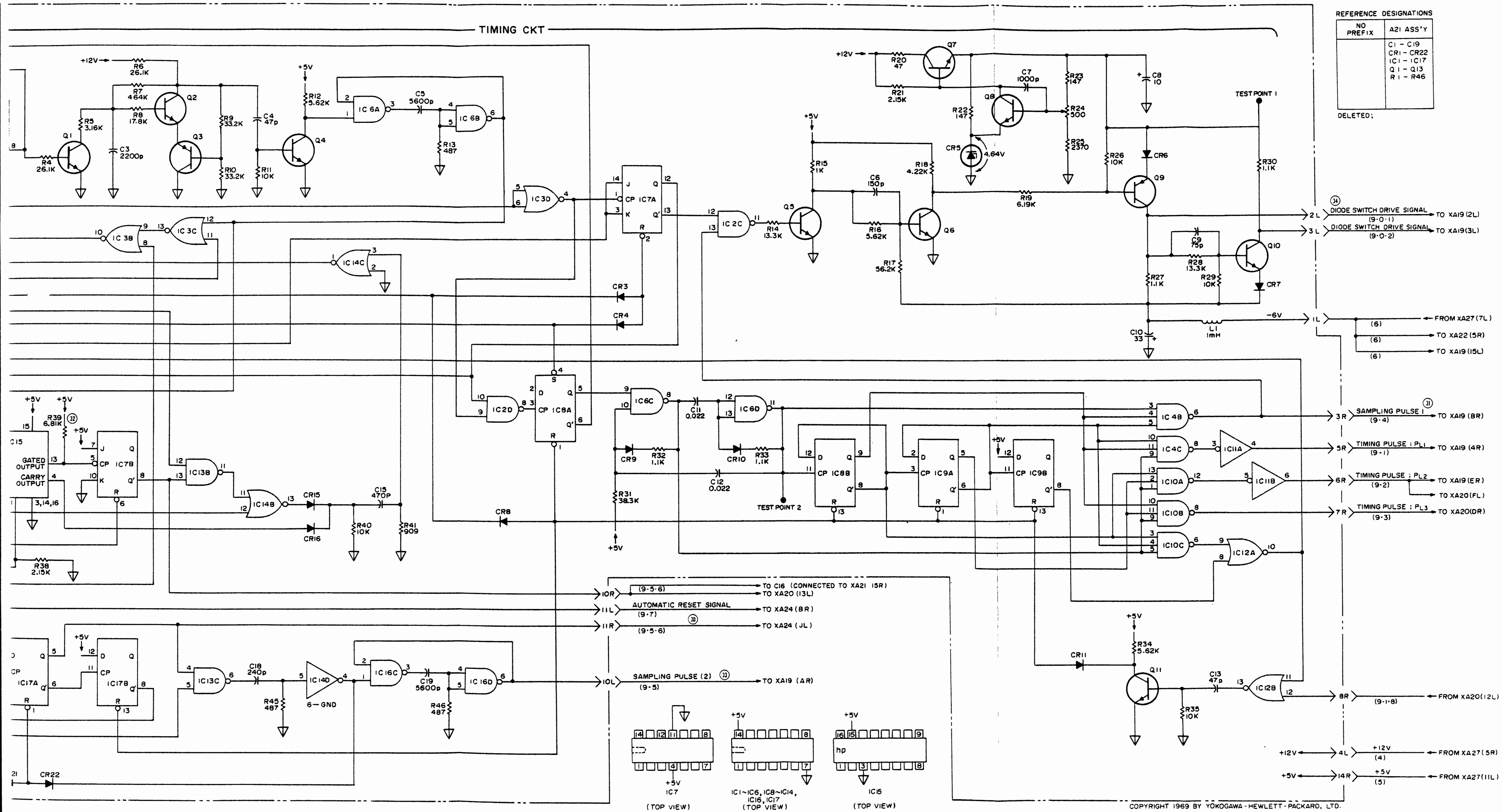


Figure 8-25. Timing Circuit Ass'y A21

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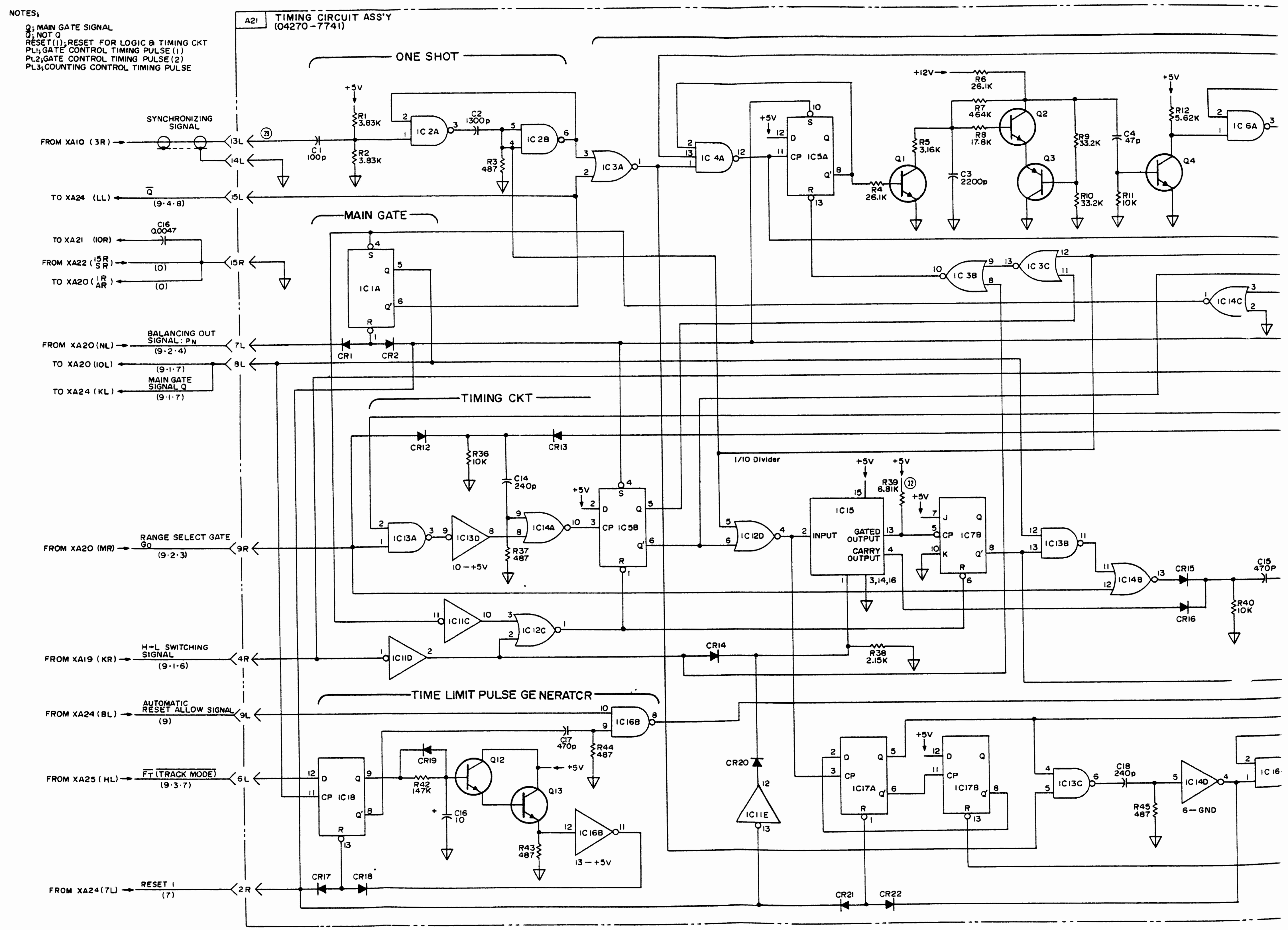

NOTES;
Q; MAIN GATE SIGNAL
Q̄; NOT Q
RESET(1); RESET FOR LOGIC & TIMING CKT
PL1; GATE CONTROL TIMING PULSE (1)
PL2; GATE CONTROL TIMING PULSE (2)
PL3; COUNTING CONTROL TIMING PULSE
A21 TIMING CIRCUIT ASS'Y (04270-7741)
ONE SHOT
MAIN GATE
TIMING CKT
TIME LIMIT PULSE GENERATOR
1/10 Divider
SYNCHRONIZING SIGNAL
FROM XA10 (3R)
TO XA24 (LL) (9·4·8)
TO XA21 (10R)
FROM XA22 (15R SR) (0)
TO XA20 (1R AR) (0)
FROM XA20 (NL) BALANCING OUT SIGNAL: PN (9·2·4)
TO XA20 (10L) (9·1·7)
TO XA24 (KL) MAIN GATE SIGNAL Q (9·1·7)
FROM XA20 (MR) RANGE SELECT GATE G0 (9·2·3)
FROM XA19 (KR) H-L SWITCHING SIGNAL (9·1·6)
FROM XA24 (8L) AUTOMATIC RESET ALLOW SIGNAL (9)
FROM XA25 (HL) FT (TRACK MODE) (9·3·7)
FROM XA24 (7L) RESET 1 (7)
13L 14L 15L 15R 7L 8L 9R 4R 9L 6L 2R
C1 100p
R1 3.83K
R2 3.83K
C2 1300p
R3 487
IC 2A
IC 2B
IC 3A
IC 4A
IC 5A
R4 26.1K
R5 3.16K
C3 2200p
R6 26.1K
R7 464K
R8 17.8K
R9 33.2K
R10 33.2K
R11 10K
C4 47p
R12 5.62K
Q1 Q2 Q3 Q4
IC 6A
C16 0.0047
IC 1A
CR1 CR2
IC 3B
IC 3C
IC 14C
CR12 CR13
R36 10K
C14 240p
R37 487
IC 13A
IC 13D
10 — +5V
IC 14A
IC 5B
IC 12D
IC 15
INPUT
GATED OUTPUT
CARRY OUTPUT
3,14,16
R39 6.81K
IC 7B
IC 13B
IC 14B
CR15
C15 470P
R40 10K
CR16
IC 11C
IC 12C
IC 11D
CR14
R38 2.15K
IC 16B
C17 470p
R44 487
CR19
R42 147K
Q12
Q13
C16 10
IC 18
R43 487
IC 16B
13 — +5V
CR17 CR18
CR20
IC 11E
IC 17A
IC 17B
CR21 CR22
IC 13C
C18 240p
R45 487
IC 14D
6 — GND
IC 16
+5V
+12V

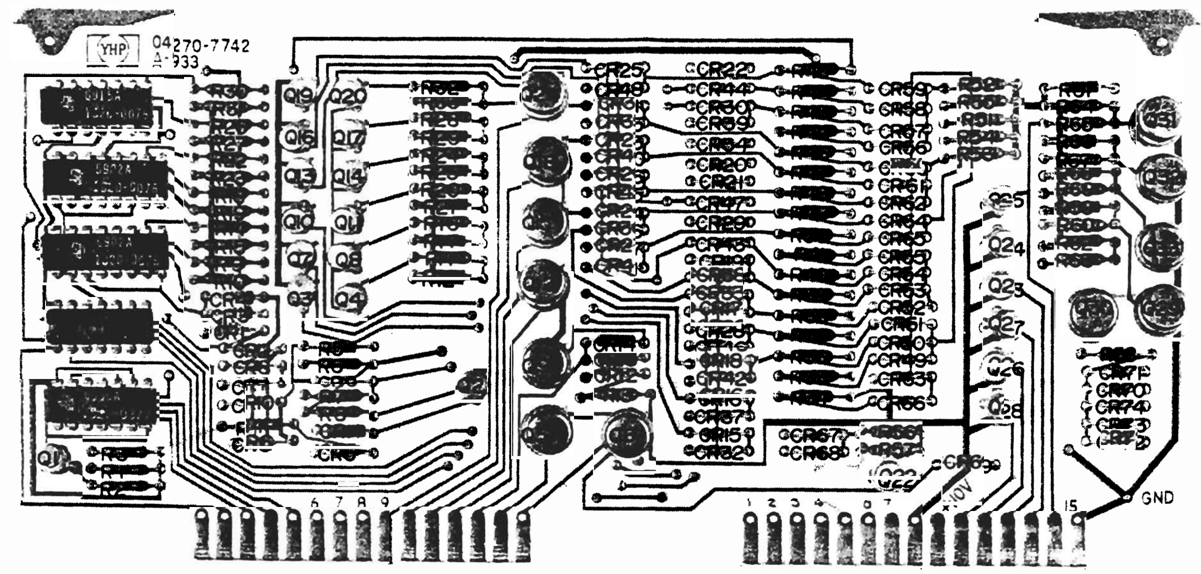
A22 TROUBLESHOOTING

Check the +10Vdc at pin 8-R, the +5Vdc at pin 1-L and the -6Vdc at pin 5-R. Turn the 4270A LINE off, then turn on. Set Range Mode control to HOLD. Check IC3B (11) which should be HIGH. If not, check Ps1 and IC3B. If it is HIGH depress RANGE STEP button and observe the unit and decimal point display on the front panel. If the range step operation is incorrect, check the Range Selector Flip Flop and transistor and diode corresponding to the incorrect range. Verify that CsMIN at pin 3-L is LOW on 100pF for 1kHz Range, on 10pF for all other frequency ranges and for all frequencies on 1000pF range of L-GND MEAS CKT. Use dc voltmeter to check OUT OF RANGE at pin J-L; it should go to about +100Vdc for 1kHz on 10pF Range, for 10kHz on 1μF range, for 100kHz on 1μF range and 100nF ranges, and for 1MHz on 1μF range 100nF and 10nF ranges. Check (1μF +1000pF · 1MHz) at pin F-R which should go LOW for all frequencies on 1μF Range and for 1MHz on 1000pF Range.

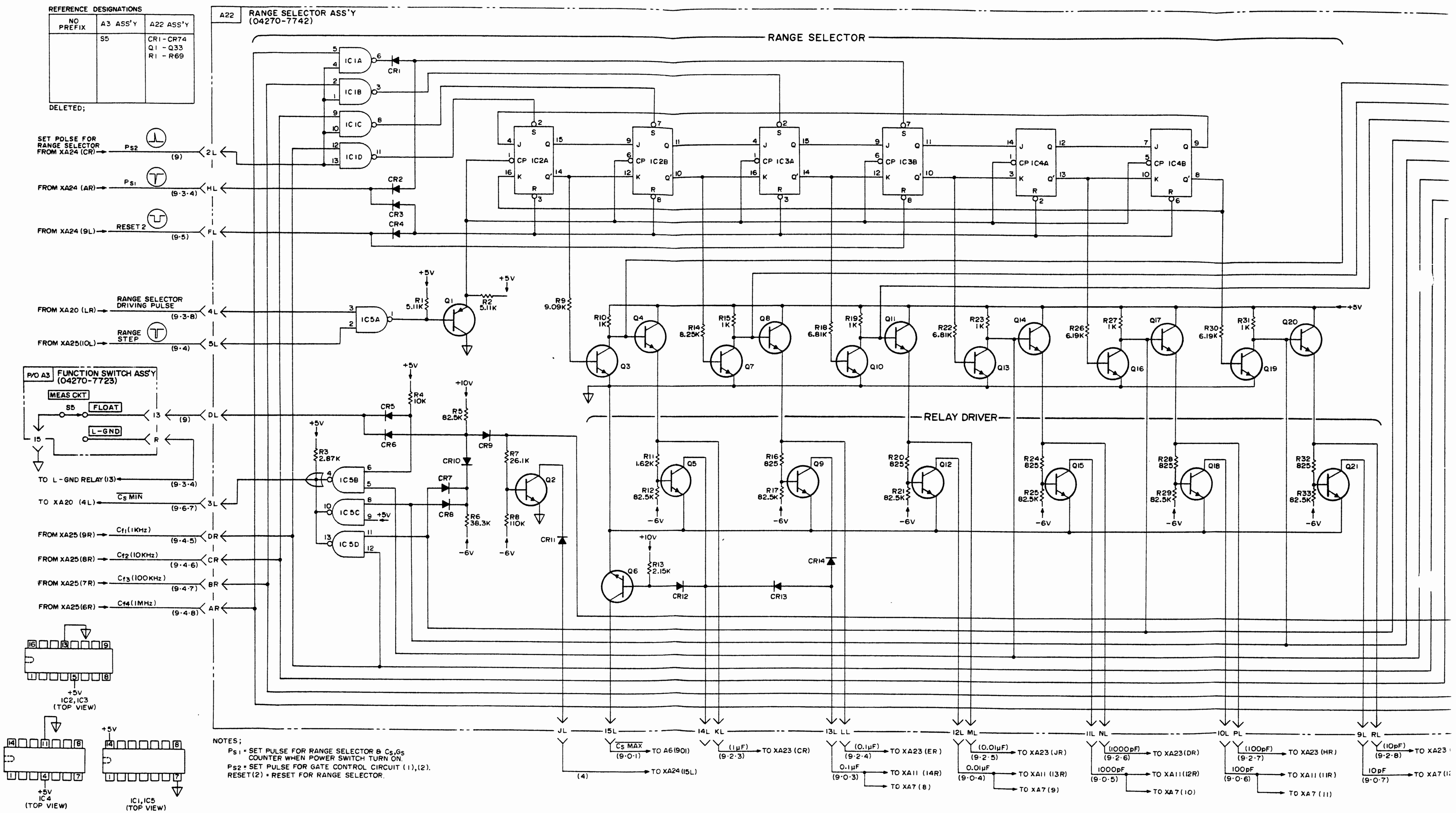
SEE INSIDE

Figure 8-25

TIMING CIRCUIT ASS'Y A21



Range Selector Ass'y A22
(04270-7742)


REFERENCE DESIGNATIONS
NO PREFIX | A3 ASS'Y | A22 ASS'Y
S5 | CR1-CR74 Q1-Q33 R1-R69
DELETED;
A22 RANGE SELECTOR ASS'Y (04270-7742)
RANGE SELECTOR
RELAY DRIVER
SET POLSE FOR RANGE SELECTOR FROM XA24 (CR)
FROM XA24 (AR)
FROM XA24 (9L)
RESET 2
FROM XA20 (LR)
RANGE SELECTOR DRIVING PULSE
FROM XA25(10L)
RANGE STEP
P/O A3 FUNCTION SWITCH ASS'Y (04270-7723)
MEAS CKT
FLOAT
L-GND
TO L-GND RELAY (13)
TO XA20 (4L)
FROM XA25(9R)
FROM XA25(8R)
FROM XA25(7R)
FROM XA25(6R)
IC2, IC3 (TOP VIEW)
IC4 (TOP VIEW)
IC1, IC5 (TOP VIEW)
NOTES;
Ps1 = SET PULSE FOR RANGE SELECTOR & Cs, Gs COUNTER WHEN POWER SWITCH TURN ON.
Ps2 = SET PULSE FOR GATE CONTROL CIRCUIT (1), (2).
RESET(2) = RESET FOR RANGE SELECTOR.
TO A6(901)
TO XA24 (15L)
TO XA23 (CR)
TO XA23 (ER)
TO XA11 (14R)
TO XA7 (8)
TO XA23 (JR)
TO XA11 (13R)
TO XA7 (9)
TO XA23 (DR)
TO XA11 (12R)
TO XA7 (10)
TO XA23 (HR)
TO XA11 (11R)
TO XA7 (11)

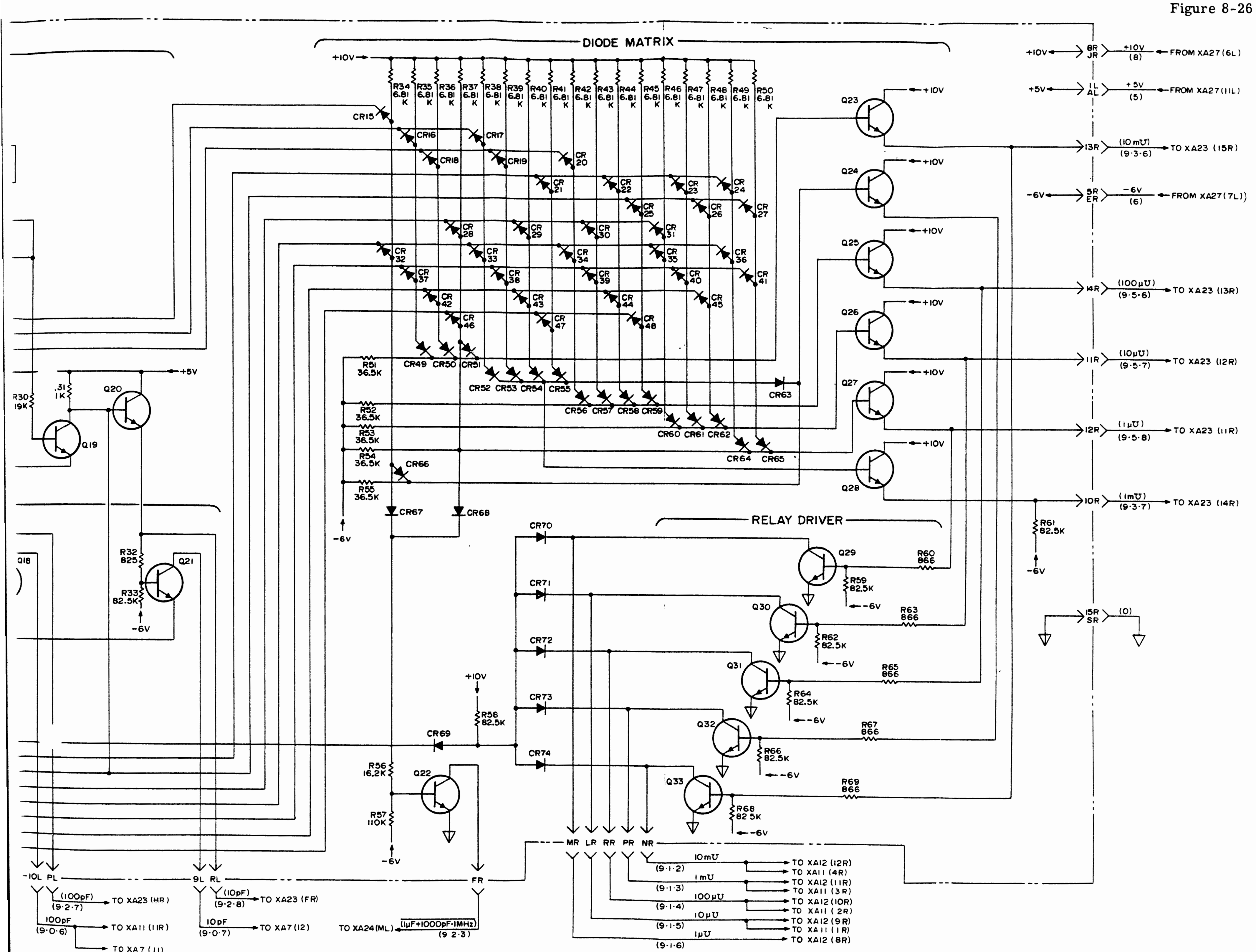


Figure 8-26. Range Selector Ass'y A22

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A23 TROUBLESHOOTING

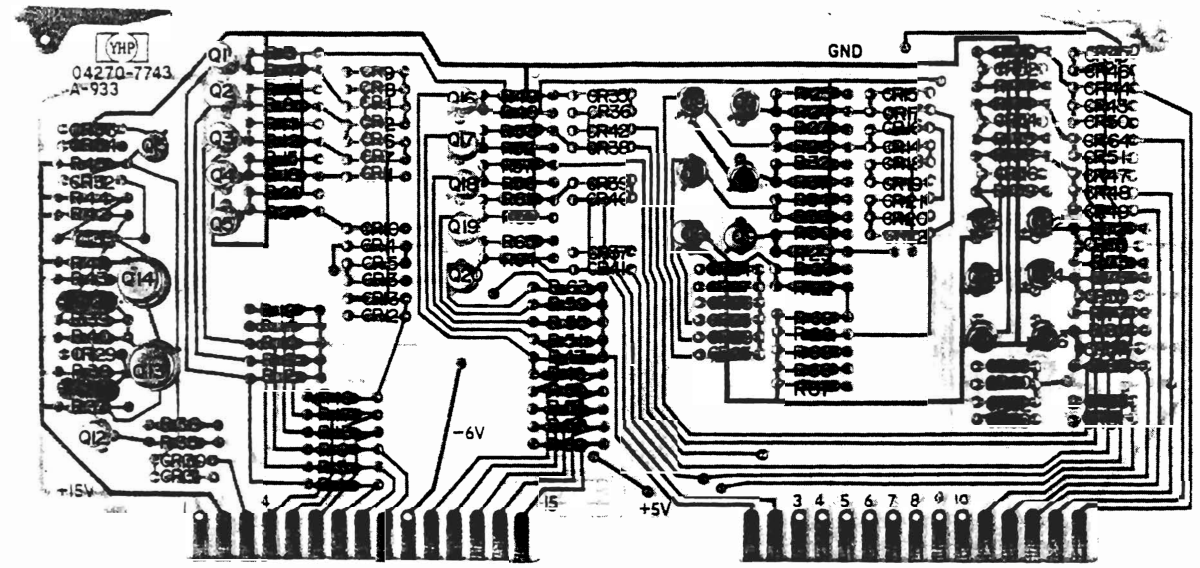
Check the +15Vdc at pin 2-L, the +5Vdc at pin 1-R and the -6Vdc at pin 10-L. Set control as shown. Select 1000pF capacitance range. The voltage at pin D-R and at pin 12-R should be 4.3Vdc, and the other voltage coming from A22 should be -0.5Vdc. The base voltage of Q9, Q11, Q21 and Q25 should be about +0.6Vdc and the base voltage of the other transistor is about -1.9V. An oscilloscope can be used to check the Transfer Multivibrator.

A2 TROUBLESHOOTING

Check +170Vdc at pin 1-L. DS1 thre DS4, DS5 thre DS7, DS 14 thru DS17 and DS18 thru DS20 are each driven through one resistor. Check the resistor if all in the group do not come on. If an incorrect lamp comes on, replace all neon lamps of the group.

SEE INSIDE

Figure 8-26
RANGE SELECTOR ASS'Y A22



Display Control Ass'y A23
(04270-7743)

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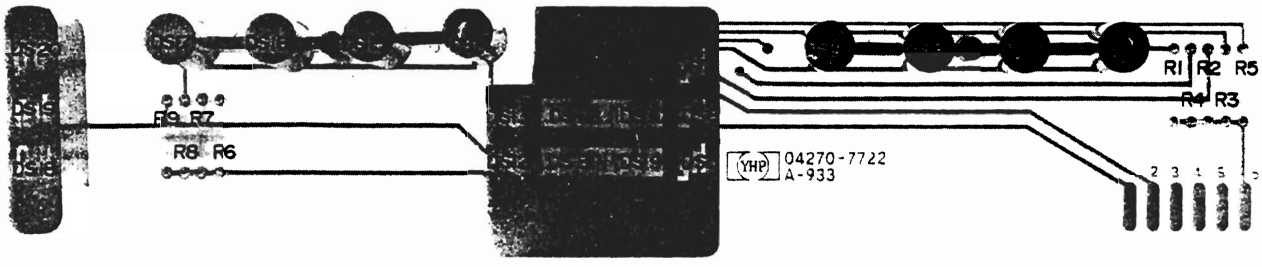
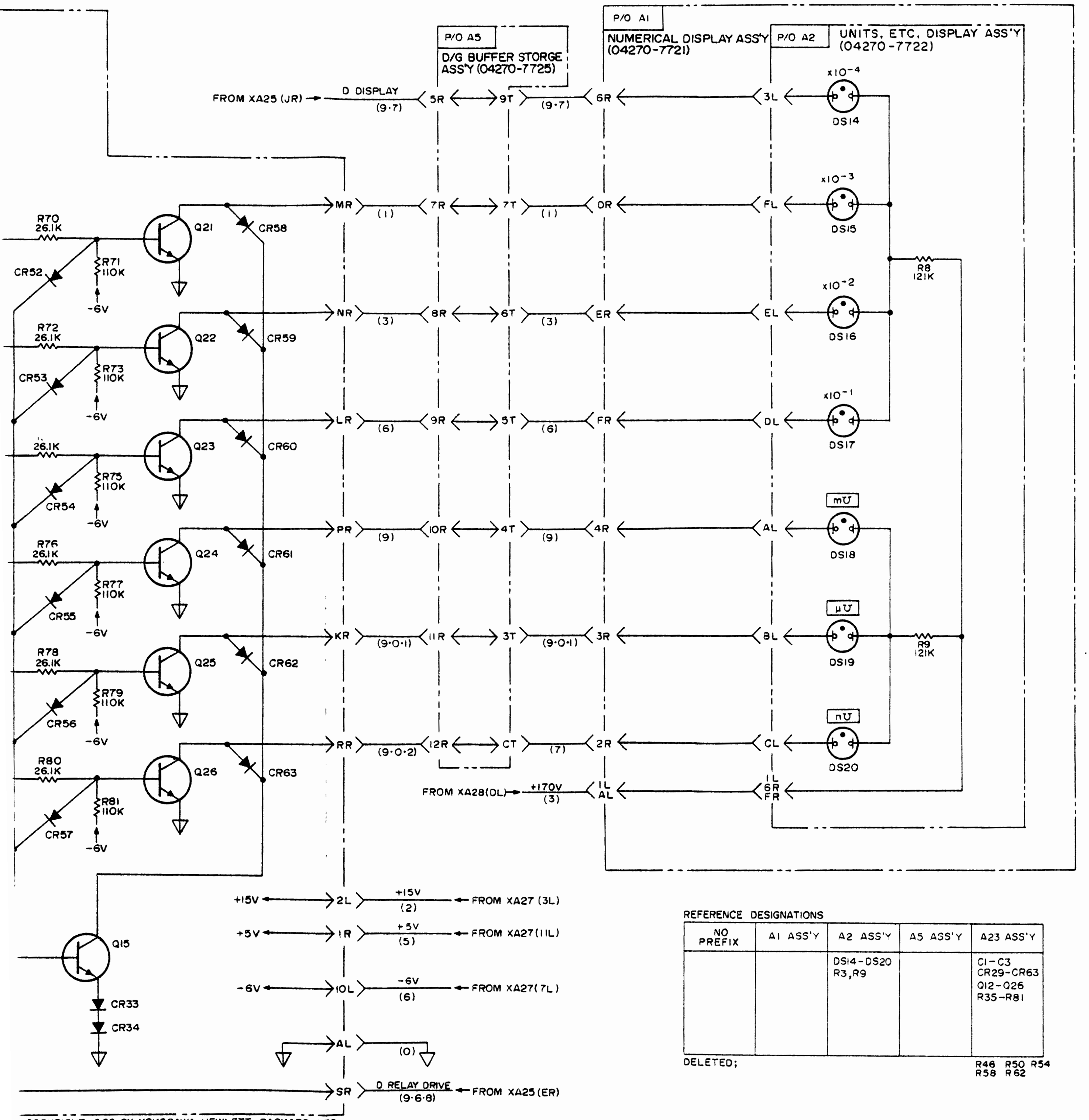


Units, ETC, Display Ass'y A2
(04270-7722)



REFERENCE DESIGNATIONS

NO PREFIX	A1 ASS'Y	A2 ASS'Y	A5 ASS'Y	A23 ASS'Y
		DS14-DS20 R3,R9		C1-C3 CR29-CR63 Q12-Q26 R35-R81

DELETED; R46 R50 R54 R58 R62

Figure 8-28. Display Control Ass'y A23 (Sheet 2 of 2)

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NOTE BCD CODE: "8421", "1" STATE POSITIVE. DECIMAL WEIGHT:

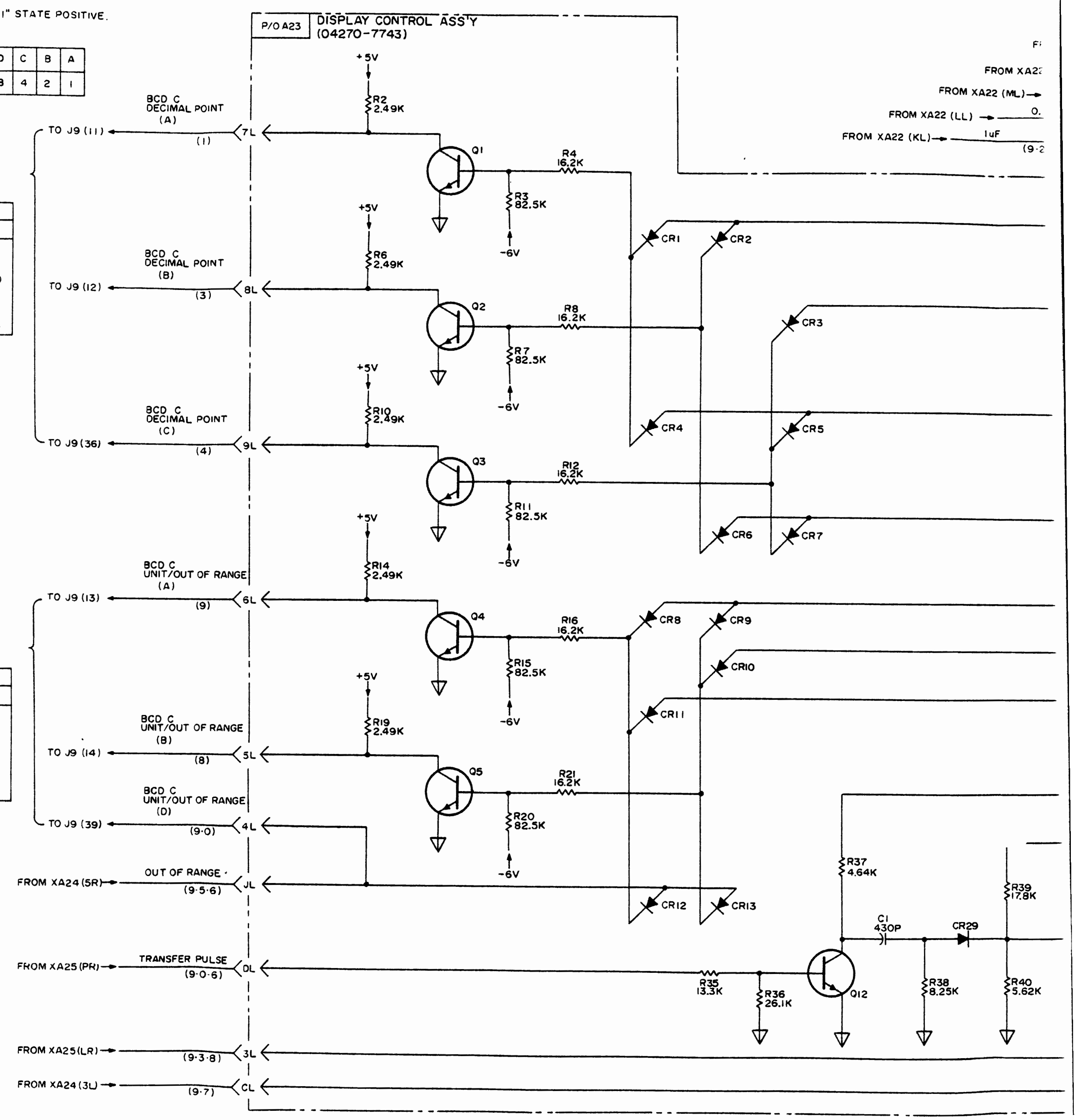
LINE	D	C	B	A
WEIGHT	8	4	2	1

C DECIMAL POINT

C	CODE			
DECIMAL POINT	8	4	2	1
0 0 0 0.0	0	0	0	1
0 0 0.0 0	0	0	1	0
0 0.0 0 0	0	0	1	1
0.0 0 0 0	0	1	0	0

C UNIT & OUT OF RANGE

C UNIT & OUT OF RANGE	CODE			
	8	4	2	1
μF	0	0	0	0
nF	0	0	0	1
pF	0	0	1	0
OUT OF RANGE	1	0	0	0



NOTE BCD CODE: "8421" 1 STATE POSITIVE.
DECIMAL WEIGHT:

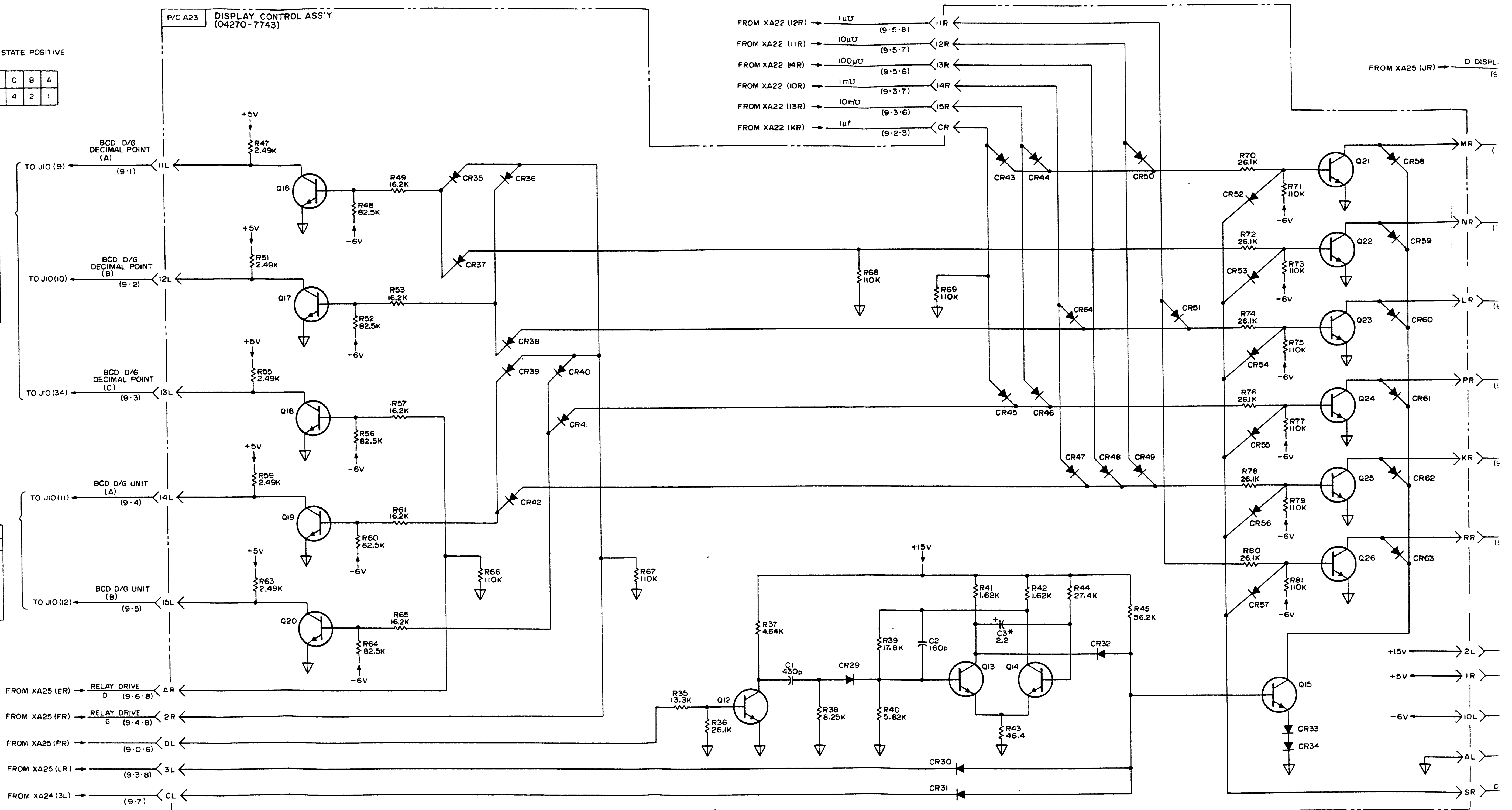
LINE	D	C	B	A
WEIGHT	8	4	2	1

D/G DECIMAL POINT

D/G DECIMAL POINT	CODE 8	4	2	1
0 0 0.0	0	0	0	1
0 0.0 0	0	0	1	0
0.0 0 0	0	0	1	1
.0 0 0 0	0	1	0	0

D/G UNIT

D/G UNIT	CODE 8	4	2	1
D	0	0	0	0
m℧	0	0	0	1
μ℧	0	0	1	0
n℧	0	0	1	1



A24 TROUBLESHOOTING

Check the +5Vdc at pin 1-L and the -6Vdc at pin 14-R. Using the Logic Probe, while operating LINE ON/OFF switch verify that INITIAL RESET PULSE Ps1 at pin A-R occurs. Monitor RESET 1 at pin 7-L with the Logic Probe; it should go LOW while RESET button is depressed and held; and should go HIGH when RESET button is released. Observe RESET 2 at pin 8-L and RESET 3 at pin 9-L on AUTO RANGE MODE in the same way as RESET 1. RESET 2 pulse does not occre on HOLD and TRACK RANGE MODE. RESET pulse 3 does not occur on TRACK RANGE MODE. If it occurs, check Reset flip/flop IC3A and the logics. If a problem exists with MEAS RATE, use the Logic Probe to check Sample Rate Generator flip/flop, Main Gate Control signal and the logics, Check the PRINT COMMAND and TRANSFER pulse.

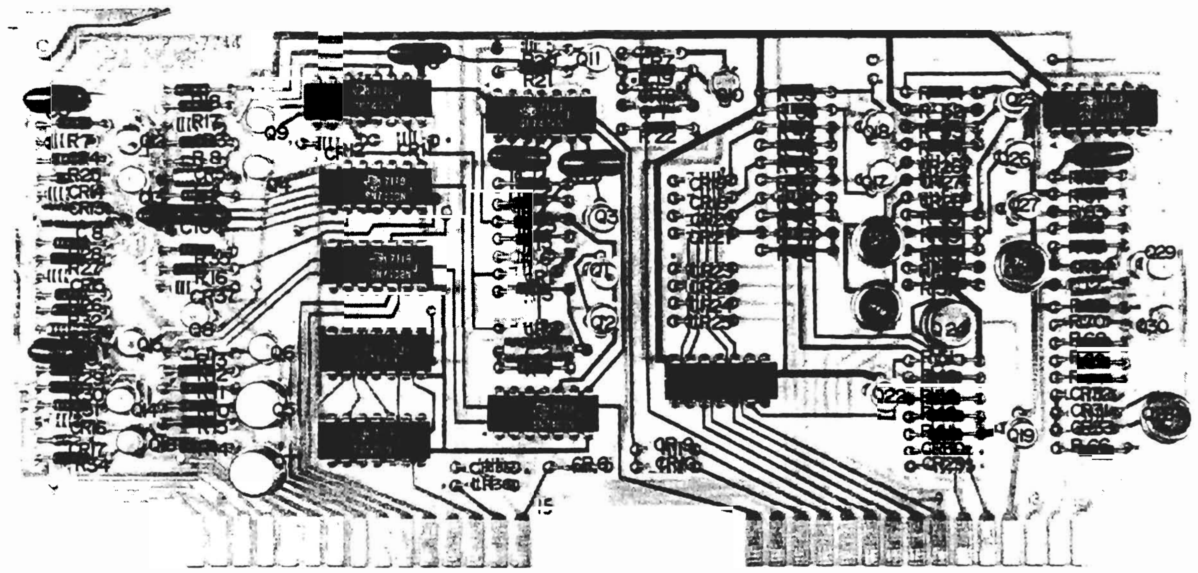
If OUT OF RANGE indicator does not operate correctly, the first step in troubleshooting is to isolate the trouble from A22 Range Selector by monitoring Q10 collector voltage; it should go LOW (+0.7V) when Cs or D/G Reversible Counter counts over the limit according to the selected Frequency and Capacitance Range, and OUT OF RANGE should come on. If Q10 collector is more than +0.7Vdc but OUT OF RANGE comes on, check A22 Range Selector.

CAUTION: If Q10 is off, the collector voltage will be about 100Vdc.

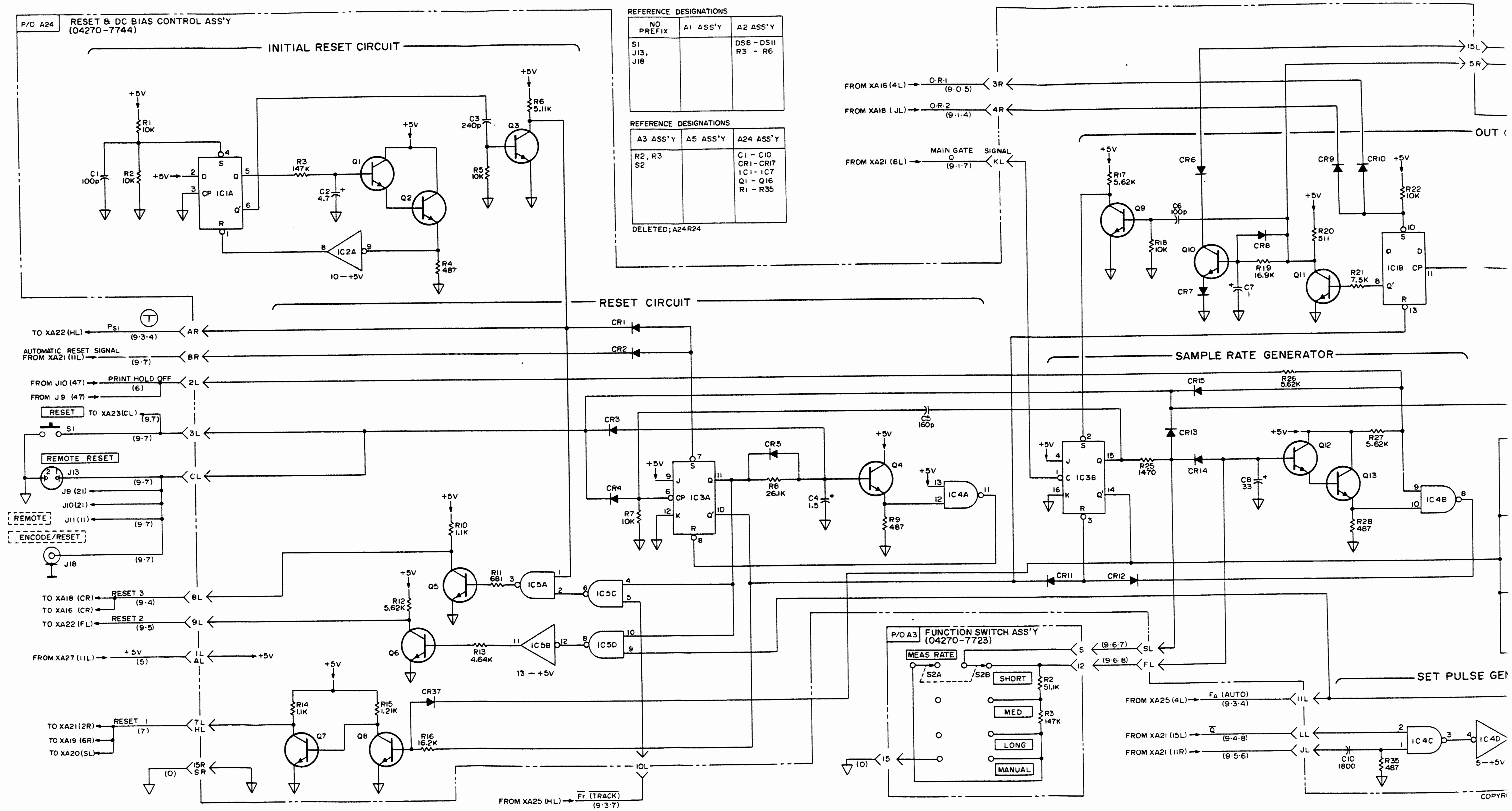
Figure 8-28

DISPLAY CONTROL ASS'Y A23
(SHEET 2 OF 2)

SEE INSIDE



Reset & DC Bias Control Ass'y A24
(04270-7744)



REFERENCE DESIGNATIONS

NO PREFIX	A1 ASS'Y	A2 ASS'Y
S1 J13, J18		DS8 - DS11 R3 - R6

REFERENCE DESIGNATIONS

A3 ASS'Y	A5 ASS'Y	A24 ASS'Y
R2, R3 S2		C1 - C10 CR1 - CR17 IC1 - IC7 Q1 - Q16 R1 - R35

DELETED; A24R24

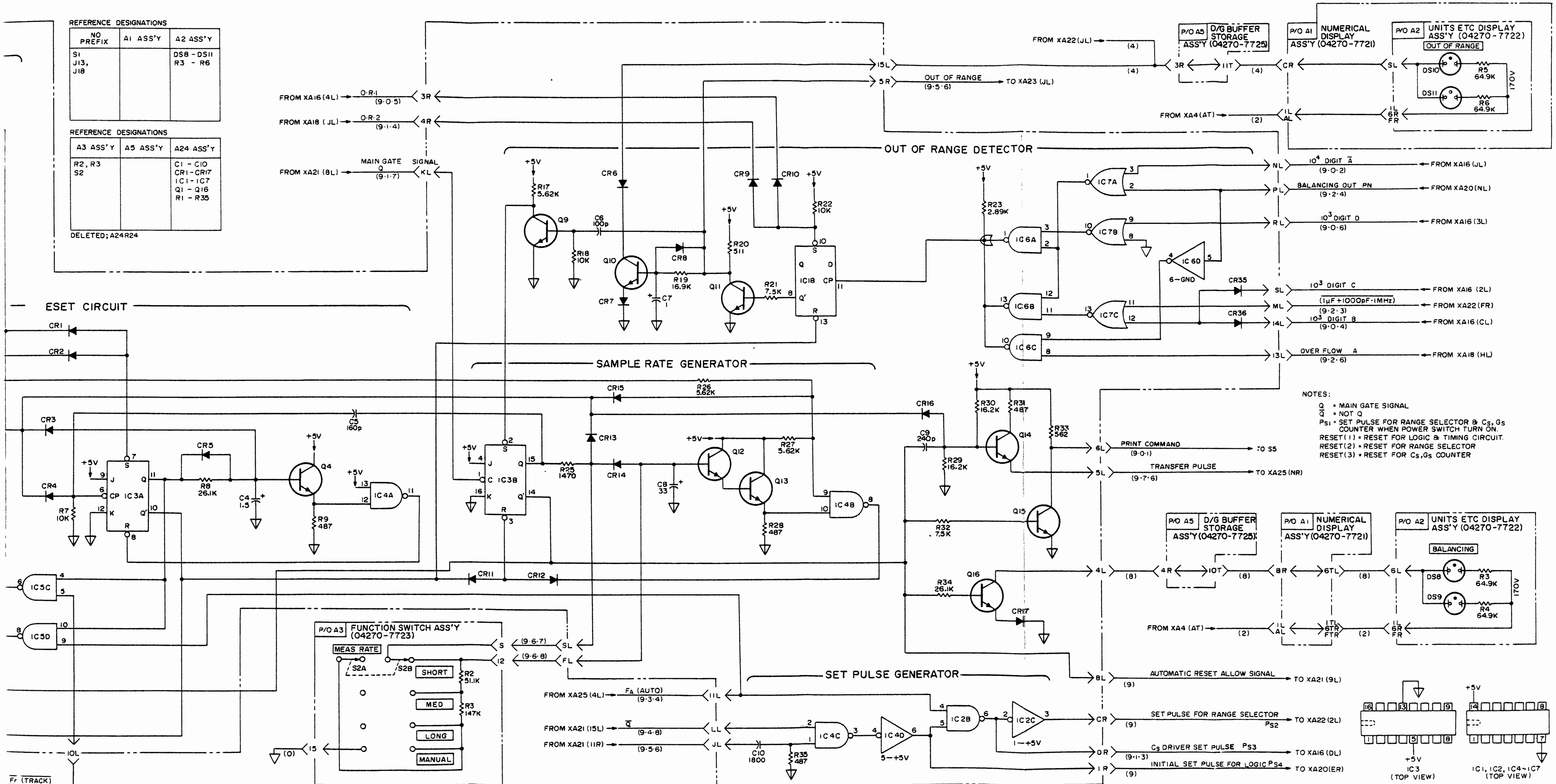


Figure 8-29. Reset & DC Bias Control Ass'y A24
(Sheet 1 of 2)

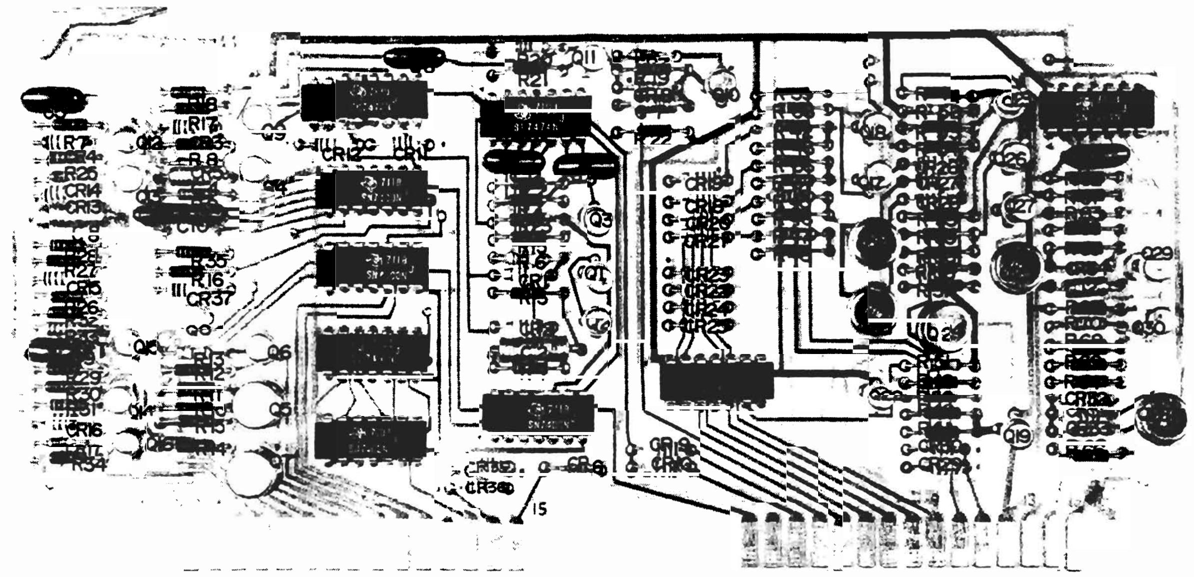
A24 TROUBLESHOOTING

To check DC Bias Control, refer to Table 8- . Use dc voltmeter to verify that all relay control signals except of DISCHARGE RELAY DRIVE are normal. Use oscilloscope to monitor the DISCHARGE RELAY DRIVE signal while operating DC BIAS RANGE Switch from OFF to 20V.

SEE INSIDE

Figure 8-29

RESET & DC BIAS CONTROL ASS'Y A24 (SHEET 1 OF 2)



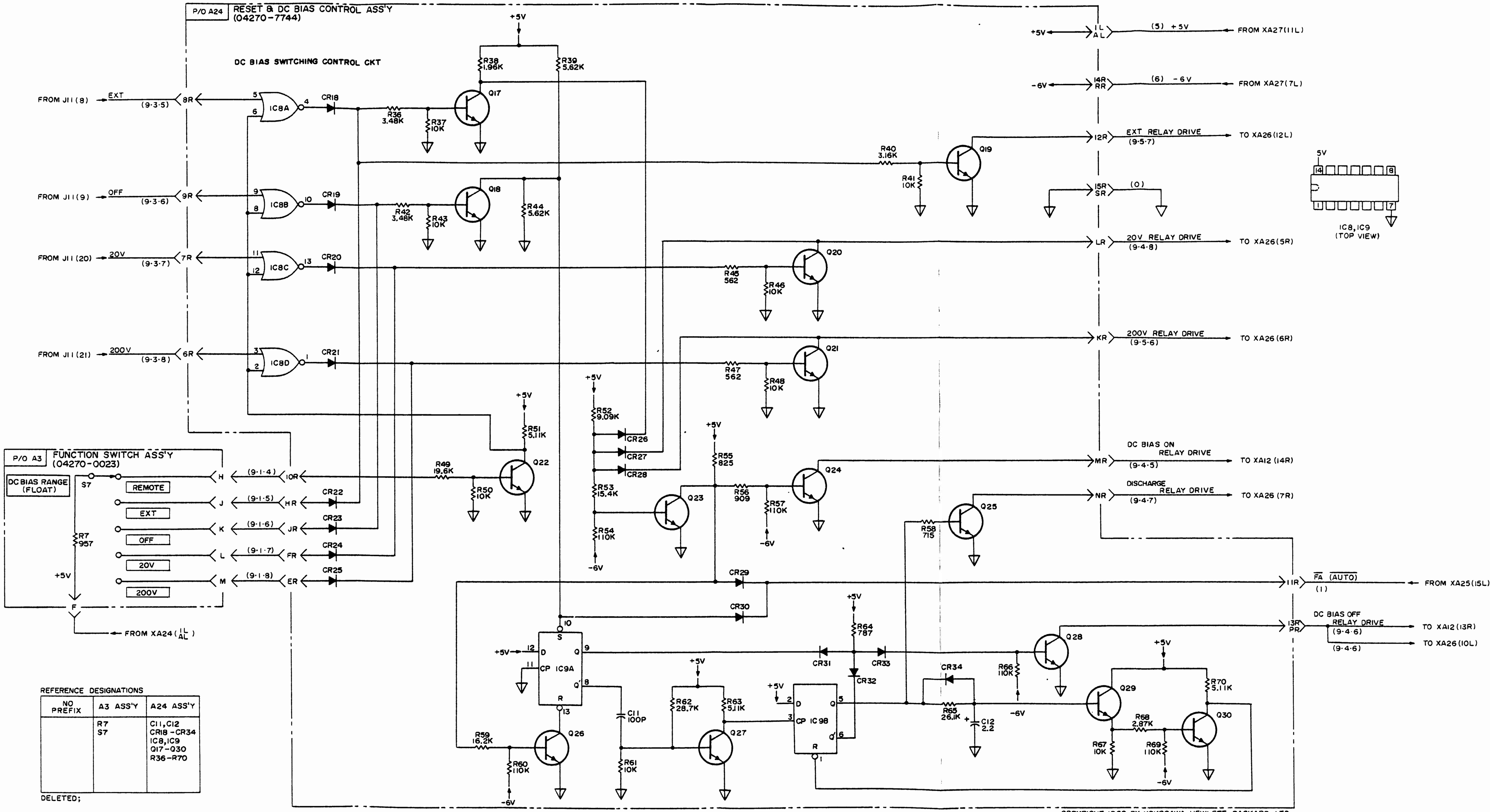
Reset & DC Bias Control Ass'y A24 (04270-7744)

Table 8-17. Relay Driving Signals

DC BIAS RANGE SETTING	CHECK POINT								
	200V A26 K1 Relay Drive Pin K-R	20V A26 K2 Relay Drive Pin L-R	EXT A26 K5 Relay Drive Pin 12-R	DC BIAS ON A12 K6 Relay Drive Pin M-R		DC BIAS OFF A26 K3 Relay Drive Pins 13-R & P-R		DISCHARGE A26 K4 Relay Drive Pin N-R	
				Auto	Hold Track	Auto	Hold Track	Auto	Hold Track
200 V	+0.1 V	+10 V	+10 V	+10 V	+0.1 V	+0.1 V	+10 V	+10 V	+10V / +0.1V To*(2)
20 V	+10	+0.1	+10	+10	+0.1	+0.1	+10	+10	+10V / +0.1V
OFF	+10	+10	+10	+10	+10	+0.1	+0.1	+10	+10V / +0.1V
EXT	+10	+10	+0.1	+10	+0.1	+0.1	+10	+10	+10V / +0.1V 30Ms
REMOTE	*(1)	*(1)	*(1)	+10	*(1)	+0.1	+10	+10	*(1)

*(1) When DC BIAS RANGE is set to REMOTE on the front panel, one of the four DC BIAS RANGES may be selected via the Remote control connector on the rear panel by grounding the appropriate pin according to the desired bias range. The relay driving signal is same as selected on the front panel.

*(2) At To the DC BIAS RANGE control should be set to OFF (excepting for REMOTE).



REFERENCE DESIGNATIONS

NO PREFIX	A3 ASS'Y	A24 ASS'Y
	R7 S7	C11, C12 CR18 - CR34 IC8, IC9 Q17 - Q30 R36 - R70

DELETED;

Figure 8-30. Reset & DC Bias Control Ass'y A24
(Sheet 2 of 2)

A25 TROUBLESHOOTING

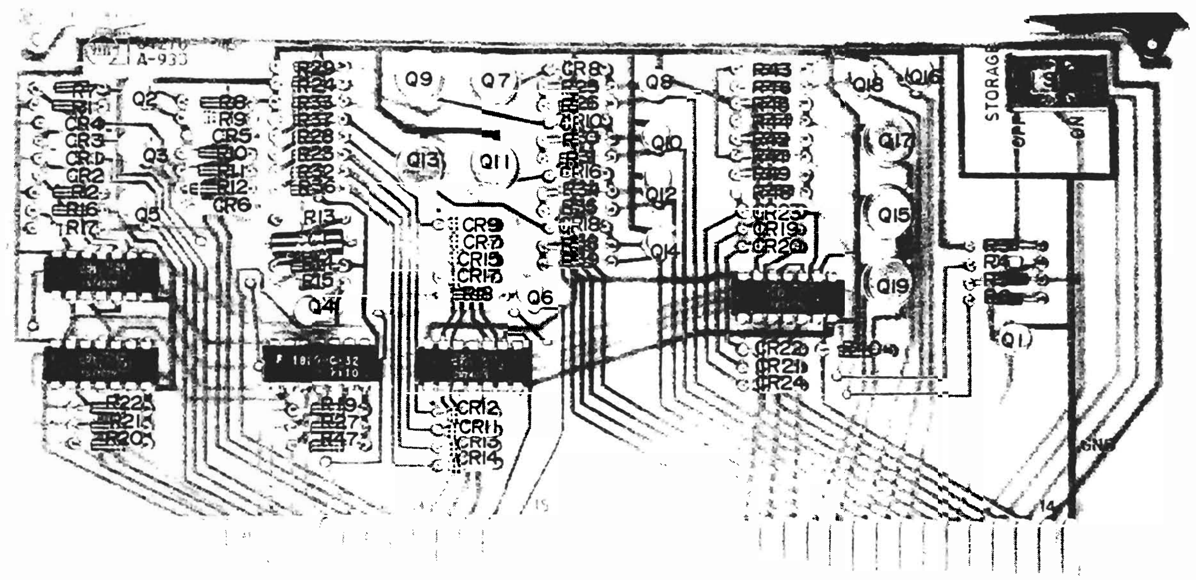
Check the +10Vdc at pin 9-L, the +5Vdc at pins 14-R and R-R, and the -6Vdc at pins 8-L and J-L. Use dc voltmeter (not the Logic Probe) to check the output signals from A25. If the trouble is found on only one of the functions, check the control signal for the function and then check the others. For example, assume that the 4270A does not operate correctly only on AUTO RANGE MODE. Check first FA (AUTO) and $\overline{\text{FA (AUTO)}}$, then check FH (HOLD), FT (TRACK) and $\overline{\text{FT (TRACK)}}$.

A3 TROUBLESHOOTING

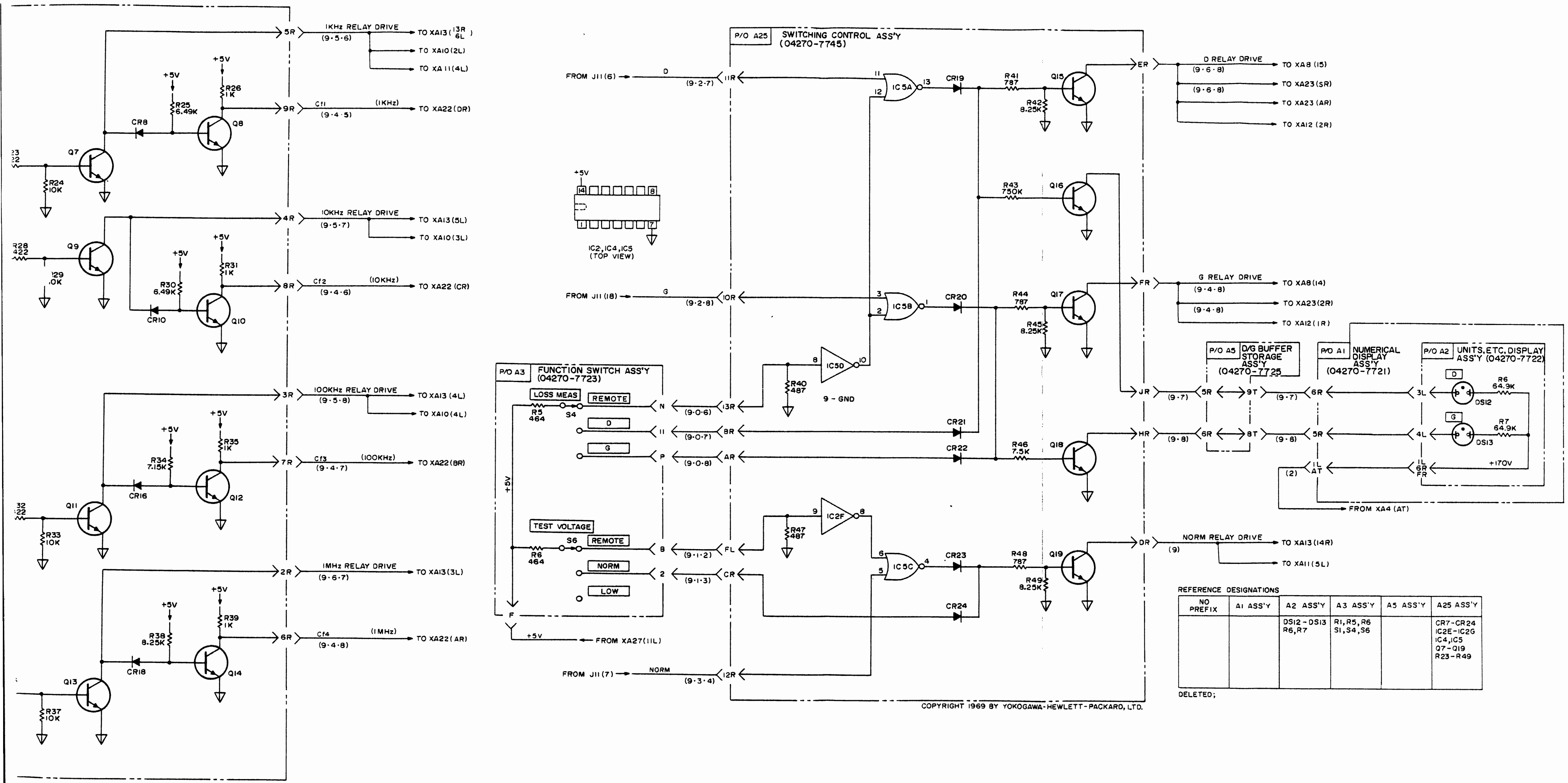
Use the Logic Probe to verify that all output signals from A3 are correct and LOCAL RANGE STEP pulse occurs at XA25. If the above tests fail, remove the A3 as described paragraph 5-59 and make resistance measurements on the switch.

SEE INSIDE

Figure 8-30
RESET & DC BIAS CONTROL ASS'Y A24
(SHEET 2 OF 2)



Switching Control Ass'y A25
(04270-7745)

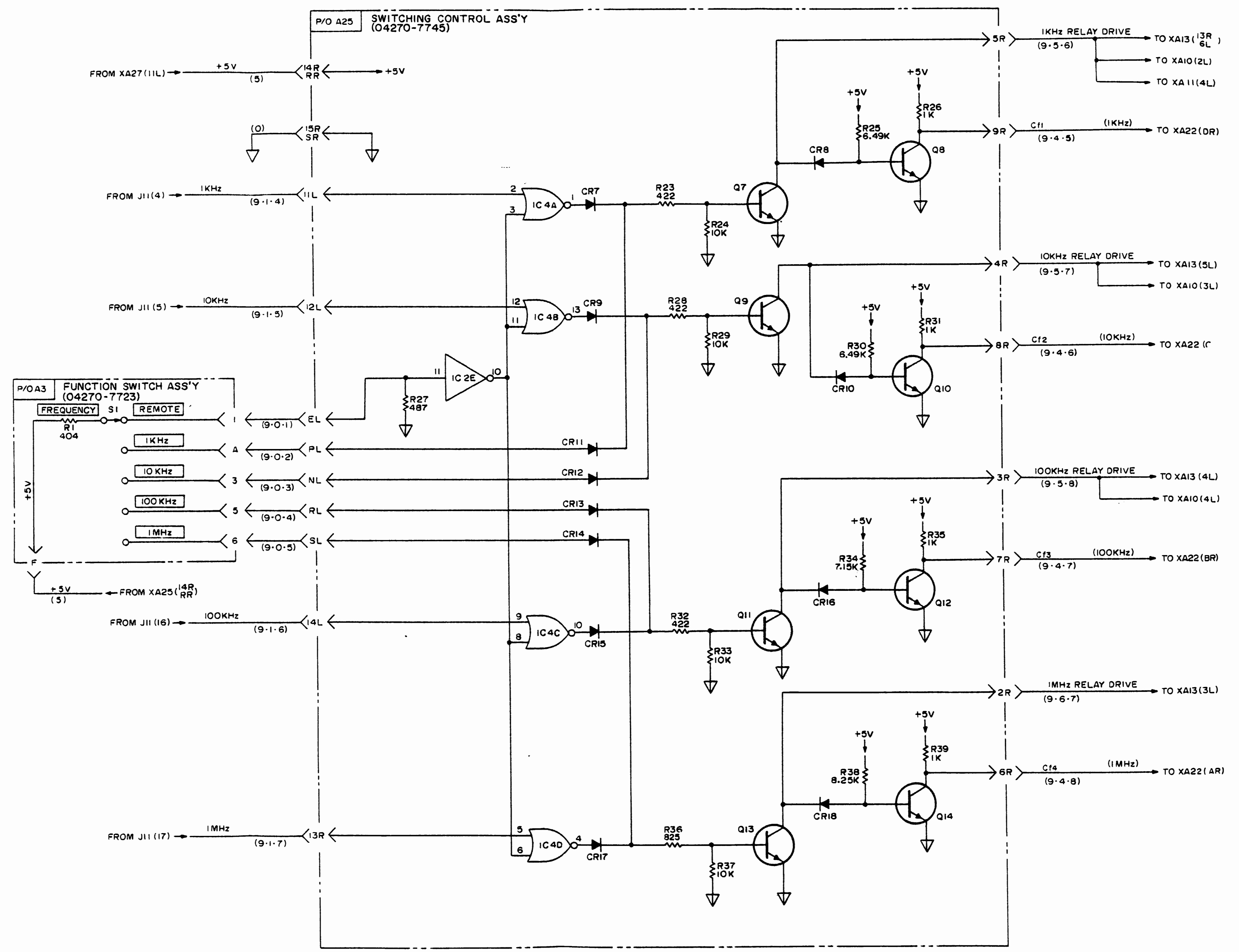


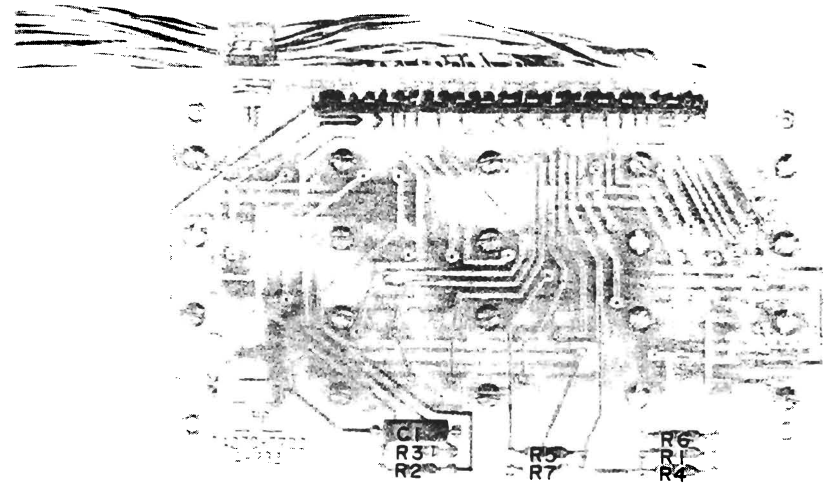
REFERENCE DESIGNATIONS

NO PREFIX	A1 ASS'Y	A2 ASS'Y	A3 ASS'Y	A5 ASS'Y	A25 ASS'Y
		DS12 - DS13 R6, R7	R1, R5, R6 S1, S4, S6		CR7-CR24 IC2E-IC2G IC4, IC5 Q7-Q19 R23-R49

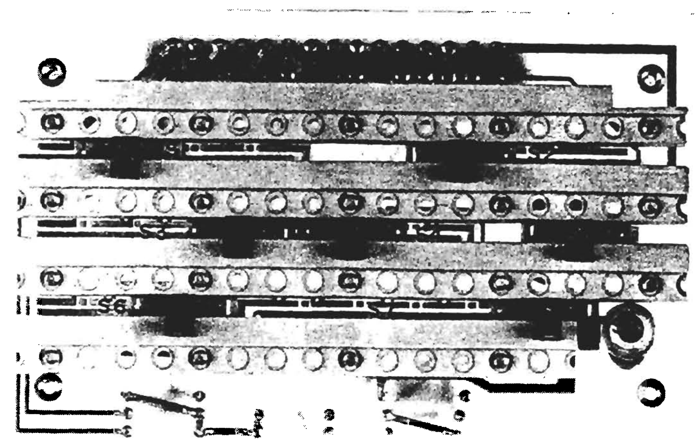
DELETED;

Figure 8-31. Switching Control Ass'y A25 (Sheet 1 of 2)


P/O A25 SWITCHING CONTROL ASS'Y (04270-7745)
P/O A3 FUNCTION SWITCH ASS'Y (04270-7723)
FREQUENCY
REMOTE
1KHz
10KHz
100KHz
1MHz
FROM XA27(11L)
FROM J11(4)
FROM J11(5)
FROM J11(16)
FROM J11(17)
FROM XA25
1KHz RELAY DRIVE
10KHz RELAY DRIVE
100KHz RELAY DRIVE
1MHz RELAY DRIVE
TO XA13
TO XA10(2L)
TO XA11(4L)
TO XA22(DR)
TO XA13(5L)
TO XA10(3L)
TO XA13(4L)
TO XA10(4L)
TO XA22(BR)
TO XA13(3L)
TO XA22(AR)



Function Switch Ass'y A3
(04270-7723)



Function Switch Ass'y A3
(04270-7723)

SEE INSIDE

Figure 8-31
SWITCHING CONTROL ASS'Y A25
(SHEET 1 OF 2)

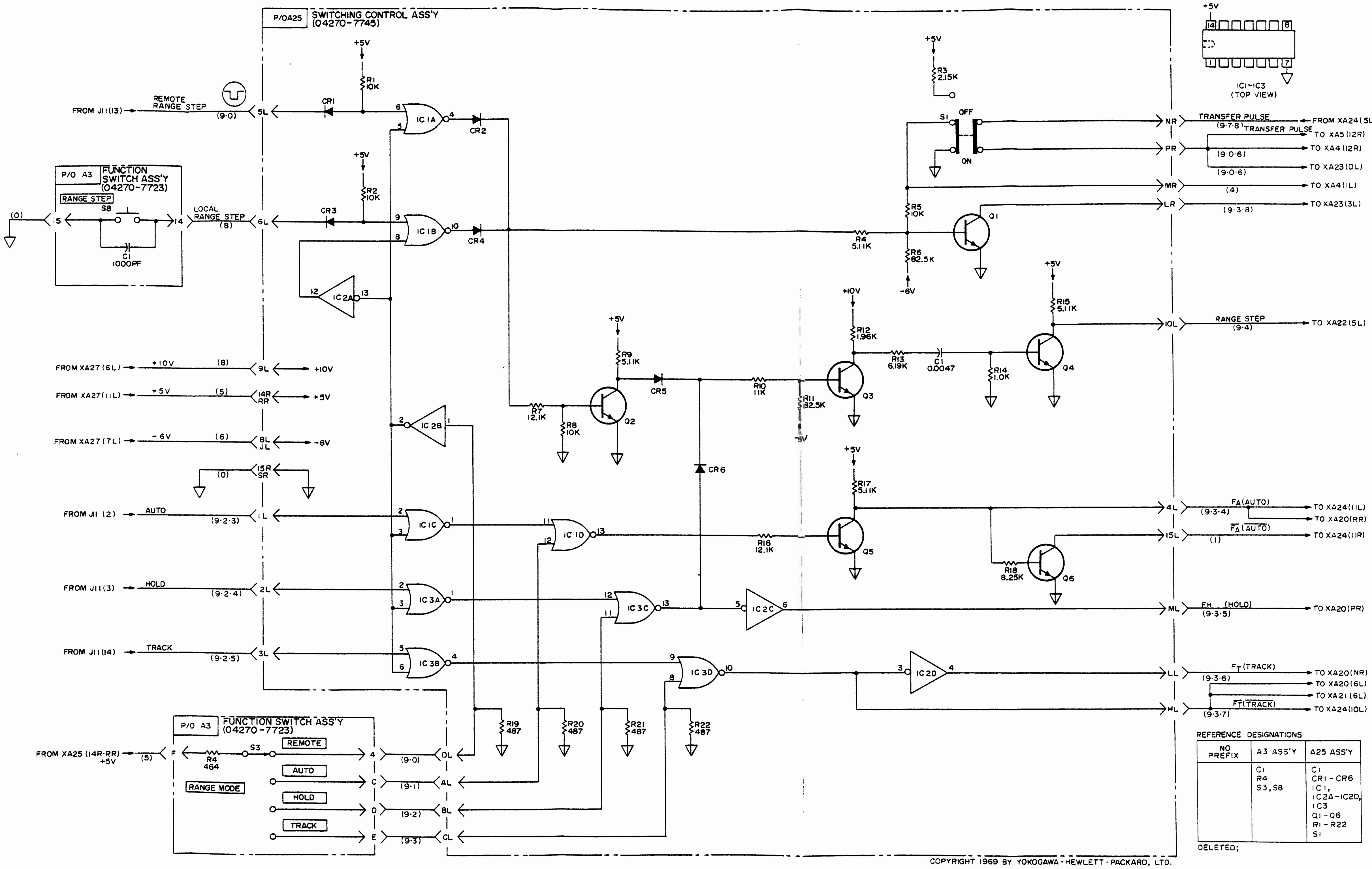


Figure 8-32. Switching Control Ass'y A25
(Sheet 2 of 2)

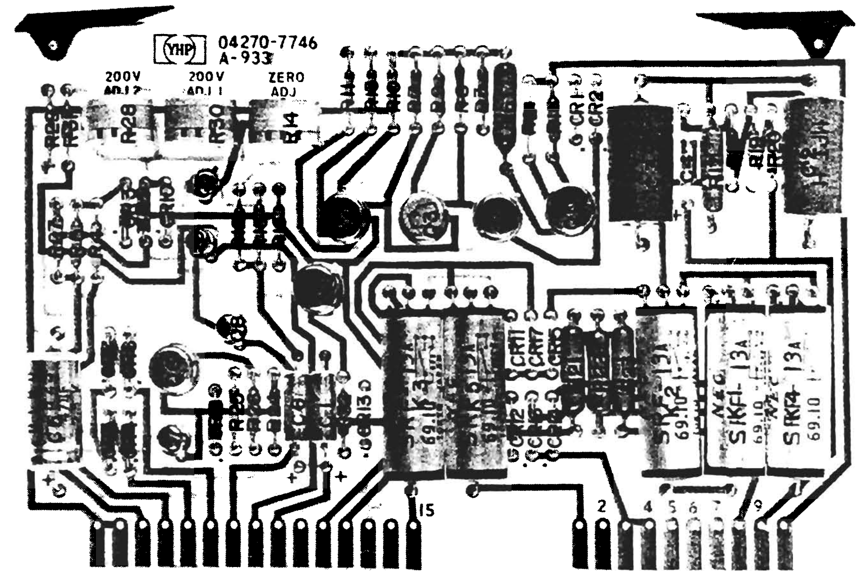
A26 TROUBLESHOOTING

Check the +15Vdc at pin 1-L, the +10V at pin 3-R and the -6Vdc at pin H-L. If trouble is encountered on both 200V and 20V range, check to see that -12V bias is correct at the anode of CR8. To check relays, refer to Table 8-

Figure 8-32

SWITCHING CONTROL ASS'Y A25 (SHEET 2 OF 2)

SEE INSIDE



DC Bias Supply Ass'y A26 (4270-7746)

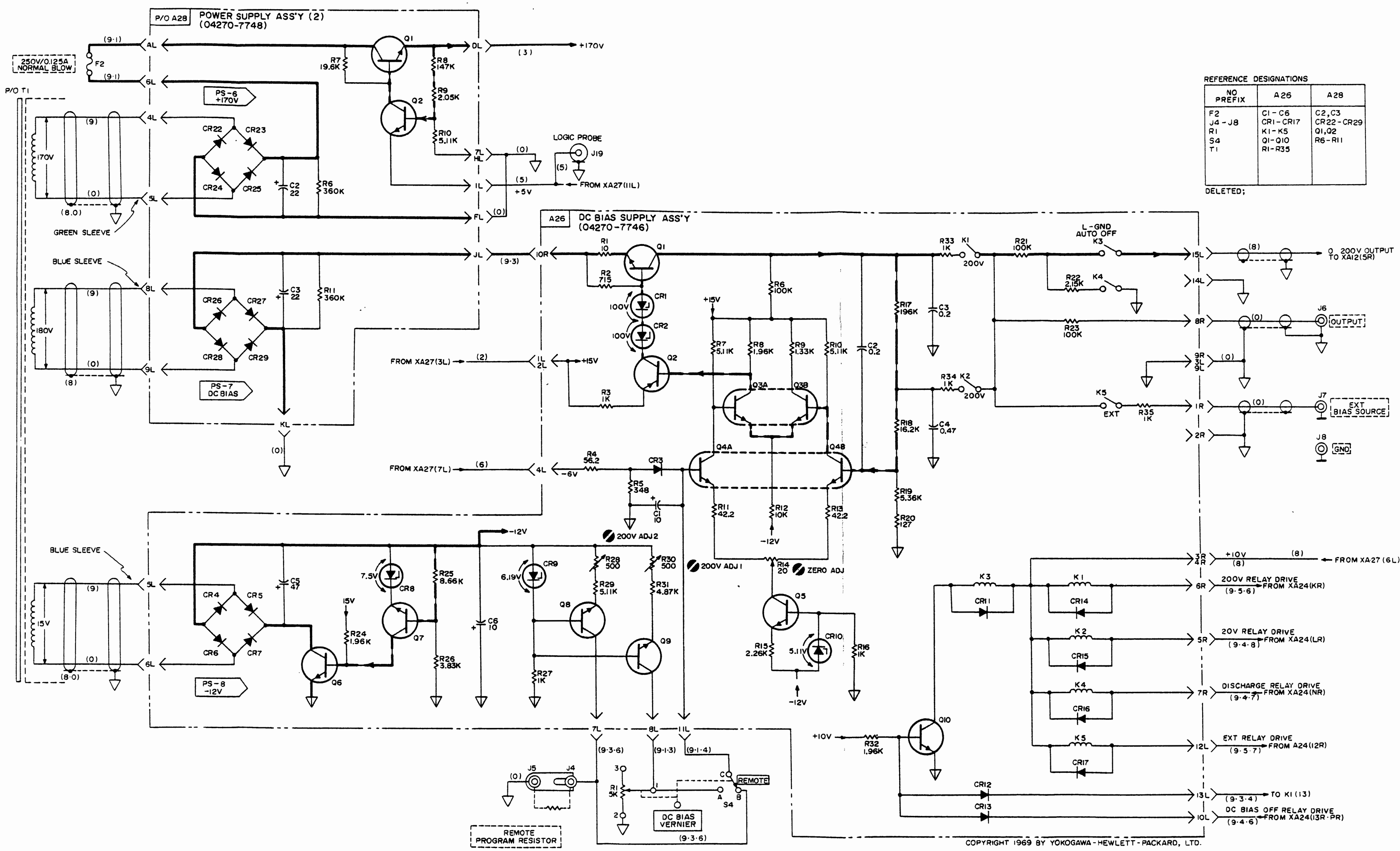
Table 8-18. Relay Driving Signals

DC BIAS RANGE SETTING	CHECK POINT						
	200V K1 Relay Drive Pin 6-R	20V K2 Relay Drive Pin 5-R	DC BIAS OFF K3 Relay Drive Pins 10-L		DISCHARGE K4 Relay Drive Pin 7-R		EXT K5 Relay Drive Pin 12-L
			Auto	Auto Track	Auto	Hold Track	
200 V	+0.1 V	+10 V	+0.1 V	+10 V	+10 V	+10V To*(2) +0.3V	+10 V
20 V	+10	+0.1	+0.1	+10	+10	+10V +0.3V	+10
OFF	+10	+10	+0.1	+0.1	+10	+10V +0.3V	+10
EXT	+10	+10	+0.1	+10	+10	+10V +0.3V	+10
REMOTE	*(1)	*(1)	+0.1	*(1)	+10	*(1)	*(1)

*(1) When DC BIAS RANGE is set to REMOTE on the front panel, one of the four DC BIAS RANGES may be selected via the Remote control connector on the rear panel by grounding the appropriate pin according to the desired bias range. The relay driving signal is same as selected on the front panel.

*(2) At To the DC BIAS RANGE control should be set to OFF (excepting for REMOTE).

60



REFERENCE DESIGNATIONS

NO PREFIX	A26	A28
F2 J4-J8 R1 S4 T1	C1-C6 CR1-CR17 K1-K5 Q1-Q10 R1-R35	C2,C3 CR22-CR29 Q1,Q2 R6-R11
DELETED:		

Figure 8-33. DC Bias Supply Ass'y A26
Power Supply Ass'y (2) A28

A27, A28 TROUBLESHOOTING

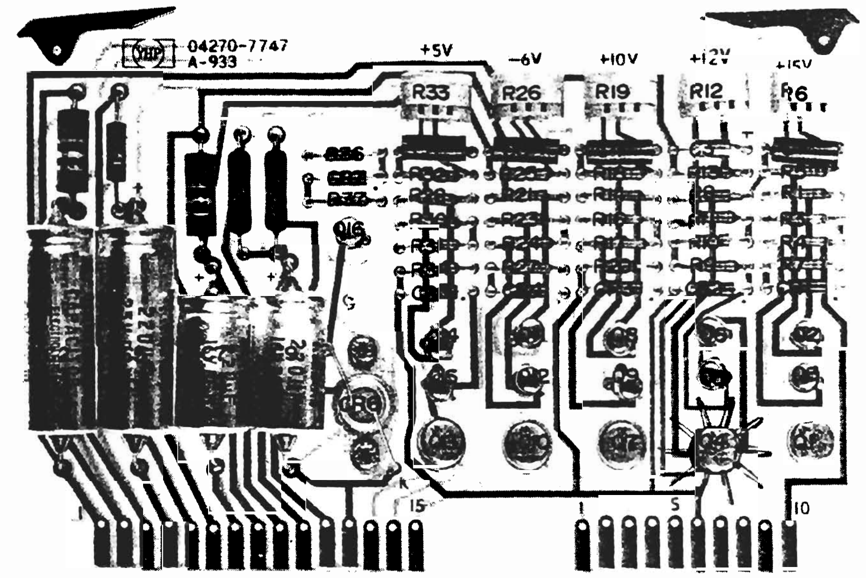
To check power supply, refer to table 8-19. If trouble is encountered with all voltages, check the +15Vdc power supply. Next, check +10Vdc power supply.
Caution: when troubleshooting this assembly be careful not to short the +5Vdc to the +10Vdc or the +15Vdc line.

Table 8-19. Power Supply Voltage

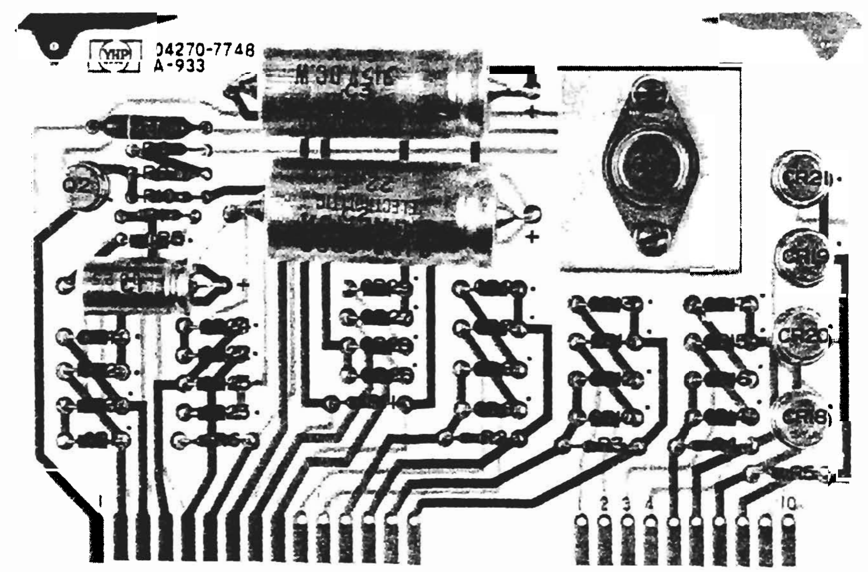
TEST POINT	POINT NO.	DC VOLTAGE	RIPPLE	ADJ
+15V	XA27 3L to GND	15. 00±. 10V	3mVp-p	A27R6
+12V	XA27 5R to GND	12. 00±. 10V	"	A27R19
+10V	XA27 6L to GND	10. 00±. 10V	"	A27R19
-6V	XA27 7L to GND	-6. 00±. 10V	"	A27R26
+5V	XA27 11L to GND	+5. 02±. 01V	"	A27R33
	XA28 DL to GND	+172±8	3V0-p	NO

SEE INSIDE

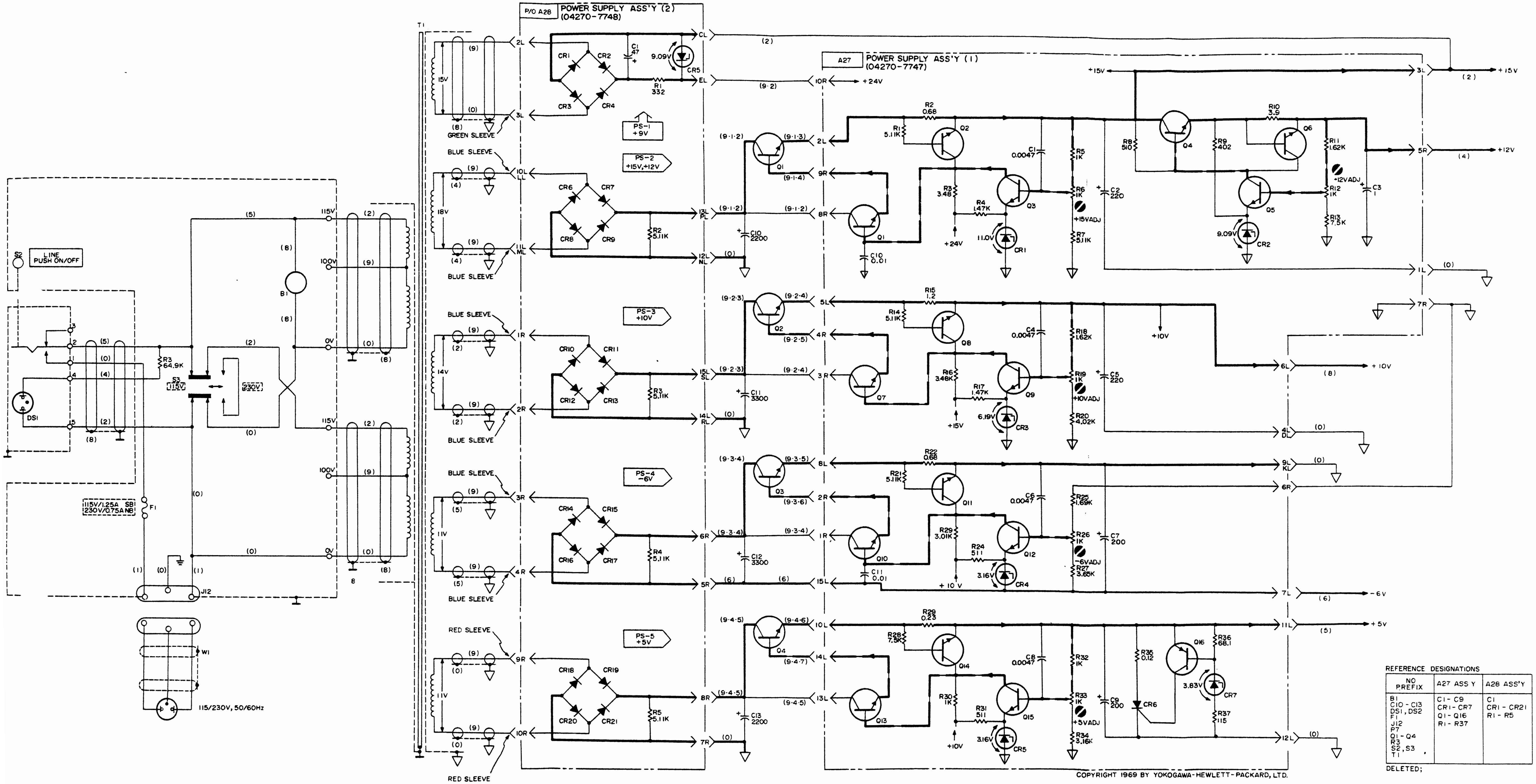
Figure 8-33
DC BIAS SUPPLY ASS'Y A26
POWER SUPPLY ASS'Y (2) A28



Power Supply Ass'y (1) A27
(04270-7747)



Power Supply Ass'y (2) A28
(04270-7748)

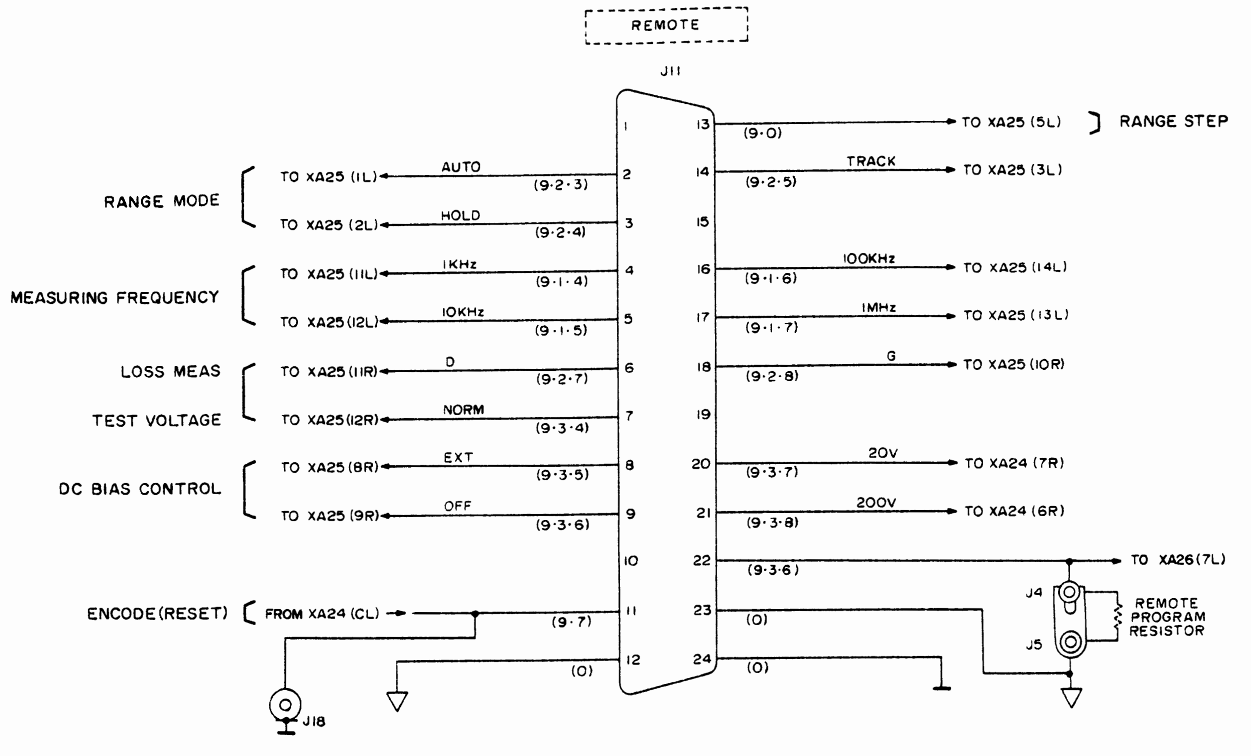


REFERENCE DESIGNATIONS

NO PREFIX	A27 ASS Y	A28 ASS'Y
B1, C10 - C13, DS1, DS2, F1, J12, P7, Q1 - Q4, R3, S2,S3, T1	C1 - C9, CR1 - CR7, Q1 - Q16, R1 - R37	C1, CR1 - CR21, R1 - R5

DELETED;

Figure 8-34. Power Supply Ass'y (1
Power Supply Ass'y (2



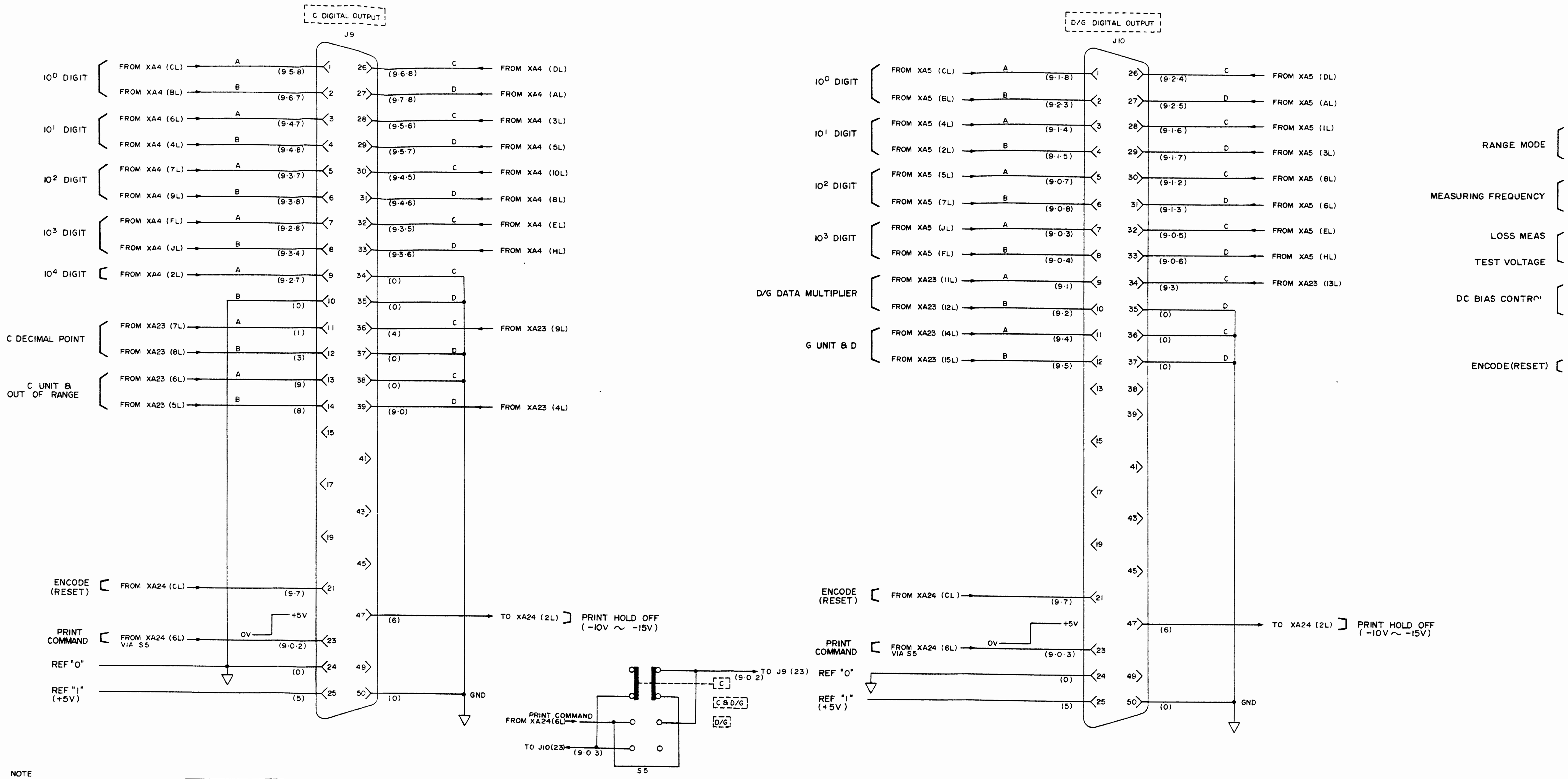
REFERENCE DESIGNATIONS

NO PREFIX	
J4, J5 J9, J10, J11 S5	

DELETED;

] PRINT HOLD OFF (-10V ~ -15V)

Figure 8-35. Rear Panel Connectors J9, J10, J11



NOTE
BCD CODE "8421" "1" STATE POSITIVE

LINE	D	C	B	A
WEIGHT	8	4	2	1

C DECIMAL POINT	CODE 8	4	2	1
0 0 0 0.0	0	0	0	1
0 0 0.0 0	0	0	1	0
0 0.0 0 0	0	0	1	1
0.0 0 0 0	0	1	0	0

C UNIT & OUT OF RANGE	CODE 8	4	2	1
μF	0	0	0	0
nF	0	0	0	1
pF	0	0	1	0
OUT OF RANGE	1	0	0	0

D/G DECIMAL POINT	CODE 8	4	2	1
0 0 0.0	0	0	0	1
0 0.0 0	0	0	1	0
0.0 0 0	0	0	1	1
.0 0 0 0	0	1	0	0

G UNIT & D	CODE 8	4	2	1
D	0	0	0	0
m℧	0	0	0	1
u℧	0	0	1	0
n℧	0	0	1	1