Errata

Title & Document Type: 4282A Digital High Capacitance Meter Operating and Service Manual

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Agilent Technologies

HP 4282A

OPERATING AND SERVICE MANUAL

DIGITAL HIGH CAPACITANCE METER

4282A

HEWLETT PACKARD

HP 4282A

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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.

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OPERATING AND SERVICE MANUAL

MODEL 4282A
DIGITAL HIGH CAPACITANCE METER

SERIAL PREFIXED : 1515J

See Section VII for Other Serial Prefixes.

Manual Part No. 04282-90001
Microfiche Part No. 04282-90051

Printed: JAN. 1982

HEWLETT PACKARD

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SECTION I
GENERAL INFORMATION

1-1. DESCRIPTION.

1-2. The HP Model 4282A Digital High Capacitance Meter is designed for easy measurement of high capacitances such as electrolytic or tantalum capacitors. For capacitance measurement, it provides nine wide ranges from 10nF to 1F full scale with high resolution provided by a display of four full digits. Dissipation factors and *ohm-farads are measureable in two suitable ranges using three full digits. These unknown characteristics, which are represented in a series equivalent circuit for capacitance and resistance, are measured by the four terminal method to minimize lead impedance effects. In addition, the instrument has the capability of a dc digital voltmeter and enables dc voltage measurements up to 600 volts to be made.

* An ohm-farad is the product of the capacitance and equivalent series resistance of a capacitor. The symbol for this unit is "ΩF" and is used throughout the manual. The ohm-farad, while not a commonly recognized electrical unit, is useful and is employed for convenience.

1-3. Measurements are performed by selecting function, range, measuring frequency, dc bias and so on at the front panel. All measurement values are displayed in the common display section utilizing five LED (light emitting diode) digits. Depending on FUNCTION switch settings, capacitance, dissipation factor, ohm-farads, dc bias voltage, dc voltage or leakage current (with option 001) are displayed singly or alternately. Overranging is 18% of range. Units and decimal point are determined by setting of FUNCTION and RANGE switch.

1-4. INTERFACING CAPABILITY.

1-5. FUNCTION, RANGE and RESET in the instrument are independently remotely programable. All lines are controlled by contact closure to ground or by TTL/DTL logic levels. Inputs for FUNCTION and RANGE are by a REMOTE IN connector on rear panel; RESET input is thru RESET EXT jack on front panel.

1-6. Measurement results are also obtainable at DIGITAL OUT connector or at ANALOG OUT terminal on rear panel for recording data on digital printer or analog recorder.

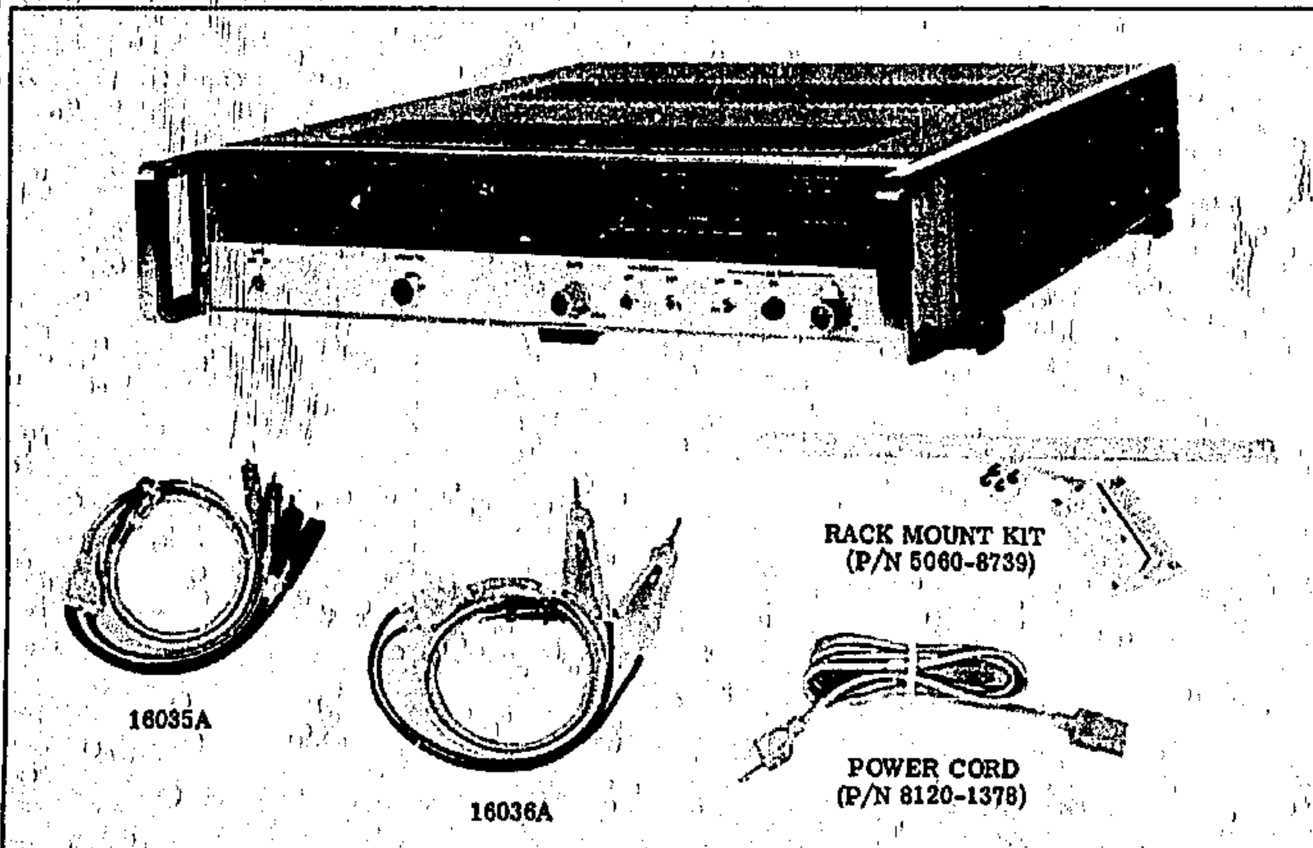


Figure 1-1. Model 4282A Digital High Capacitance Meter.

1-7. SPECIFICATIONS.

1-8. Specifications for Model 4282A are listed in Table 1-1. See Figure 1-3 for measurment accuracy graphs. Table 1-2 lists typical operating characteristics for instruments and Table 1-3 those for test leads. Also included are specifications for Option 001 - Leakage Current Measurement.

1-9. ACCESSORIES FURNISHED.

1-10. Figure 1-1 shows furnished accessories which include Model 16035A Test Leads with four alligator clips, Model 16036A Test Leads with alligator-jaw contacts and a power cord (HP P/N 8120-1521).

1-11. ACCESSORIES AVAILABLE.

1-12. Additionally available accessories for Model 4282A are:

Model 16037A Test Fixture for axial and vertical lead capacitors.

Model 16498A Interconnect Cable for connecting HP 5050B/5055A Digital Recorder.

Mating connector (HP Part No. 1250-0317) for UNKNOWN connector.

Mating Plug (HP Part No. 1251-0918) for RESET EXT jack.

1-13. Typical operating characteristics for the Model 16037A Test Fixture is listed in Table 1-3. Both models are completely identical except that standard model is for axial lead and opt 001 is for vertical lead capacitors. The contact sections are interchangeable between models (see Figure 1-2).

1-14. INSTRUMENT IDENTIFICATION.

1-15. Hewlett-Packard uses a two-section ten-character (0000J00000) serial number. The first four digits (serial prefix) identify a series of instruments; 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 (J=Japan, A=U.S.A., G=West Germany, U=United Kingdom). 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.

1-16. MANUAL CHANGES.

1-17. This manual provides operating and service information for HP Model 4282A. Information in this manual applies directly to instruments (as manufactured) with serial numbers prefixed by the four digits indicated on title page. If serial prefix of instrument is above that on title page, a "Manual Change" sheet supplied will describe changes which will adapt this manual to provide correct coverage. Technical corrections (if any) due to known errors in print are called Errata and are shown on change sheet. If prefix or serial number of instrument is below that on title page, see Section VII MANUAL CHANGES AND OPTIONS. For information on manual coverage of any HP instrument, contact nearest HP Sales/Service Office (addresses are listed at rear of this manual).

1-18. OPTION.

1-19. An option to Model 4282A permits Leakage Current Measurements (option 001). This enables measurement of leakage current which flows through the unknown capacitor. Five ranges from [illegible] to 10mA full scale are provided with three full digits display. Bias voltage is available up to 600Vdc.

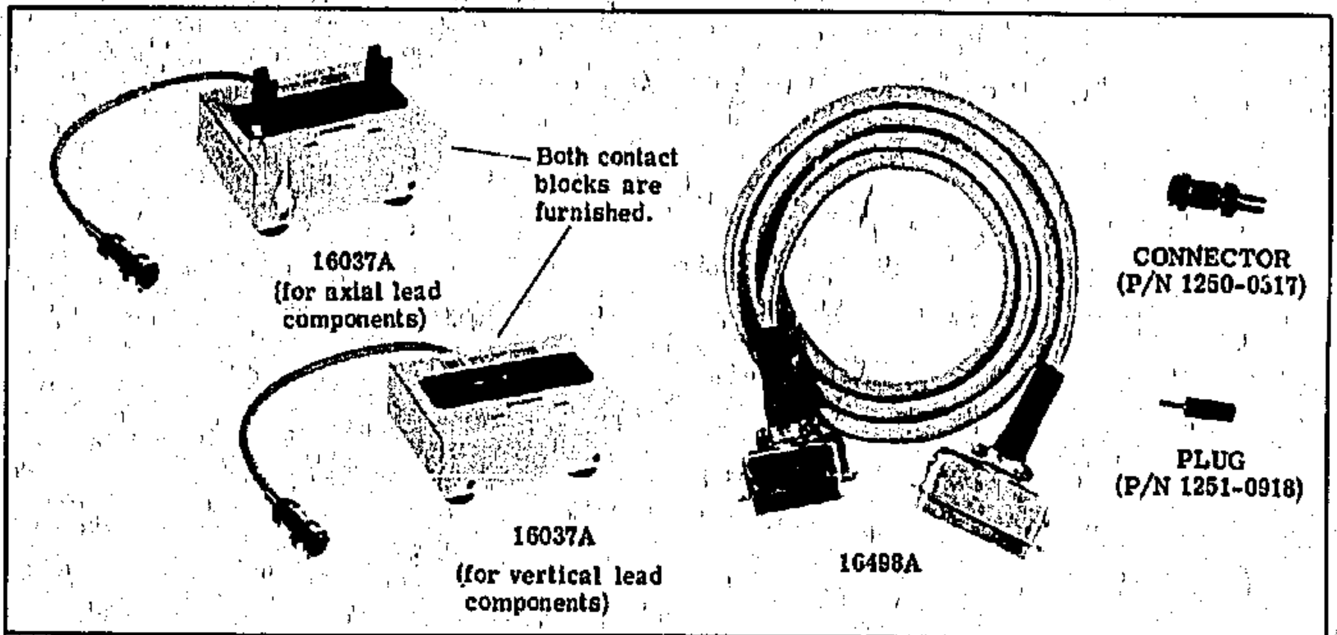


Figure 1-2. Test Fixtures and Accessories.

Table 1-1. Specifications (Page 1 of 2).

Measuring Functions: Capacitance, Dissipation Factor, *Ohm-farad and dc Voltage. Selectable by FUNCTION switch.

* Ohm-farad: the product of capacitance and equivalent series resistance of a capacitor.

Function Switch Setting	Function and Display
C	Capacitance measurement.
D	Dissipation factor measurement.
ΩF	Ohm-farad measurement.
C-D	Capacitance and dissipation factor measurements alternately.
C-ΩF	Capacitance and ohm-farad measurements alternately.
V	DC bias voltage or external dc voltage measurements.
	Note All measurements are continuously repeated as long as unknown is connected.

Measuring Ranges:

Function	Full-scale Display	Over-ranging
C (capacitance)	10.000nF to 1.0000F, four full digits, 9 ranges in decade steps, manual selection.	18%
D (dissipation factor)	1.000 to 10.000, three full digits, 2 ranges, auto selection.	18%
ΩF (ohm-farad)	1.000ΩmF to 10.00ΩmF, three full digits, 2 ranges, auto selection.	18%
V (dc voltage)	10.00V to 1.000kV, three full digits, 3 ranges, in decade steps, manual selection (maximum voltage is 600V).	18%

Measuring Circuit: Series equivalent circuit using four-terminal method.

Measuring Frequencies: 50Hz, 60Hz, 100Hz and 120Hz (50Hz and 60Hz synchronized by line frequency). Accuracy: ±1.5%

Measuring Voltages:

10nF to 10mF ranges: <1Vrms.

100mF range: <0.1Vrms.

1F range: <10mVrms.

Accuracy (+23°C ±5°C after half hour warm up): ±(% of reading + % of full-scale).

Capacitance—

C Range	% of reading	% of full-scale
10nF	1.0 + 0.9 · Drdg	0.2
100nF	0.5 + 0.5 · Drdg	0.1
1μF to 1mF	0.4 + 0.5 · Drdg	0.05
10mF	1.0 + 0.5 · Drdg	0.05
100mF	1.5 + 0.5 · Drdg	0.5
1F	2.5 + 0.5 · Drdg	1.0

Dissipation Factor—

C Range	% of reading	% of full-scale
10nF	1.5 + 0.5 · Drdg	0.2 · Cfs/Crdg + 0.3
100nF to 1mF	1.5 + 0.2 · Drdg	0.2 · Cfs/Crdg + 0.3
10mF	1.5 + 0.2 · Drdg	0.2 · Cfs/Crdg + 0.5
100mF, 1F	1.5 + 0.2 · Drdg	0.2 · Cfs/Crdg + 3

Ohm-Farad—

C Range	% of reading	% of full-scale
10nF	1.0 + 0.5 · ΩFrdg	0.2 · Cfs/Crdg + 0.3
100nF to 1mF	1.0 + 0.2 · ΩFrdg	0.2 · Cfs/Crdg + 0.3
10mF	1.0 + 0.2 · ΩFrdg	0.2 · Cfs/Crdg + 0.5
100mF, 1F	1.0 + 0.2 · ΩFrdg	0.2 · Cfs/Crdg + 3

Drdg: Dissipation factor reading.
ΩFrdg: Ohm-farad reading.
Crdg: Capacitance reading.
Cfs: C range setting full-scale.

DC voltage measurement accuracy—

10V range: ±(0.05% of reading + 0.1% of full-scale).

100V and 1kV ranges: ±(0.2% of reading + 0.1% of full-scale).

Table 1-1. Specifications (Page 2 of 2).

Temperature Coefficient (referred to + 23°C and temperature range of 0°C to 50°C):

Function	Temperature Coefficient
C	± 0.02% of reading/°C
D, ΩF	± 0.03% of reading/°C
V	±0.01% of reading/°C

Option 001: Leakage Current Measurement.

Adds following capabilities to standard model:

Leakage Current Measurement (I_L)—

Ranges: 1.000μA to 10.00mA, 5 ranges, three full digits.

Overranging: 18%.

Accuracy:

1μA range: ±(2% of reading +2.0% of full-scale).

10μA to 10mA ranges: ±(2% of reading + 0.3% of full-scale).

Bias Voltages:

Internal Source: 0 to 10V, 0 to 100V, 2 ranges, continuously variable over each range.

Maximum current is 100mA for 10V range and 60mA (for 1minute) for 100V range.

External Source: Useable up to 600Vdc across EXT BIAS terminals on rear panel.

Protective Resistor: 1kΩ for 100V range and for external bias, 1Ω for 10V range.

Table 1-2. Typical Operating Characteristics.

DC Bias Voltage: 0 to 10V, continuously adjustable with DC BIAS control. Maximum charging current is 100mA.

Balancing Time: Normally one second (when measuring on C ranges of 10nF through 10mF, capacitance value near full-scale, dissipation factor less than one and without dc bias).

Reading Rate: Continuously variable from 0.3 seconds to 2 seconds with RATE control.

Reset: One reading is initiate by depressing RESET INT push button or by contact closure to ground or TTL low level at RESET EXT line. Mating plug for RESET EXT jack: HP Part No. 1251-0918.

Digital Output:

Output Signals: BCD +1-2-4-8, data parallel, decimal point, function and unit, overload and unbalance, and polarity.

Level:

State	Level	Characteristics
Low	0.3V ± 0.3V	Max. sink current 15mA.
High	3.9V ± 1.5V	Max. load current 300μA.

Print Command Output: Negative going TTL pulse of approx. 1ms.

Printer Hold Input: TTL low level or contact closure to ground.

Connector: Mating, HP P/N 1251-0084; Amphenol 57-30360-375 (36-pin blue ribbon).

Remote Programable Functions: C range and I range (option 001). Reset is by TTL low level or contact closure to ground.

Connector: Mating, HP P/N 1251-0084; Amphenol 57-30360-375 (36-pin blue ribbon).

Analog Output: Dc output of 1V full-scale in proportion to displayed value.

Accuracy: Add ±0.5% of reading to accuracy specification.

Operating Environment: 0°C to +50°C, <90% RH.

Power Requirements: 100V, 120V, 220V or 240V ±10%, 50Hz or 60Hz, approx. 70VA.

Dimensions: 425 (W) x 88 (H) x 467 (D) mm.

Weight: Net 8.8kg,

Shipping 12.9kg.

Accessories Furnished:

Model 16035A Test Leads: Four alligator clips.

Model 16036A Test Leads: Two alligator-jaw clips.

Power Cord: 230cm (7-1/2 ft), HP Part No. 8120-1378.

Rack Mount Kit: HP Part No. 5060-8739.

Table 1-3. Test Lead Characteristics.

		Test Leads		
		16035A	16036A	16037A
Useable 4282A Measuring Ranges	Capacitance	$1\mu F$ - 1F	10nF - 10mF	10nF - 1mF
	Dissipation Factor	1 - 10	1 - 10	1 - 10
	Ohm-farad	1ΩmF - 10ΩmF	1ΩmF - 10ΩmF	1ΩmF - 10ΩmF
	Leakage Current (Option 001)	$1\mu A$ - 10mA		
Maximum Voltage		300Vdc	100Vdc	600Vdc
Measuring Terminal		4 alligator clips	2 alligator-jaw clips	2 fixed spring clips (for axial style leads)
Lead Length (approx.)		105 cm		30 cm
Net Weight (approx.)		120g	140g	320g
Dimensions (H x W x D)				75 x 110 x 80 (mm)

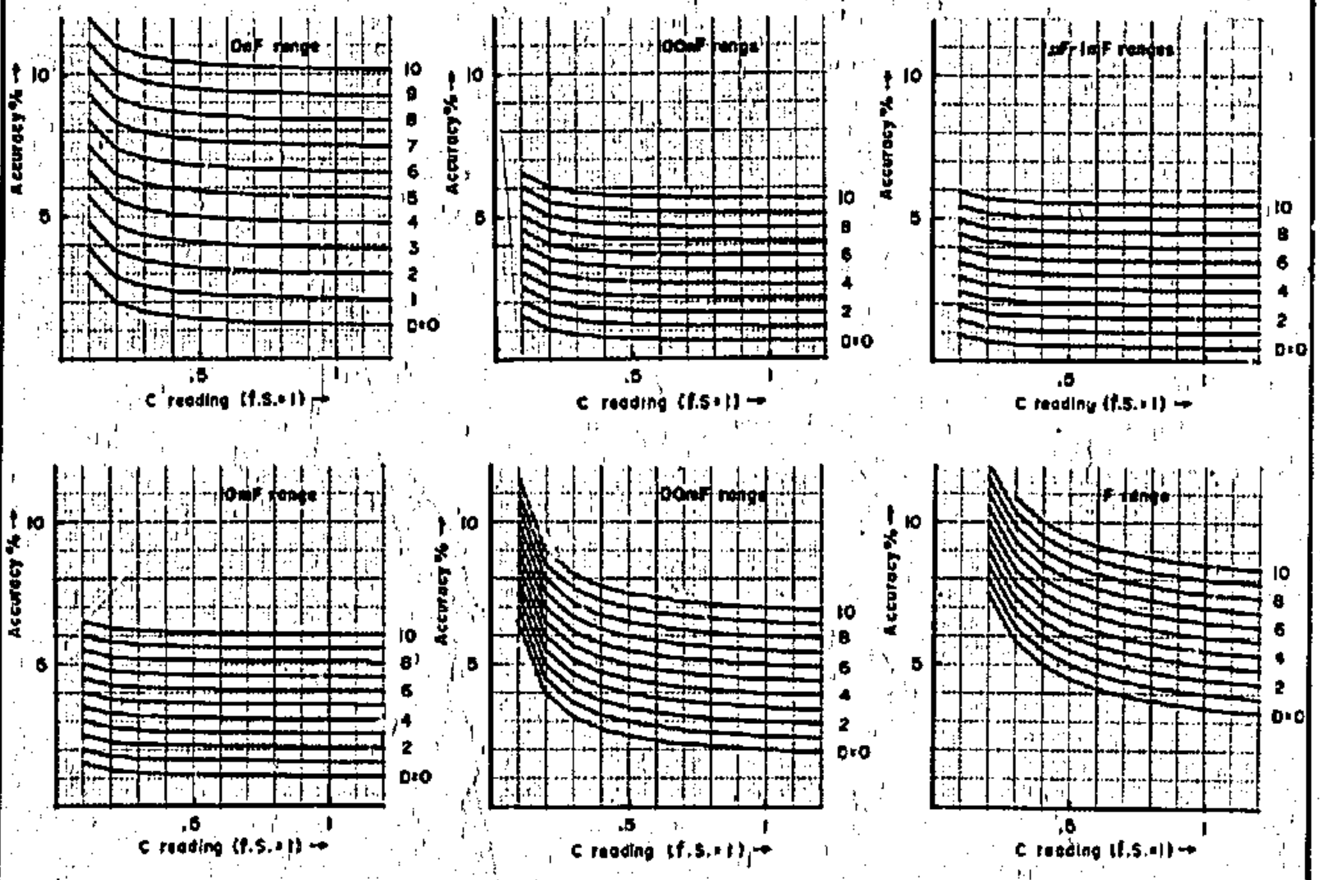


Figure 1-3. Measurement Accuracy (sheet 1 of 2).

D and ΩF MEASUREMENT ACCURACY

When applying these curves in ΩF measurements, subtract 0.5% from accuracy readings.

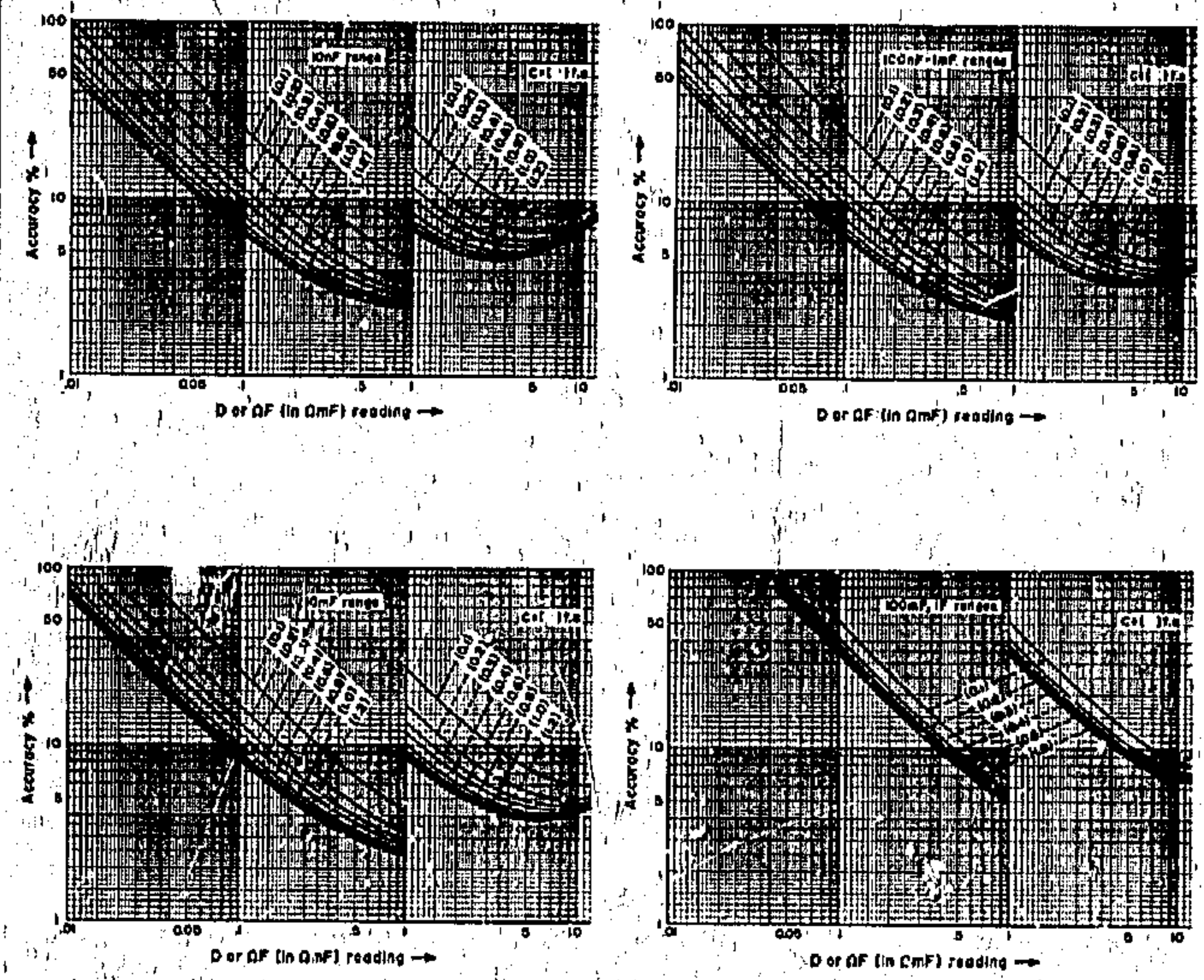


Figure 1-3. Measurement Accuracy (sheet 2 of 2).

SECTION II
INSTALLATION

2-1. INTRODUCTION.

2-2. This section contains information for unpacking, inspection, repacking, storage and installation of the Model 4282A Digital High Capacitance Meter. Also included are instructions for installing Option 001 Leakage Current Measurement.

2-3. UNPACKING AND INSPECTION.

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

2-5. PERFORMANCE CHECKS.

2-6. The electrical performance of the Model 4282A should be verified upon receipt. Performance checks suitable for incoming inspection are given in Section V, Maintenance.

2-7. REPACKAGING FOR SHIPMENT.

2-8. The following paragraphs contain a general guide for repackaging instrument for shipment. Refer to Paragraph 2-9 if original container to is be used; otherwise see paragraph 2-10. If you have any questions, contact your Hewlett-Packard Sales and Service office (see rear of manual for locations).

NOTE

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

2-9. Place instrument in original container with appropriate packing material and seal well with strong tape or metal bands.

2-10. If original container is not to be used, pack as follows:

a. Wrap instrument in heavy paper or plastic before placing in an inner container.

b. Place packing material (3 to 5 inches) around all sides of instrument and protect panel face with cardboard strips.

c. Place instrument and inner container in a heavy carton or wooden box and seal with strong tape or metal bands.

d. Mark shipping container "DELICATE INSTRUMENT", "FRAGILE", etc.

2-11. ENVIRONMENT.

2-12. Conditions during operation and storage should normally be limited as outlined below.

2-13. Conditions during operation:

a. Minimum temperature 32°F (0°C).

b. Maximum temperature 122°F (50°C).

c. Relative humidity less than 90%.

2-14. Conditions during storage:

a. Minimum temperature -22°F (-30°C).

b. Maximum temperature 167°F (75°C).

2-15. INSTALLATION.

2-16. Bench Use.

2-17. The Model 4282A is shipped with plastic feet and tilt stand in place, ready for use as a bench instrument. The instrument can be set firmly on other -hp- full module instruments on its plastic feet.

2-18. Rack Use.

2-19. The Model 4282A may be rack mounted by attaching the furnished rack mount kit. When mounted in a rack using rack mount kit, additional support at the rear of instrument should be provided.

To install rack mount kit, 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 at front end sides.

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 INSTRUMENTS DO NOT DISCHARGE HOT AIR NEAR COOLING VENTS.

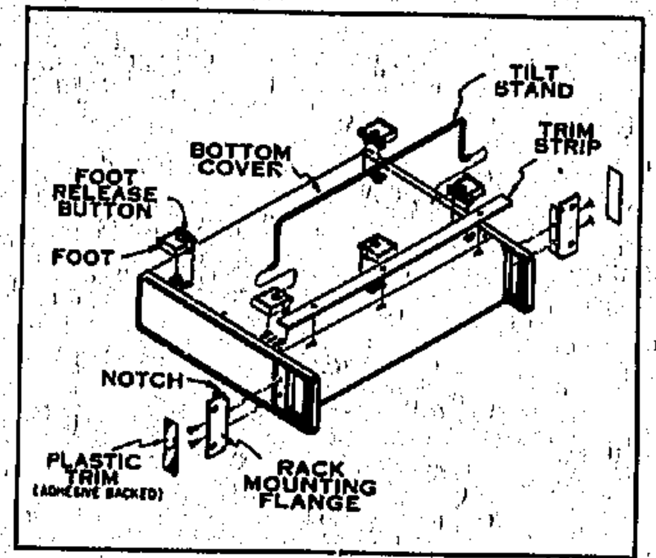


Figure 2-1. Preparation for Rack Mounting.

2-20. POWER CONNECTION.

2-21. Line Voltage. The instrument can be operated from 100, 120, 220 or 240Vrms (±10%) and 50 or 60Hz power lines. Voltage selection is made by a plug-in "circuit card" as shown in Figure 2-2. Table 2-1 shows required ac line fuses.

CAUTION !

To avoid damage to the instrument, complete line voltage conversion and replacement of fuse before connecting power cable.

Table 2-1. Line Voltage Conversion.

Line Voltage Conversion	100 Volt or 120 Volt	220 Volt or 240 Volt
Circuit Card	Expose 100 or 120 Volt Mark	Expose 220 or 240 Volt Mark
AC Line Fuse	1 Ampere, Slow Blow HP 2110-0007	0.5 Ampere, Slow Blow HP 2110-0202

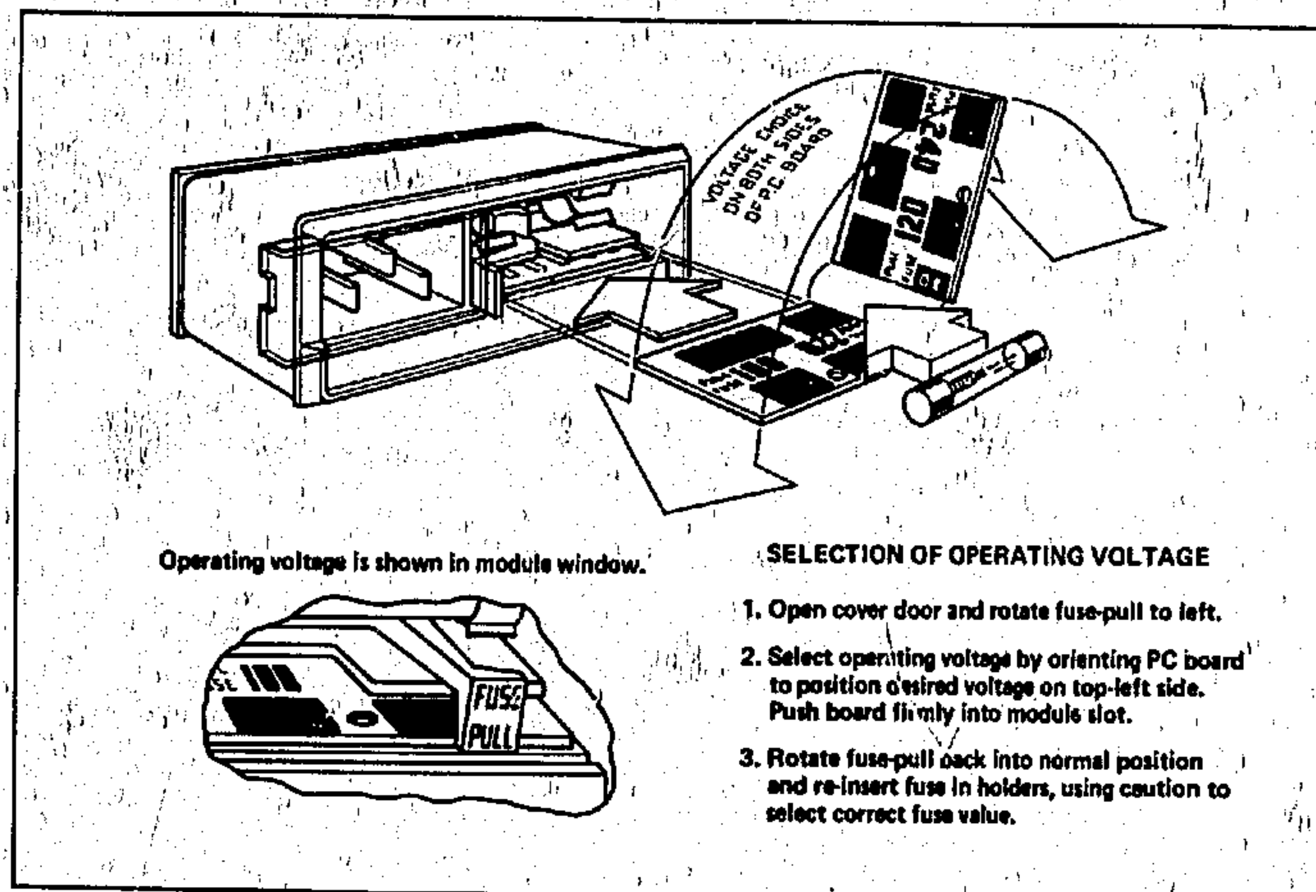


Figure 2-2. Line Voltage Selection.

2-22. Power Cable. To protect operating personnel, the National Electrical Manufacturer's Association (NEMA) recommends that instrument panels and cabinets be grounded. Accordingly, the Model 4282A 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 round pin on plug for safety. When only 2-blade outlet is available, use connector adapter (-hp- Stock No. 1251-0048), then connect short wire from side of adapter to ground to preserve protection feature.

2-23. OPTION 001: LEAKAGE CURRENT INSTALLATION.

2-24. When it is desired to add leakage current measurement function to a standard 4282A, order Leakage Current Board (A7) Kit (HP Part No. 04282-76001). To install, follow instructions below. After installation make performance check according to Paragraph 5-20. The A7 board has been factory adjusted, so it should meet specifications. If not, make adjustments according to paragraph 5-56.

Leakage Current Board A7 Installation Procedure.

a. Loosen the 4 screws in top cover and lift off.

b. The Leakage Current Board (A7) mounts on the 4 studs inside top left corner of instrument. To begin installation, unfasten connector board (HP Part No. 04282-77207) mounted on left rear stud. This board provides part of connection between A7 board and rest of instrument.

c. Refer to Figure 2-3(a). Loosen the two screws indicated by arrows.

d. Set instrument on its left side. Loosen the four bottom cover screws and lift cover off.

e. Loosen the 10 screws marked by "✓" on A3 and A4 boards. Open out the A3 and A4 boards (up and down). Note the Display Board A5 is directly connected to A4 board and A4 must be pulled away from A5 to disconnect.

f. Feed cable of Leakage Current Board (A7) through the small rectangular hole near left side frame. Dress cable as shown in Figure 2-3(b). Remove board (HP Part No. 04282-87207) from the A3XA3 socket. Discard board. Install connector board at end of W6 cabling in A3XA3. Pin A of new connector board should mate with pin A on A3XA3 (marked on board) as shown in Figure 2-3(b).

g. Install cable clamp at the two points illustrated in Figure 2-3(b).

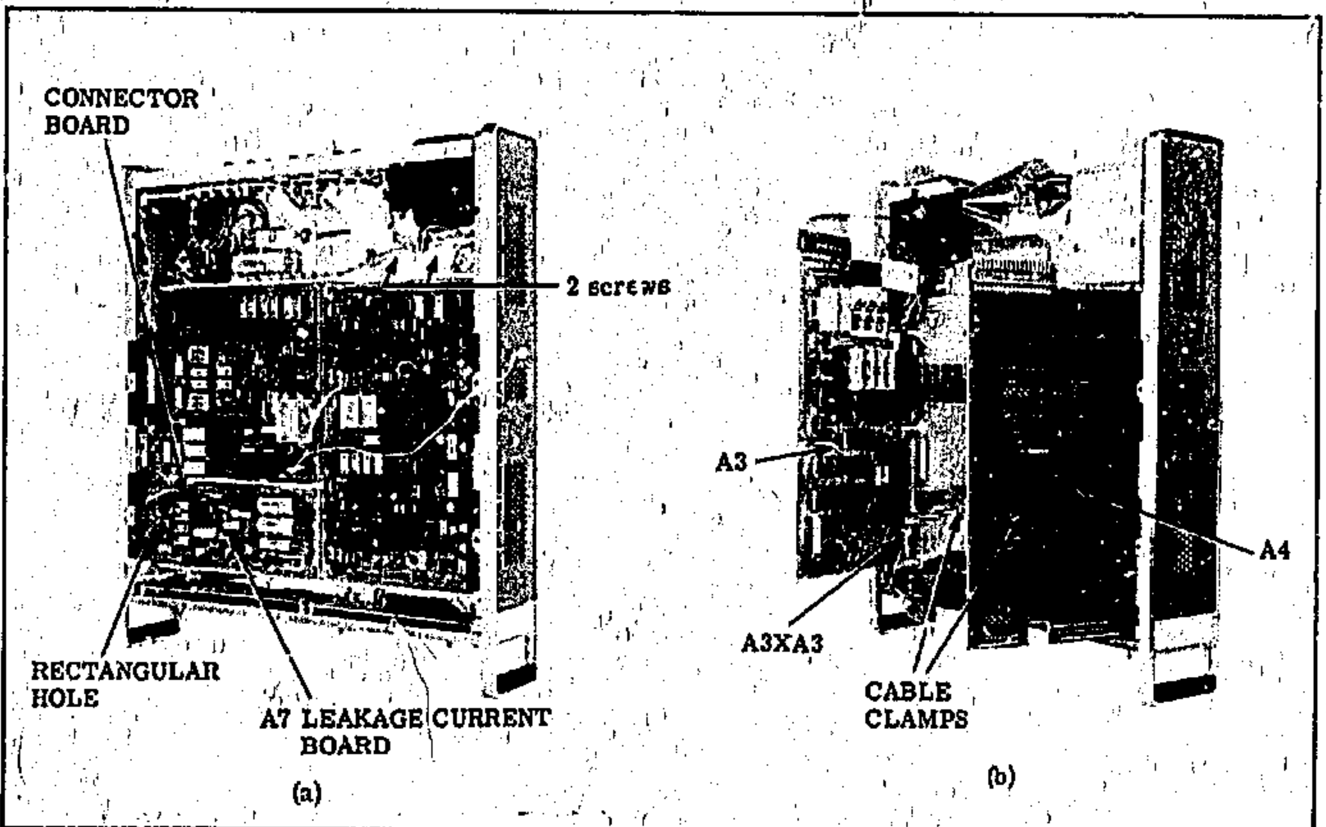


Figure 2-3. Installation of Option 001 Leakage Current Measurement.

h. Reinstall A3 and A4 boards. Tighten screws. Note: Insert A5 board firmly into the A4 connector.

i. Reinstall bottom cover. Turn instrument top side up.

j. Install A7 board with the four screws.

k. Push Connector Board (HP Part No. 04282-77207) into connector on A7 board. Pin A on connector board should mate with pin A on the A7 board (marked on board).

l. Tighten two screws indicated with arrows in Figure 2-3(a).

m. Replace top cover.

n. Remove the "NO" label from above I_L position of FUNCTION switch on front panel.

SECTION III
OPER. ION

3-1. INTRODUCTION.

3-2. This section contains instructions for operating the Model 4262A Digital High Capacitance Meter. Included are descriptions of front and rear panel controls and connectors, measurement procedures, and interfacing instructions for peripheral equipment.

3-3. FRONT AND REAR PANELS.

3-4. Figures 3-6 and 3-7 show front and rear panel controls and connectors with a brief description of each. These figures are to enable you to become familiar with the Model 4262A.

3-5. MEASUREMENT CAPABILITIES.

3-6. Besides its capability of measuring the basic characteristics of high value capacitors, the instrument also serves as a digital voltmeter to 600Vdc.

3-7. Basic characteristics of the unknown capacitor are represented as a series equivalent circuit in Figure 3-1 and are measured by the Four-Terminal Method. Measurable characteristics are capacitance (C), dissipation factor (D) and ohm-farad (ΩF)* as established by FUNCTION switch settings. When FUNCTION switch is set to C-D or C-ΩF, capacitance and dissipation factor or capacitance and ohm-farad are displayed alternately. The unit also features measurements with internal dc bias up to +10volts.

*Ohm-farad: the product of capacitance and equivalent series resistance of capacitor. The unit "ΩF" is employed throughout this manual and while not yet a commonly used electrical unit, it is useful and is provided for convenience.

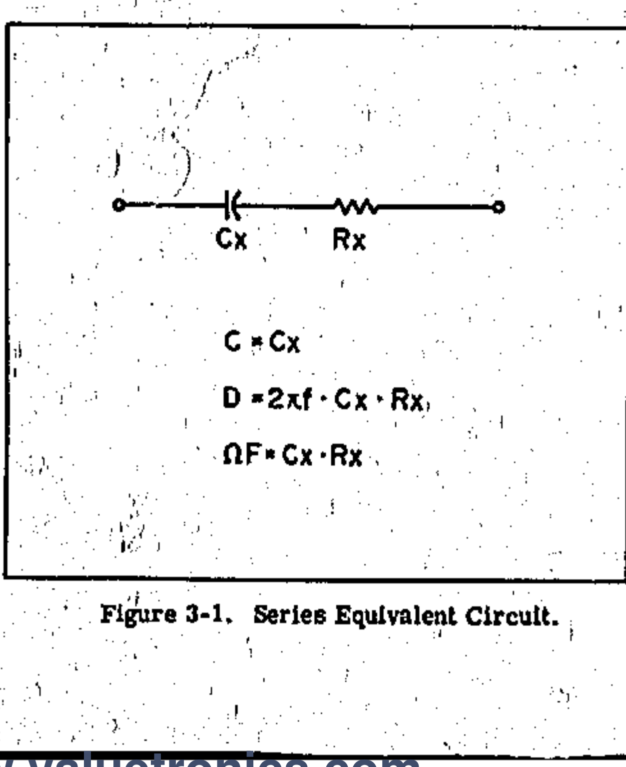


Figure 3-1. Series Equivalent Circuit.

3-8. The instrument measures dc voltage up to 600 volts when FUNCTION switch is set to V. This feature can be used not only to measure dc bias voltage but also to measure an external dc voltage (single ended input).

3-9. When equipped with Option 001 Leakage Current, the instrument measures leakage current flowing through unknown capacitor when FUNCTION switch is set to I_L. The basic measuring circuit is shown in Figure 3-2.

Note

On standard instruments (no option), a "NO" mark is put above I_L position, which means that I_L is not a function of unit.

3-10. Balancing Time and Reading Rate.

3-11. Bridge balance takes approximately 1 second on ranges through the 10mF range, 2 seconds on 100 mF range and 4 seconds on the 1F range after connecting unknown and setting to appropriate range. This balancing time changes somewhat depending upon timing of range selection and unknown capacitance or dissipation factor. When making dc biased measurements, bridge section balances after dc bias reaches a near constant value.

3-12. Digital voltmeter section reads analog output from bridge section and displays result. DVM reads

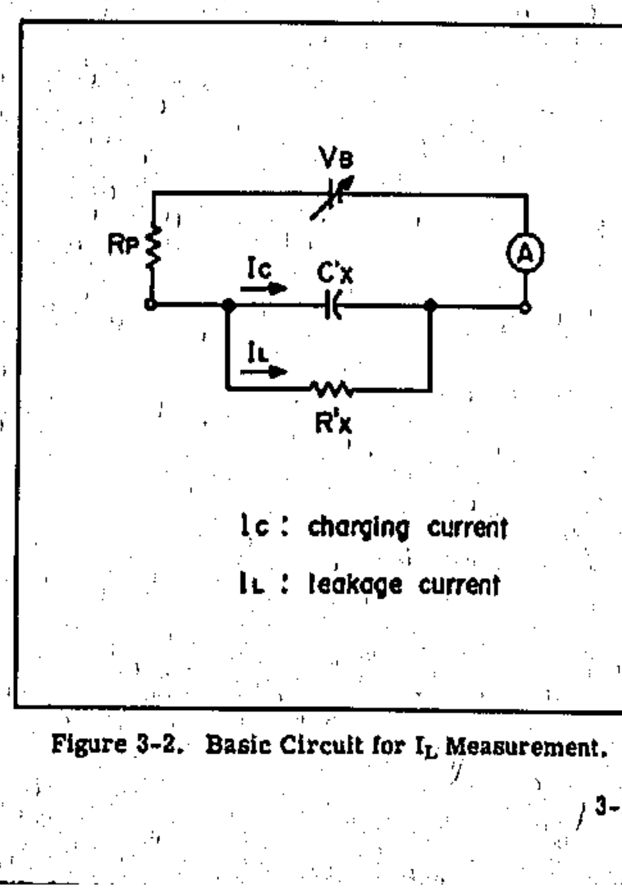


Figure 3-2. Basic Circuit for I_L Measurement.

with own reading rate if bridge section is in a balanceable condition. This reading period is continuously variable from about 0.3 to 2 seconds. It is a function of RATE control setting. When this control is set to HOLD, the display is held infinitely (this permits manual or external control by applying a reset signal). Reading rate is annunciated by a single LED which lights for about 100ms during each reading period.

3-13. Measuring Frequencies.

3-14. Four measuring frequencies are provided, namely: 50, 60, 100 and 120Hz. However, 50Hz is not available at 60Hz line operation and vice versa for 50Hz line operation.

3-15. Measuring Voltage.

3-16. Table 3-1 lists measuring voltages. This table may be used as a reference to set an appropriate bias voltage. The voltage between current leads is about 1Vrms when open.

Table 3-1. Measuring Voltage.

C Range	Measuring Voltage
10nF to 10mF	<1 Vrms
100mF	<0.1 Vrms
1F	<10 mVrms

3-17. UNBALance and OVERLOAD Annunciators.

3-18. When RANGE switch setting is invalid or exceeds measurable range, UNBALance and/or OVERLOAD annunciators light. UNBALance lights when bridge section is out of range. OVERLOAD lights when the unknown value exceeds overranging capability of RANGE selected (it may occur near 20% overranging). Since OVERLOAD and UNBALance usually light together, it means "up-ranging" is required. In voltage or leakage current (option 001) measurements, UNBALance does not function. An OVERLOAD light means that "up-ranging" is required (except 1kV range). Do not exceed maximum voltage input because OVERLOAD does not operate on 1kV range. When OVERLOAD lights, all digits are blanked.

3-19. When only UNBALance annunciator lights, the RANGE selected is too high (generally) or dissipation factor of unknown is out of measurable range. "Down-ranging" is usually necessary.

3-20. CHECK FUSE Annunciator.

3-21. A 2A fast action fuse is inserted in series with the measuring circuit to protect it from damage from excessive charge or discharge current. CHECK FUSE annunciator lights when this fuse blows and signals a disabled measurement condition. Fuse replacement is then required. This fuse is located in MEAS CKT fuse holder on rear panel.

Note

1. When changing dc bias voltage, CHECK FUSE annunciator may light momentarily. This is meaningless and is normal.

2. In I_L measurements (option 001) if this fuse blows, the annunciator does not light. If I_L function appears to be disabled, discharge unknown capacitor externally and remove. Set FUNCTION switch to C. CHECK FUSE sensor will then annunciate indicating that replacement of fuse is required.

3-22. Capacitance (C) Measurement.

3-23. When FUNCTION switch is set to C, capacitance C (shown in Figure 3-1) is measured in 9 ranges of 10nF to 1F full scale. Display is four full digits with 18% overranging. When C RANGE switch is set to an improper position, OVERLOAD and/or UNBALance annunciators will light, which indicates that C RANGE switch must be reset. Measured values are displayed with unit and decimal point after selecting proper range.

Note

Step by step procedures covering measurement described in paragraphs 3-22 through 3-31 are given in Figure 3-8.

3-24. Dissipation Factor (D) Measurement.

3-25. When FUNCTION switch is set to D, dissipation factor D (shown in Figure 3-1) is measured in 2 ranges of 1 or 10 full scale. Display is three full digits with 18% overranging. D range selection is automatic but UNBALance annunciator may light if C RANGE setting is not proper. Measured values are displayed automatically with decimal point.

3-26. Ohm-farad (ΩF) Measurement.

3-27. When FUNCTION is set to ΩF, the ohm-farad ΩF (shown in Figure 3-1) is measured in 2 ranges of 1ΩmF or 10ΩmF full scale. Display is three full digits with 18% overranging. ΩF range selection is automatic but UNBALance annunciator may light if C RANGE setting is improper. Measured values are displayed with unit and decimal point. This value divided by C value displayed when FUNCTION switch is set to C equals value of equivalent series resistance Rx (see Figure 3-1).

3-28. C-D Alternating Measurement.

3-29. When FUNCTION switch is set to C-D, capacitance C and dissipation factor D (shown is Figure 3-1) are measured alternately. Measurement capabilities are the same as if functions were selected individually except for alternating measuring rate which is set by RATE control.

3-30. C-ΩF Alternating Measurement.

3-31. When FUNCTION switch is set to C-ΩF, capacitance C and ohm-farad ΩF (shown in Figure 3-1) are measured alternately. Measurement capabilities are the same as if functions were selected individually, except for alternating measuring rate which is set by RATE control.

3-32. Capacitance Measurement with DC Bias.

3-33. All measurements described in paragraphs 3-22 through 3-31 can be also performed when dc bias (up to 10 volts) is applied. When DC BIAS RANGE switch is set to 10V, DC BIAS ON/OFF switch to ON (ON lamp lights) dc bias up to 10 volts is available and may be set with DC BIAS control. Bias voltage can be measured (three full digits) by setting FUNCTION switch to V. Step by step procedure is given in Figure 3-9.

CAUTION

ON STANDARD INSTRUMENTS, BIAS VOLTAGE ABOVE 10 VOLTS IS NOT APPLIED WHEN DC BIAS RANGE SWITCH IS SET TO 100V OR EXT POSITIONS. BUT IN OPTION 001 INSTRUMENTS, WHEN, IN ADDITION TO SETTING DC BIAS RANGE SWITCH TO 100V OR TO EXT, THE FUNCTION SWITCH IS SET TO I_L, DAMAGE TO UNKNOWN MAY OCCUR.

3-34. Extremely High Capacitances.

3-35. The Four-Terminal Method is an ideal measurement method but requires some careful application when measuring extremely high capacitances. This is because a voltage E_M is induced in voltage leads by mutual inductance M and measuring current I (see Figure 3-3) which produces an error. Since the effect is most pronounced at extremely high capacitances, it generally effects measurements taken on the 100mF and 1F ranges. E_M may be a positive or negative value with respect to E_X, thus it is not necessarily always a plus or always a minus error.

3-36. For a more accurate measurement, the obvious answer is to reduce E_M. This need is not apparent from reading the display. E_M is proportional to ω, M and I [see Figure 3-3(a)]. Considerations for these three factors are:

a. Angular velocity ω ($2\pi f$).
Since a lower ω contributes to reduce an error, a lower measuring frequency is recommended. Thus, measuring frequencies of 50 or 60Hz produce better results than 100 or 120Hz.

b. Mutual inductance (M).
Longer test leads and a shorter distance between voltage and current leads increase error. Short test leads with voltage and current leads separated as much as possible are best. It is also useful to twist the two voltage leads together and same for current leads as voltages induced in short twisted sections interact inversely with each other. In addition, it helps to set voltage leads and current leads at right angles to each other. This prevents interlinking of magnetic flux [see Figure 3-3(b)].

c. Measuring current (I).
This is an independent value and is fixed by value of unknown. Because larger capacitances produce less Ex and larger E_M, the 1F range is most affected.

3-37. It is recommended that Model 16035A Test

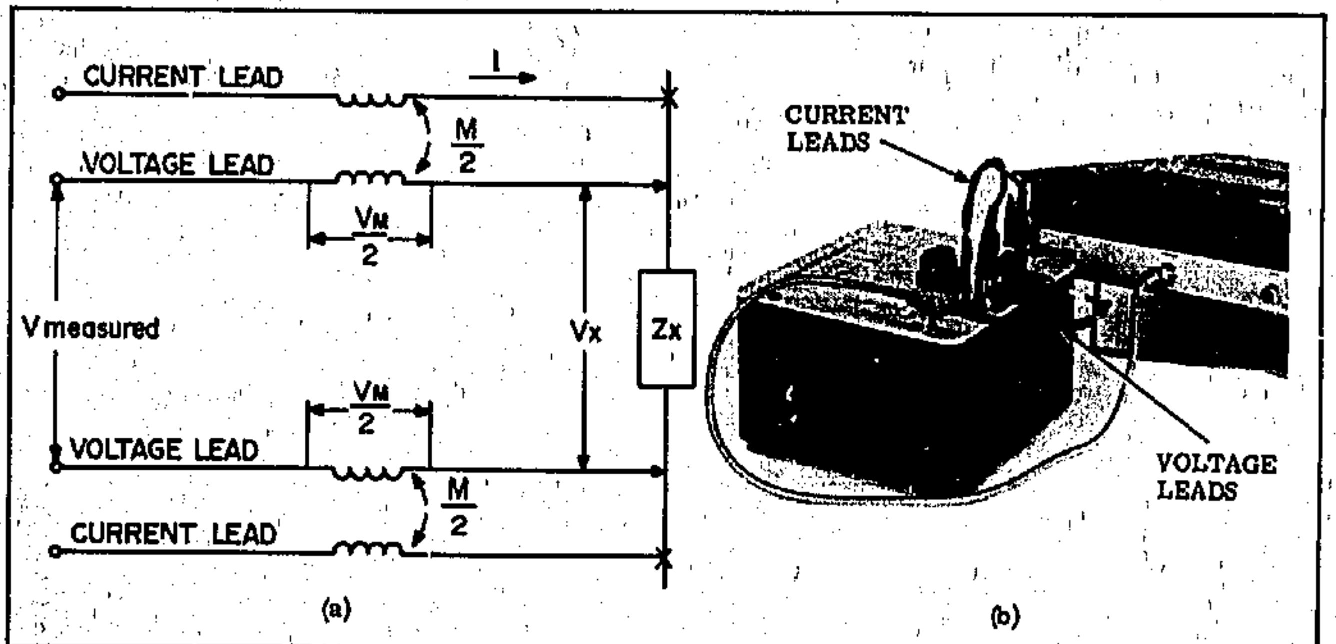


Figure 3-3. Test Lead Effects (Hi-C Measurements).

leads be used on 100mF and 1F ranges. The Model 16036A Test Leads have significantly greater mutual inductance on these two ranges and their use should be restricted to lower capacitance ranges.

3-38. Low Capacitance Measurements.

3-39. Distributed capacitances between test leads themselves and between test leads and ground affect measuring accuracy, especially on 10nF and 100nF ranges. The instrument is adjusted for use with Model 16036A Test Leads or 16037A Test Fixtures expecially in consideration of lower capacitance ranges. Thus, when user designed test leads are employed, it is necessary to check and possibly adjust instrument to ensure that measurement specifications are met. Please consult your HP Sales and Service Office for assistance.

3-40. DC Voltage Measurement.

3-41. When DVM INPUT SELECTOR switch is set to EXT on rear panel and FUNCTION switch to V, the instrument is capable of measuring dc voltages up to ±600 volt (10V, 100V and 1kV ranges). Display is three full digits plus 18% overranging except 1kV range. When overranging (near 20%) of RANGE selected is exceeded, OVERLOAD annunciator lights and all digits are blanked. Voltage range is selected by DC BIAS RANGE switch. The 1kV range is EXT position. Input is applied at DVM INPUT terminals on rear panel. Measured values are displayed with unit, decimal point and minus polarity as necessary. Step by step procedure is given in Figure 3-10.

CAUTION

MAXIMUM INPUT IS ±600VDC. NO OVERLOAD ANNUNCIATION IF EXCEEDED!

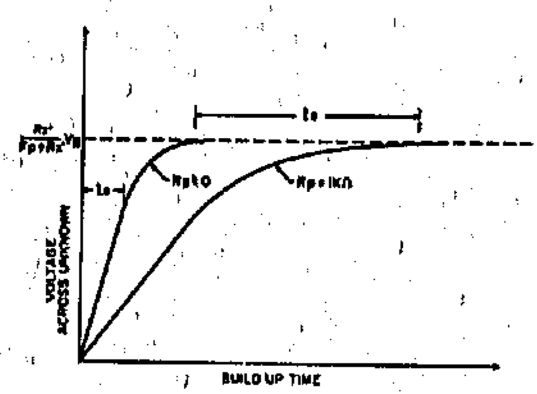
3-42. I_L - Leakage Current Measurement (Option 001).

3-43. When instrument is equipped with Option 001 Leakage Current Measurement, and FUNCTION switch set to I_L, the instrument measures leakage current of an unknown capacitor in 5 ranges of 1μA to 10mA full scale. Display is three full digits with 18% overranging. I_L RANGE selection is manual. When overranging (near 20%) of I_L RANGE selected is exceeded, OVERLOAD annunciator lights and all digits are blanked. Available internal bias voltage range up to 100Vdc and to 600Vdc external. Bias voltage is measurable by setting FUNCTION switch to V. Measured values are displayed with unit and decimal point.

3-44. To improve I_L display stability on (only) 1μA and 10μA ranges a large capacitor is inserted into the circuit. This increases typical detector responce time to 20 seconds. I_L measurements then, on these two ranges, takes somewhat longer. Step by step procedures are given in Figure 3-11.

WARNING

DO NOT TOUCH UNKNOWN CAPACITOR WHEN MAKING I_L MEASUREMENTS! PERSONAL INJURY MAY RESULT! AFTER EACH MEASUREMENT SET DC BIAS ON/OFF SWITCH TO OFF AND DISCHARGE UNKNOWN CAPACITOR.



1. "t_a" is adjustable range which can be adjusted by Rp (≑ A7R1).

2. "t_c" is time that 60mA charging current flows. It should be less than one minute which is endurance time limit of internal 100V range source when resistor Rp is near zero ohms (A7R1 = 0).

3. Curves show tendency of effect of protective resistor Rp (≑ A7R1) adjustment. This is directly applicable for capacitors below:

$$Cx(mF) = 30(mF) \cdot \frac{100(V)}{V_B(V)}$$

where Cx(mF) = unknown capacitance
100(V) = internal bias range
V_B(V) = actual applied bias

4. It is recommended that an external bias source is provided for capacitors above:

$$Cx(mF) = 30(mF) \cdot \frac{100(V)}{V_B(V)}$$

When using internal bias sorrce on 100V range, lower limit of Rp (= A7R1) is restricted to:

$$Rp(=A7R1) = \frac{V_B(V) - 3.6/Cx(F)}{0.012 + 0.00012 \cdot V_B(V)}$$

(in ohms)

Figure 3-4. Effect and Adjustment of Protective Resistor in Bias Circuitry.

CAUTION

WHEN MAKING LEAKAGE CURRENT (I_L) MEASUREMENT, OBSERVE THE FOLLOWING TEST LEADS VOLTAGE LIMITS:

Model 16035A Test Leads:

600Vdc maximum.

Model 16036A Test Leads:

100Vdc maximum.

3-45. Series Protective Resistor Adjustment.

3-46. In the leakage current measuring circuit, when DC BIAS RANGE switch is set to 100V or EXT position, a 1kΩ resistor A7R1 (see Rp in Figure 3-2) is inserted in series with unknown to limit excessive charging current. This means that it takes a relatively long time to build up a very large capacitor. For example, the time constant τ is 50 seconds when Rp is 1kΩ, Cx' is 100mF and Rx' is 1kΩ as shown in Figure 3-3. If, for example, it takes 5τ to complete build up of the unknown capacitor, a total build up time of 250 seconds would be required. Therefore, it is recommended and practical that the resistance value of the protective resistor be reduced in these instances. The effect of the adjustment is shown in Figure 3-4 (with notes). Here is how the protective resistor may be adjusted:

1. Remove top cover by loosening the four screws and lifting off cover.

2. Connect desired resistance value in parallel with A7R1. Solder resistor to position shown in Figure 3-5. Use following formula to compute value:

$$\mathrm{Rext}(\Omega) = \frac{1000 \cdot \mathrm{Rp}(\Omega)}{\mathrm{Rp}(\Omega) - 1000}$$

where, Rext(Ω) is resistor that should be installed in parallel with A7R1.
Rp(Ω) is protective resistance value after padding adjustment.

3. Reinstall top cover.

CAUTION

1. WHEN USING EXTERNAL BIAS SOURCE, CHARGE OR DISCHARGE CURRENT MUST NOT EXCEED 1A.

2. WHEN APPLYING BIAS USING INTERNAL SOURCE, DO NOT SHORT TERMINALS FOR MORE THAN ONE MINUTE (60MA CHARGING CURRENT FLOWS).

3-47. Test Fixtures.

3-48. Available test fixtures are Model 16037A Test Fixture for capacitors with axial leads and Model 16037A Opt. 001 Test Fixture for capacitors with vertical leads. These facilitate ease of use for making measurements on capacitors up to 1mF as readings may be taken by simply inserting unknown into contact section of test fixture. Both test fixtures are identical except for the contact portion which is interchangeable. The operating characteristics for the fixtures are given in Table 1-3.

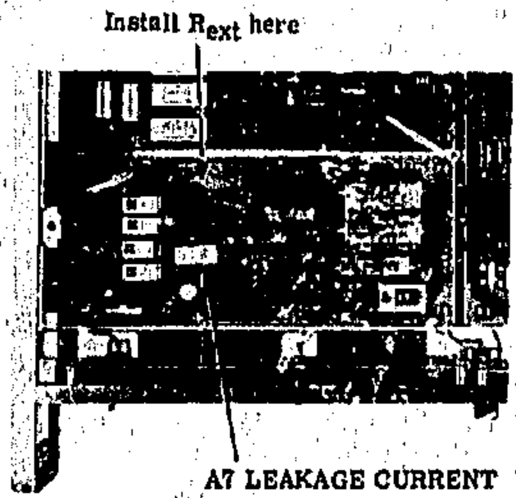


Figure 3-5. Protective Resistor Location.

3-49. INTERFACING WITH PERIPHERALS.

3-50. The instrument provides a REMOTE IN connector for remote programming, a DIGITAL OUT connector for digital printer and ANALOG OUT terminals for an analog recorder. These connectors and terminals provide direct control access and data output routes for interfacing the instrument with peripheral equipment.

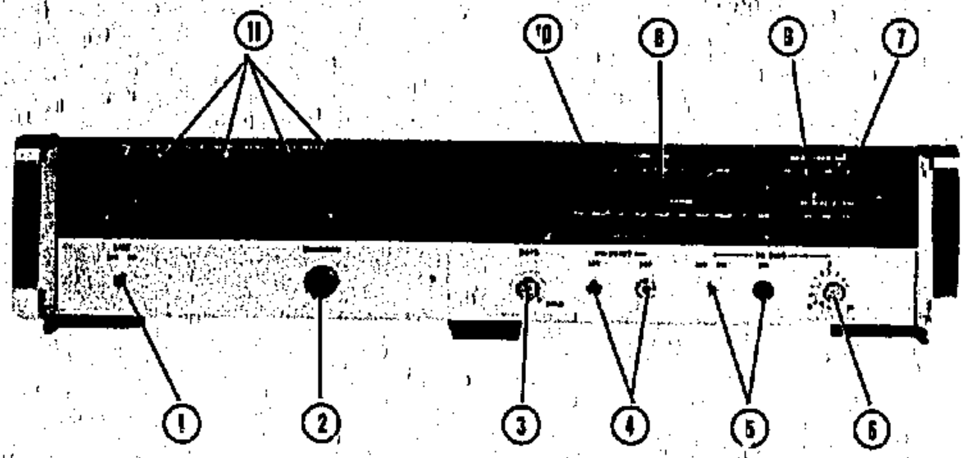
3-51. Remote Programming.

3-52. Function C/I_L Range and/or Reset can be controlled remotely through REMOTE IN connector on rear panel. All lines for remote operation are controlled by TTL/DTL logic level signals or contact closure to ground. When instrument is not being programmed, all lines are at high level.

3-53. Figure 3-13 describes requirements for remote programming. Operating procedure is as follows:

a. Set FUNCTION and/or C/I_L RANGE switch to REM. If only FUNCTION or C/I RANGE switch is set to REM, the other may be set as desired.

b. For C, D or ΩF measurements, set MEAS FREQ switch as desired.



FRONT PANEL

Front Panel Controls and Indicators.

1. LINE ON/OFF switch: Turns power ON or OFF.

2. UNKNOWN connector: For attaching test leads to instrument.

3. RATE control: Controls single or alternating reading rate. Reading rate is annunciated by single LED (see 11).

4. RESET switch (INT): Permits pushbutton manual trigger when RATE control set to HOLD. RESET jack (EXT): Enables remote trigger by TTL/DTL low levels or contact closure to ground when RATE control set to HOLD.

Note

Bias controls include 5, 6 & 7.

5. DC BIAS ON/OFF switch: When ON, enables DC BIAS RANGE switch and DC BIAS control. ON lamp lights. When OFF, in I_L measurement, a discharging resistor (400Ω) is connected across unknown capacitor.

6. DC BIAS control: When DC BIAS ON/OFF switch set to ON, variable continuously over range selected (except in EXT position).

7. DC BIAS RANGE switch: Is valid when DC BIAS ON/OFF switch set to ON and provides three functions as given in following table:

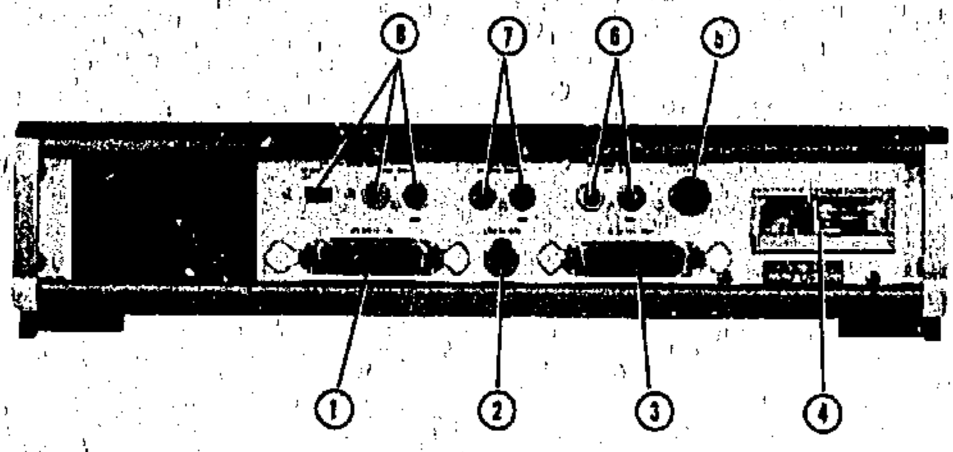
Function	Available Settings
C, D, ΩF	10V range only.
V	10V, 100V and EXT ranges.
I_L (option 001)	10V, 100V and EXT ranges.

8. FUNCTION switch: Selects measurement functions as given in following table:

Function	Measurement(s)
C	Capacitance only.
D	Dissipation factor only.
ΩF	Ohm-farad only.
C-D	Capacitance/dissipation factor (alternately).
C-ΩF	Capacitance/ohm-farad (alternately).
V	DC voltage.
I_L (option 001)	Leakage current.
REM	Enables remote selection of above.

9. MEAS FREQ switch: Selects measuring frequencies of 50 (50Hz line only), 60 (60Hz line only), 100 or 120Hz.

Figure 3-6. Controls, Connectors and Indicators (Cont'd in Figure 3-7).



REAR PANEL

Front Panel Controls Cont'd.

10. C/I_L RANGE switch: Provides following ranges according to FUNCTION switch settings:

Function	Available Ranges
C, D, ΩF	10nF to 1F, 9 ranges in decade steps.
I_L (option 001)	1μA to 1mA, 5 ranges in decade steps.

REM of Range enables remote selection of above.

11. Display Section:
Numerical value: Displays measured values with decimal point. In C measurement, four full digits and for others, three full digits. Overranging is 10%.

Units: Are displayed corresponding to FUNCTION and/or RANGE switches settings.

Annunciators: UNBALance, OVERLOAD and CHECK FUSE annunciators (refer to paragraphs 3-17 and 3-20).

Reading rate annunciator: Single LED annunciates DVM reading rate.

Rear Panel Controls and Connectors.

1. REMOTE INPUT connector: Use for remote programming. Valid when FUNCTION and/or C/I_L RANGE switch set to REM (refer to Figure 3-13).

2. UNKNOWN connector: For test lead connections when UNKNOWN connector on front panel is not used. Useful in system measurements.

3. DIGITAL OUT connector: Provides +1-2-4-8 BCD coded information of measured values (refer to Figure 3-12).

4. Line Module: Line connector including line fuse and line voltage selector "plug-in" board (refer to paragraph 2-15).

5. MEAS CKT fuse: A 2A fast action fuse to protect measuring circuit from excessive charge or discharge current. If fuse blows, CHECK FUSE annunciator lights.

6. ANALOG OUT terminals: Provides analog output of 0 to 1V full scale (proportional to displayed values). Black terminal is chassis ground.

7. EXT BIAS terminals: Single ended (black is ground). Valid when instrument equipped with Option 001: Leakage Current Measurement and DC BIAS RANGE switch set to EXT. MAXIMUM INPUT IS +600Vdc.

8. DVM INPUT terminals: Single ended input terminal (black terminal is ground). Valid when FUNCTION switch set to V and DVM INPUT SELECTOR switch to EXT. MAXIMUM INPUT IS ±600Vdc.

Figure 3-7. Controls, Connectors and Indicators (Cont'd from Figure 3-6).

Note

The test frequency of 50Hz is not available for 60Hz line and vice versa for 50Hz line.

c. Set RATE control as desired.

Note

Reading rate may be set by either RATE control on front panel, TTL/DTL remote signals or by contact closure to ground via J4(18) EXT Trigger line (after setting RATE control to HOLD). Minimum reading period is less than 0.3 seconds.

d. Select desired function from remote location as enabled in Step a.

e. Select desired range from remote location as enabled in Step a.

f. For C, D, ΩF or I_L (option 001) measurements, connect suitable test leads to only one of either front or rear panel UNKNOWN connectors.

Note

When providing special test leads, it may be necessary to adjust instrument to achieve specifications. Please consult your HP Sales and Service Office for assistance.

g. Connect test leads to unknown capacitor.

h. If desired, apply allowable dc bias using DC BIAS RANGE, DC BIAS ON/OFF and DC BIAS control. The bias voltage can be monitored by programming V line or setting FUNCTION switch to V, according to whichever is set in Step a.

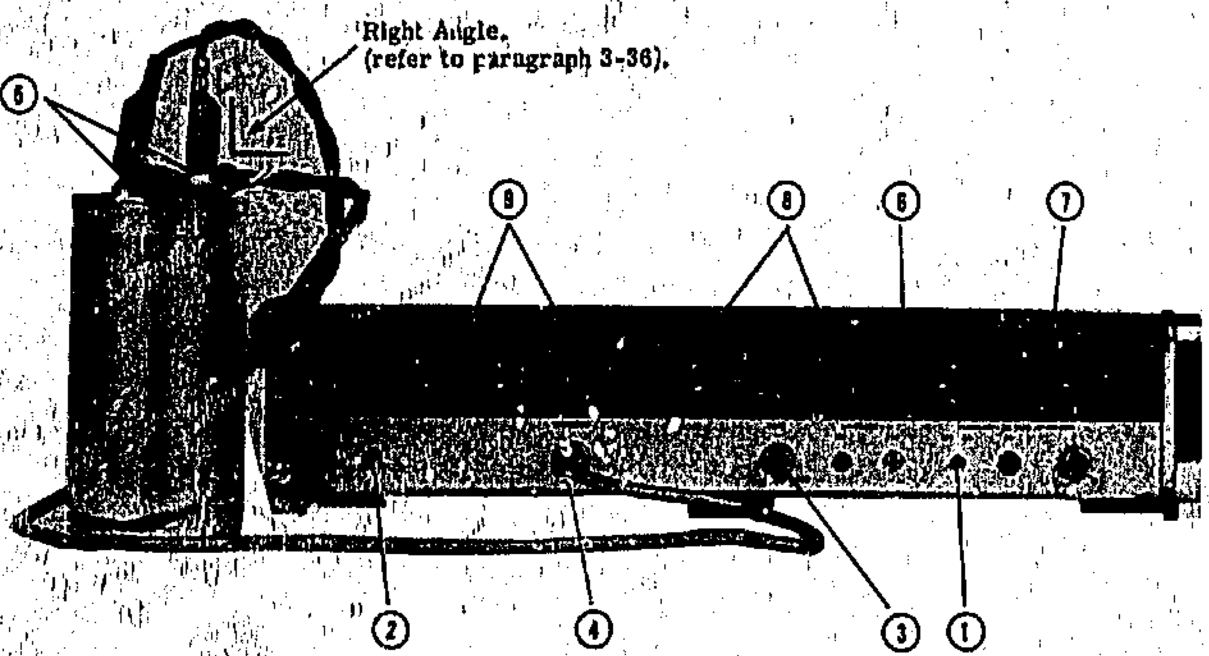
3-54. Digital Output.

3-55. Figure 3-12 illustrates print out information using HP *5050B/5055A Digital Recorders. Model 16498A Interconnection cable is available for connection between both instruments. Figure 3-12 also includes pin connections of DIGITAL OUT connector J5.

* With option 050 or 051.

3-56. Analog Output.

3-57. Measured data are also provided as 1 volt full scale analog information at ANALOG OUT terminals on rear panel. Output impedance is approximately 1kΩ.



1. Set BIAS ON/OFF switch to OFF.
2. Set LINE switch to ON.
3. Adjust reading rate with RATE control.
4. Select suitable test leads and attach to UNKNOWN panel connector.
5. Check polarity of test leads and connect to unknown capacitor.

Note 1

Do not connect test leads to a charged capacitor. It may damage instrument.

Note 2

When measuring capacitance values greater than 10mF, use Model 16035A Test Leads and twist the two voltage leads together and the two current leads together (voltage & current pairs independent of each other). In addition, set voltage leads and current leads at right angles to each other to reduce measurement interaction.

6. Set FUNCTION switch to desired function. See Table A.

Table A.

Function	Display
C	Capacitance only.
D	Dissipation factor only.
ΩF	Ohm-farad only.
C-D	Capacitance/dissipation factor (alternately).
C-ΩF	Capacitance/Ohm-farad (alternately).

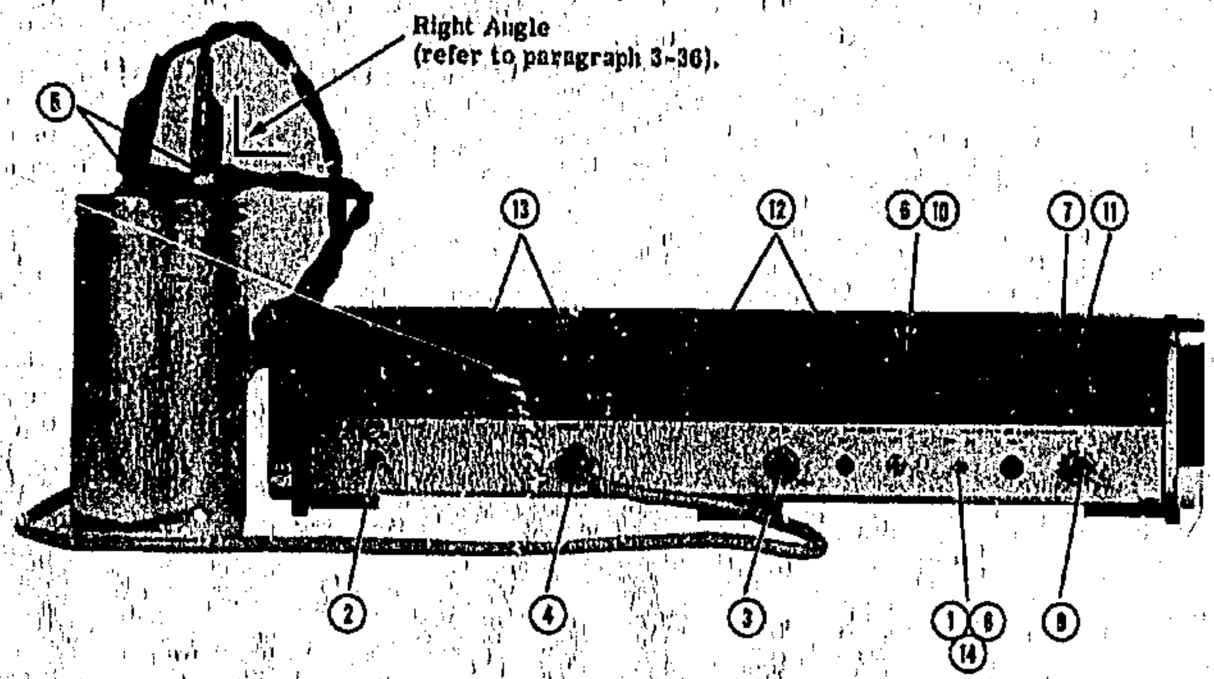
7. Set MEAS FREQ switch to desired test frequency (50Hz only on 50Hz line and 50Hz only on 60Hz line).
8. Select appropriate capacitance range with C RANGE switch and verify that UNBALance and/or OVERLOAD annunciators are not lit (refer to paragraph 3-17).

Note 3

A more suitable capacitance range results in better D or ΩF measurement accuracy.

9. Read measured value from display with unit and decimal point.

Figure 3-8. Capacitance, Dissipation Factor and Ohm-farad Measurements.



1. Set BIAS ON/OFF switch to OFF.

2. Set LINE switch to ON.

3. Adjust reading rate with RATE control.

4. Select suitable test leads and attach to UNKNOWN connector.

5. Check polarity of test leads and connect to unknown capacitor.

Note 1

Do not connect test leads to a charged capacitor. It may damage instrument.

Note 2

When measuring capacitance values greater than 10mF, use Model 16035A Test Leads and twist the two voltage leads together and the two current leads together (voltage & current pairs independent of each other). In addition, set voltage leads and current leads at right angles to each other to reduce measurement interaction.

6. Set FUNCTION switch to V.

7. Set DC BIAS RANGE switch to 10V.

8. Set DC BIAS ON/OFF switch to ON (ON lamp lights).

9. Rotate DC BIAS control from 0 clockwise to set desired bias voltage as indicated by monitored display.

10. Set FUNCTION switch to desired function. See Table A.

Table A.

Function	Display
C	Capacitance only.
D	Dissipation factor only.
ΩF	Ohm-farad only.
C-D	Capacitance/dissipation factor (alternately).
C-ΩF	Capacitance/Ohm-farad (alternately).

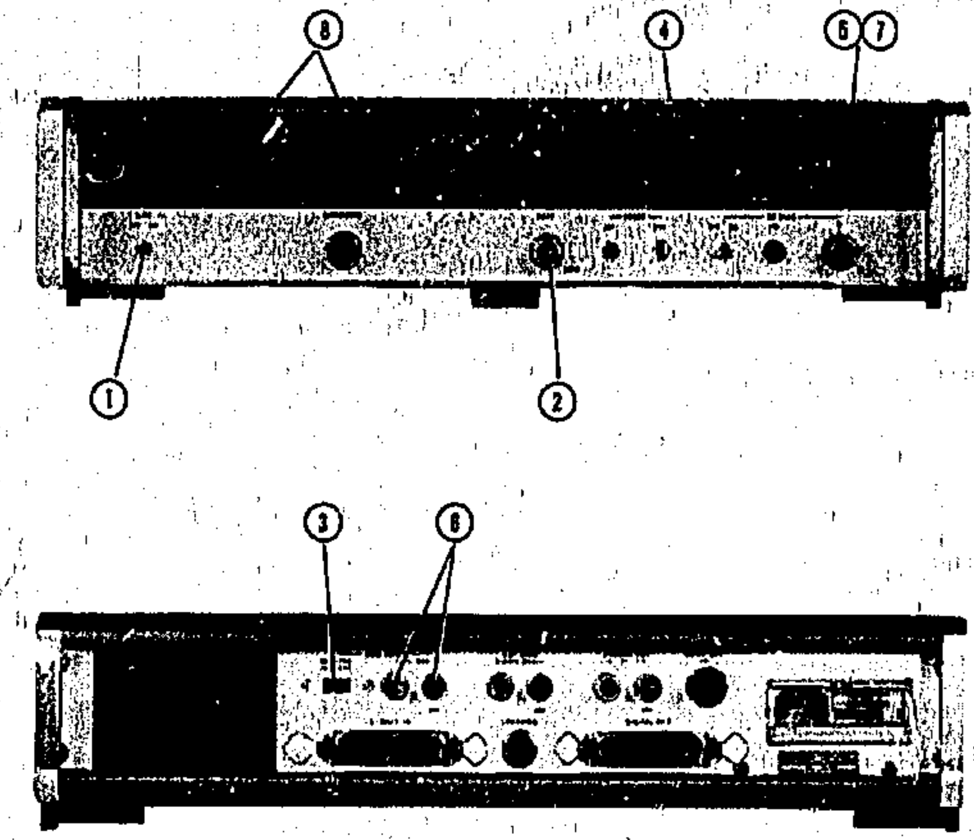
11. Set MEAS FREQ switch to desired frequency. (50Hz only on 50Hz line and 60Hz only on 60Hz line).

12. Select most appropriate capacitance range with C RANGE switch. Verify that UNBALANCE and OVERLOAD annunciators are not lit (refer to paragraph 3-17).

13. Read measured value from display with unit and decimal point.

14. Set DC BIAS ON/OFF to OFF to discharge capacitor. Discharge can be monitored by setting FUNCTION to V.

Figure 3-9. Capacitance, Dissipation Factor and Ohm-farad Measurements with DC Bias.



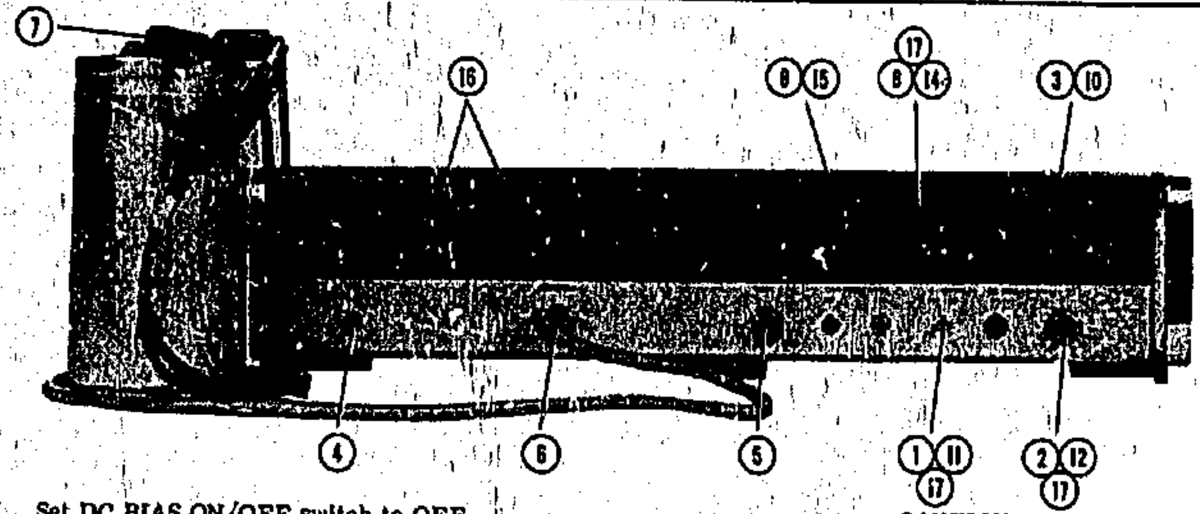
1. Set LINE switch to ON.
2. Set reading rate with RATE control.
3. Set DVM INPUT SELECTOR switch to EXT (rear panel).
4. Set FUNCTION switch to V.
5. Set DC BIAS RANGE switch to EXT (1kV range --- see CAUTION below).
6. Apply voltage to DVM INPUT terminal on rear panel (black terminal is grounded).

CAUTION

MAXIMUM INPUT VOLTAGE IS ±600VDC.

7. DC BIAS RANGE switch may now be moved to 100V or 10V according to input voltage.
8. Read measured value from display with polarity ("-" minus display only), unit and decimal point.

Figure 3-10. DC Voltage Measurement.



1. Set DC BIAS ON/OFF switch to OFF.

2. Turn DC BIAS control to full counter clockwise position.

3. Set DC BIAS RANGE switch to 10V.

4. Set LINE switch to ON.

5. Adjust reading rate with RATE control.

6. Select suitable test leads and attach to UNKNOWN connector.

CAUTION

MAXIMUM TEST LEAD VOLTAGES ARE:

For Model 16035A - 600VDC
16036A - 100VDC

DO NOT EXCEED THESE LIMITS!

7. Using only current leads, connect test leads to unknown capacitor. Observe polarity; protect voltage leads (if attached) and keep from touching undesired places.

CAUTION

DO NOT CONNECT TEST LEADS TO A CHARGED CAPACITOR.

8. Set FUNCTION switch to V.

9. Set I_L RANGE switch to 10mA.

10. Set DC BIAS RANGE switch to desired range. When using external dc source, set DC BIAS RANGE switch to EXT. Connect positive external voltage source to EXT BIAS terminals such that black terminal is ground.

CAUTION

OBSERVE POLARITY WHEN CONNECTING EXTERNAL VOLTAGE. BLACK TERMINAL GROUNDED. DO NOT EXCEED 600VDC MAXIMUM. ALLOWABLE CURRENT IS 1A.

11. Set DC BIAS ON switch to ON (ON lamp lights).

12. Voltage Sources:

a. If using internal source: Rotate DC BIAS control clockwise from 0 (zero) to get desired bias voltage as read from monitored display.

b. If using external source, set desired externally applied bias as read from monitored display.

Note

For capacitors above 10mF, it is practical to reduce protective resistor in series with charging path. See paragraph 3-42.

13. Allow sufficient time or known predetermined time for capacitor to charge. If displayed bias voltage is changing, charging current is still flowing into unknown capacitor.

14. When displayed bias voltage has reached desired voltage, set FUNCTION switch to I_L.

15. Select proper I_L range with I_L RANGE switch.

16. Read measured value as displayed with unit and decimal point.

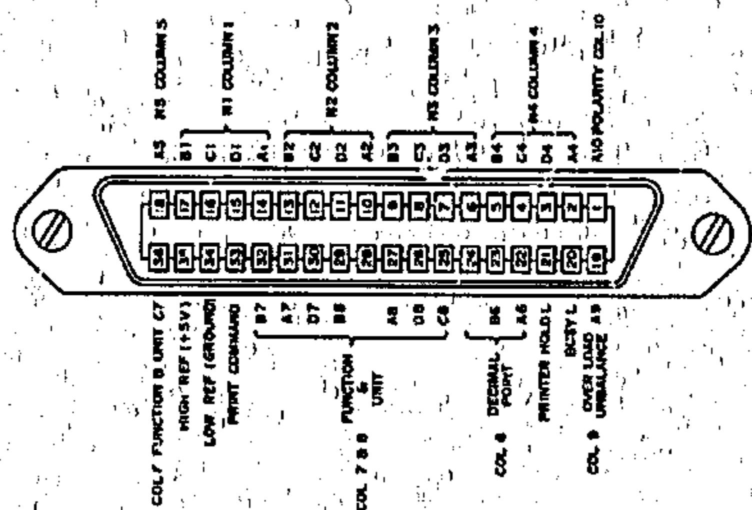
17. After each measurement, set DC BIAS ON switch to off. Set DC BIAS control to 0 to discharge capacitor. Discharge can be monitored by setting FUNCTION switch to V.

CAUTION

DO NOT TOUCH MEASUREMENT TERMINALS WHILE MAKING A MEASUREMENT.

Figure 3-11. Leakage Current Measurement (Option 001).

DIGITAL OUT connector J5.



Logic Levels.

Output Lines: High = +3.9 ±1.5V, 300µA max.
Low = +0.3 ±0.3V, 15mA max.

Input Lines: High = +3.9 ±1.5V, 100µA max.
Low = +0.3 ±0.3V, 2mA max.

L after signal name means Low is true.

Output Signals.

Print Command: negative going TTL pulse of approx. 1ms occurs at end of measurement.

Busy: holds TTL low level during measurement.

Input Signals.

Printer Hold: TTL low level disables automatic sampling.

DIGITAL RECORDER PRINT CODES.

Equipment: HP *5050B/5055A Digital Recorders with standard +1-2-4-8 print wheels using 16498A Interconnect Cable. * With option 050 or 051.

Columns 1 through 5 (Numerals).

Columns 1 through 5 print numerical value of measurement data. For D, ΩF, V or I_L measurements, column 1 prints an asterisk (*).

Columns 7 and 8 (Function and Unit).

Note: To distinguish between the recording of function C (in F units) and the recording of function D, an asterisk is printed in column 1 when D data is being recorded.

Function and Unit	Column 7 D	C	B	A	Print	Column 8 D	C	B	A	Print
C, F	L	L	L	L	0	L	L	L	L	0
C, mF	L	H	L	L	4	L	L	L	L	0
C, µF	L	L	H	L	2	L	L	L	L	0
C, nF	L	L	L	H	1	L	L	L	L	0
D, —	L	L	L	L	0	L	L	L	L	0
ΩF, ΩmF	H	L	L	L	8	L	L	L	L	0
I , mA	L	L	L	L	0	H	L	L	L	8
I , µA	L	L	L	L	0	L	H	L	L	4
V, V	L	L	L	L	0	L	L	H	L	2
V, kV	L	L	L	L	0	L	L	L	H	1

Column 6 (Decimal Point).

Decimal Point	D (GND)	C (GND)	B	A	Print
DP 3	L	L	H	L	2
DP 4	L	L	L	H	1
DP 5	L	L	L	L	0

Data	N5	N4	N3	N2	N1
Decimal Point	DP 5	DP 4	DP 3		

Column 9 (Annunciator).

Annunciator	D (GND)	C (GND)	B (GND)	A	Print
UNBAL + OL	L	L	L	L	0
NORMAL	L	L	L	H	1

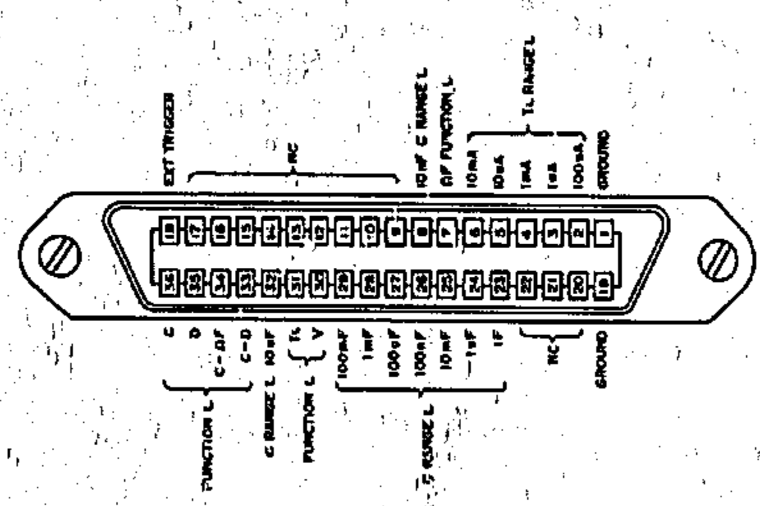
Note: UNBAL + OL = unbalance or overload.

Column 10 (Polarity).

Polarity	D (NC)	C (GND)	B (NC)	A	Print
+	H	L	H	L	+
	H	L	H	H	-

Figure 3-12. DIGITAL OUT Connector J5 (for HP 5050B/5055A Digital Recorder).

REMOTE IN connector J4.



Logic Levels.

Input Lines:

High = +3.9V ±1.5V, 100μA max or open circuit.

Low = +0.3V ±0.3V, 2.5mA max or contact closure to ground.

L after signal name means Low is true.

Input Signals.

Function Programming: TTL low level or contact closure to ground after FUNCTION switch set to REM.

Range Programming: TTL low level or contact closure to ground after C/I_L RANGE switch set to REM.

External Trigger: negative transition of TTL signal or momentary contact closure to ground after RATE control set to HOLD.

Figure 3-13. REMOTE IN Connector J4.

SECTION IV
THEORY OF OPERATION

4-1. INTRODUCTION.

4-2. This section describes basic operating theory of Model 4282A. Descriptions of each schematic may be found in Section VIII.

4-3. MAJOR SECTIONS.

4-4. The instrument basically consists of two major sections, a bridge section and a DVM section. The bridge section, which is an automatic balancing type bridge, measures characteristics of unknown capacitors by the Four-Terminal Method and provides analog voltages which represent these characteristics. The DVM section, which is a digital voltmeter based upon pulse width modulation techniques, measures output of Bridge Section and displays measured values.

4-5. FOUR-TERMINAL METHOD.

4-6. Since the Four-Terminal Method can eliminate effects of test leads, the method is especially useful for measuring characteristics of low impedance components. Figure 4-1 shows connections for the Four-Terminal Method used in Model 4282A. If resistance rv distributed in voltage leads is negligibly small in proportion to input impedance Z1 of amplifier, it produces merit such that rv can be eliminated as a cause of measurement error. Also, resistance ri in current leads has no effect on voltage vector ratio of V_R and V_X, so no measurement considerations for ri are required.

4-7. BRIDGE SECTION.

4-8. Introduction.

4-9. The Bridge Section is the heart of the Model 4282A and it includes some relatively complex circuits. Figure 4-2 shows simplified block diagram of Bridge Section and Figure 4-3 is its vector analysis.

4-10. Consider the three currents ix, ir and ic shown in Figure 4-2:

1. ix.

   Measuring voltage V_X, which is the product of measuring current i and unknown impedance Z_X is applied to xk1-Amplifier and again to

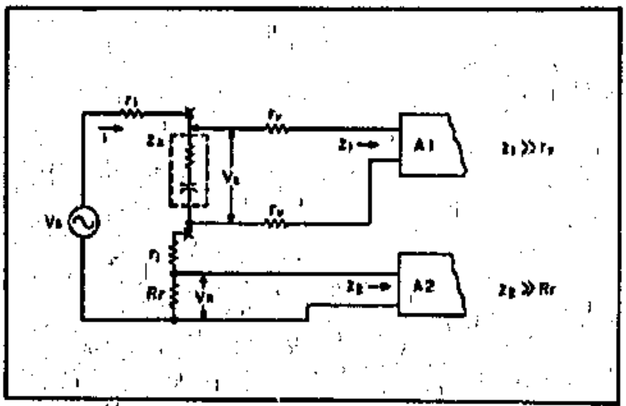


Figure 4-1. Four-Terminal Method.

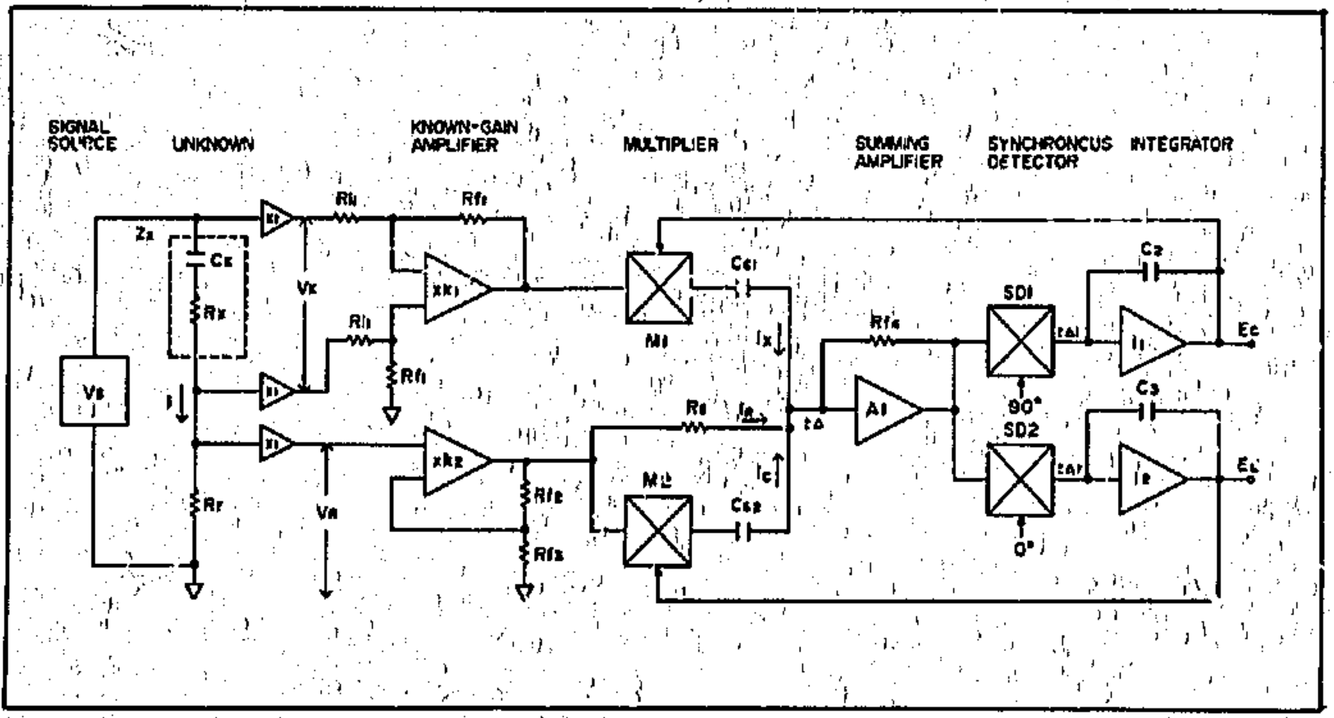


Figure 4-2. Simplified Block Diagram of Bridge Section.

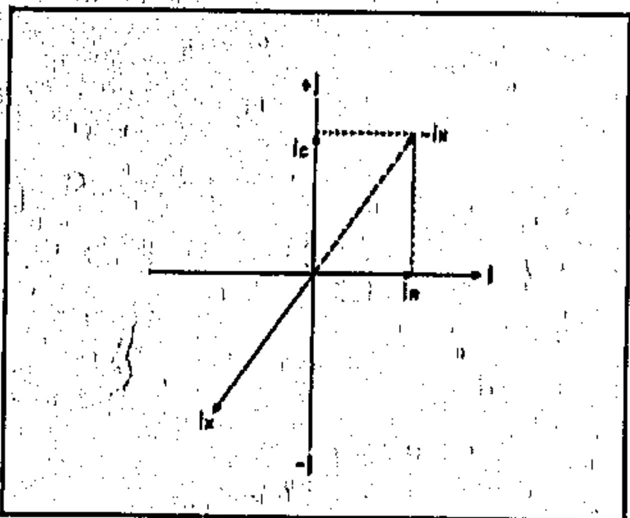


Figure 4-3. Vector Analysis.

Multiplier M1. M1 allows another input, Ec, which is Integrator I1 output. The output of M1 is the product of Vx and Ec. M1 output divided by the reactance of capacitor Cs1 equals ix. The current ix has components both in-phase with i and 90° out of phase.

2. i_R and ic.

Reference voltage V_R, which is the product of measuring current i and range resistor Rr, is fed into xk2-Amplifier. The current i_R is xk2-Amplifier output divided by resistor Rs. Amplifier-xk2 output is also applied to Multiplier M2. M2, similar to M1, allows another input E_L which is Integrator I2 output. M2 output is the product of V_R and E_L. The current ic is M2 output divided by reactance of capacitor Cs2.

4-11. Under the above conditions, the in-phase component of ix is controlled by E_C so that it equals i_R. In addition, E_L acts to maintain ic equal to the 90° out of phase component of ix. These relationships are expressed by following equations:

$$ix = i \cdot \left(Rx + \frac{1}{j\omega Cx}\right) \cdot (-k1) \cdot E_C \cdot K1 \cdot j\omega Cs1$$

$$= -\left(i \cdot \frac{1}{Cx} \cdot k1 \cdot Ec \cdot K1 \cdot Cs1 + i \cdot Rx \cdot k1 \cdot Ec \cdot K1 \cdot j\omega Cs1\right) \quad ①$$

$$i_R = i \cdot Rr \cdot k2 \cdot \frac{1}{Rs} \quad ②$$

$$ic = i \cdot Rr \cdot k2 \cdot E_L \cdot K2 \cdot j\omega Cs2 \quad ③$$

where, K1, K2: constant

When bridge has balanced, equations ①, ② and ③ may be shown as follows:

$$ix + i_R + ic = 0 \quad ④$$

Now, set the sum of the real or imaginary parts of the equations to zero, respectively, and the following equations may be derived:

$$Cx = K1 \cdot \frac{k1}{k2} \cdot \frac{Rs}{Rr} \cdot Cs1 \cdot Ec \quad ⑤$$

$$Rx = \frac{K2}{K1} \cdot \frac{k2}{k1} \cdot Rr \cdot \frac{Cs2}{Cs1} \cdot \frac{E_L}{Ec} \quad ⑥$$

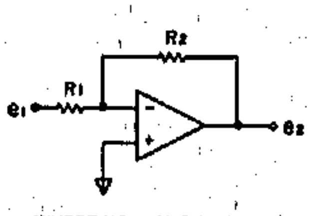
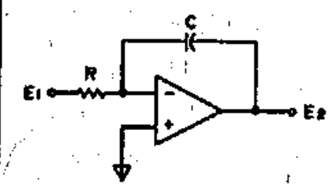
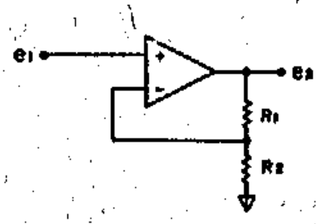
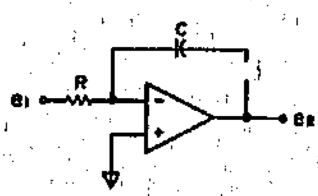
Basic Circuit	Gain & Phase	Basic Circuit	Gain & Phase
 INVERTING AMPLIFIER	$\frac{e2}{e1} = -\frac{R2}{R1}$ Phase difference: $-\pi$	 INTEGRATOR	$\frac{E2}{E1} = -\frac{t}{CR}$ E2 is a negative or positive going ramp depending upon E1 polarity (plus or minus)
 NON-INVERTING AMPLIFIER	$\frac{e2}{e1} = 1 + \frac{R1}{R2}$ Phase difference: 0	 90° PHASE SHIFTER	$\frac{e2}{e1} = -j \cdot \frac{1}{\omega CR}$ Phase difference: $-\frac{\pi}{2}$

Figure 4-4. Fundamental Circuit of Operational Amplifier.

$$D_x = \omega C_x \cdot R_x = K2 \cdot \omega C_{s2} \cdot R_s \cdot E_L \qquad (7)$$

It will be found that Ex and E_L equations (6) and (7) can represent Cx and Dx, respectively.

4-12. In the process of balancing the bridge, equation (4) produces error currents as $+\Delta 1$ (or $-\Delta 2$). Summing Amplifier A1 detects error current and amplifies it to feed the Synchronous Detectors SD1 or SD2. SD1 and SD2 detect in-phase components and 90° out of phase components respectively of the error signal, and again feed Integrator I1 or I2 to provide Ec or E_L which is negatively fed back to Multipliers M1 or M2 and also used to feed input of DVM. This closed loop operates to produce zero error signal and Integrators I1 or I2 store results of the integration. At this time, the bridge is completely balanced and verifies equations (5) and (7).

4-13. Operational Amplifier.

4-14. Figure 4-4 shows fundamental circuit of operational amplifier employed variously in the Model 4262A.

4-15. Multiplier M1 and M2.

4-16. The Multipliers employed in Model 4262A are a kind of voltage controlled attenuators and act to cause bridge to balance automatically. C-side Multiplier M1 and Loss-side Multiplier M2 are almost identical. C-side Multiplier M1 (only) is described.

4-17. Figure 4-5 shows block diagram of Multiplier M1. Figure 4-3 shows waveforms. In upper half of Figure 4-5, Es, the reference voltage is modulated to pulse width by Ex (ac input from xkl-Amplifier). In the lower half, Ec (Integrator I1 output) is again modulated to pulse width by timing produced by the upper half. As a result Multiplier performs the calculation Eo = Ex · Ec/10.

4-18. For purposes of this explanation, it may be assumed that the Ex signal is constant and that it changes in steps because its frequency is low (50, 60, 100 or 120Hz) compared with the 200kHz sawtooth. This approach makes it easier to understand. Figure 4-6 begins at a point (in a continuous sequence) when FET switch Q9 is off. At this time Ix plus Is (the sum is negative) is applied to Integrator U4 input through R30 to R32 and R37. U4 output produces a positive going ramp in the positive domain and is fed to Zero Comparator Q10, U5 through R41. On the other hand, a sawtooth signal from 200kHz Clock Generator Q11 to Q14 is also fed to Zero Comparator Q10 through R44.

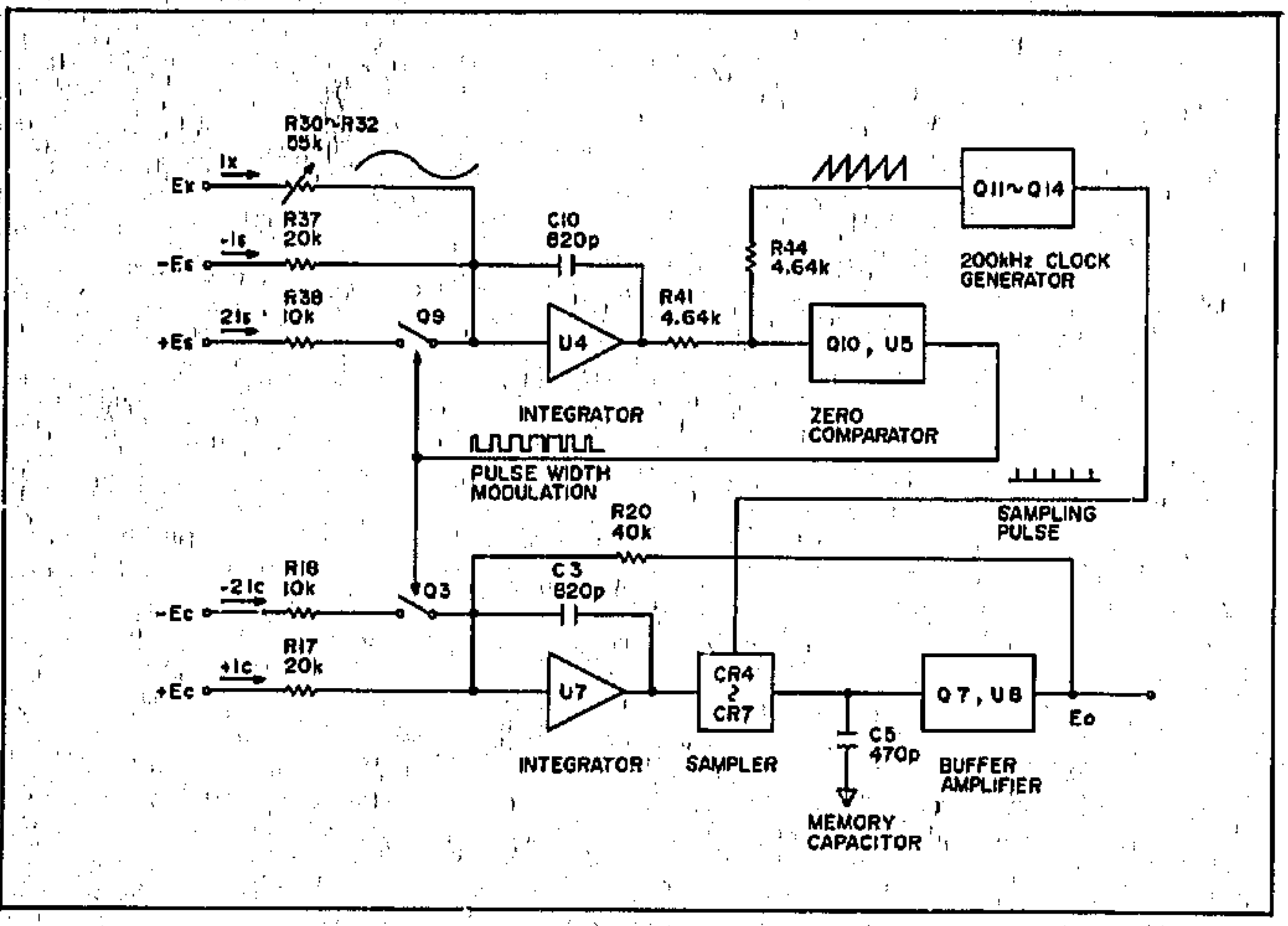


Figure 4-5. Block Diagram of C-Side Multiplier.

When sawtooth just exceeds U4 output, Q10 is turned off and provides high level at U5 output to turn Q9 on. At this moment, U4 input changes to Ix plus Is (the sum is positive) through R30 to R32, R37 and R38 (R37 = 2R38). U4 output turns into a negative going ramp in the positive domain. As time proceeds, the sawtooth goes to low (U4 output is still positive), which turns Q10 and Q9 off. This completes one cycle. This closed loop acts such that the sum of U4 input during one sawtooth period goes to zero by itself and this means a1 = a2, b1 = b2, etc.... in Figure 4-6. A small delay occurs here. In time, the following equation is established:

$$Ex = K3 \cdot \frac{t_{M}2 - t_{M}1}{T_M} \cdot Es \qquad \text{(I)}$$

where t_M1: off time of Q9
t_M2: on time of Q9
T_M: one period of 200kHz sawtooth signal ($= t_M1 + t_M2$)
K3: constant

4-19. Zero Comparator U5 output also drives FET switch Q3 with opposite phase timing. This permits ±Ec (output of Integrator I1) to be connected to Integrator U7 input during t_M1 or t_M2, respectively. U7 output resulting from integration during T_M is sampled by Sampler CR4 to CR7 driven by sampling pulse (coming at end of each sawtooth period). Memory Capacitor C5 stores Sampler output and holds level to apply to Buffer Amplifier Q7, U8 input. U8 provides output E_0 whose envelope is formed by 200kHz staircase. The voltage E_0 is represented as follows:

$$E_0 = K4 \cdot \frac{t_M2 - t_M1}{T_M} \cdot Ec \qquad \text{(II)}$$

where K4: constant

Here, the following is derived from equations (I) and (II):

$$E_0 = K \cdot \frac{Ex \cdot Ec}{Es} \qquad \text{(III)}$$

where K = K4/K3

Equation (III) shows that E_0 represents the product of Ec and Ex. In addition, E_0 is similar in phase to Ex.

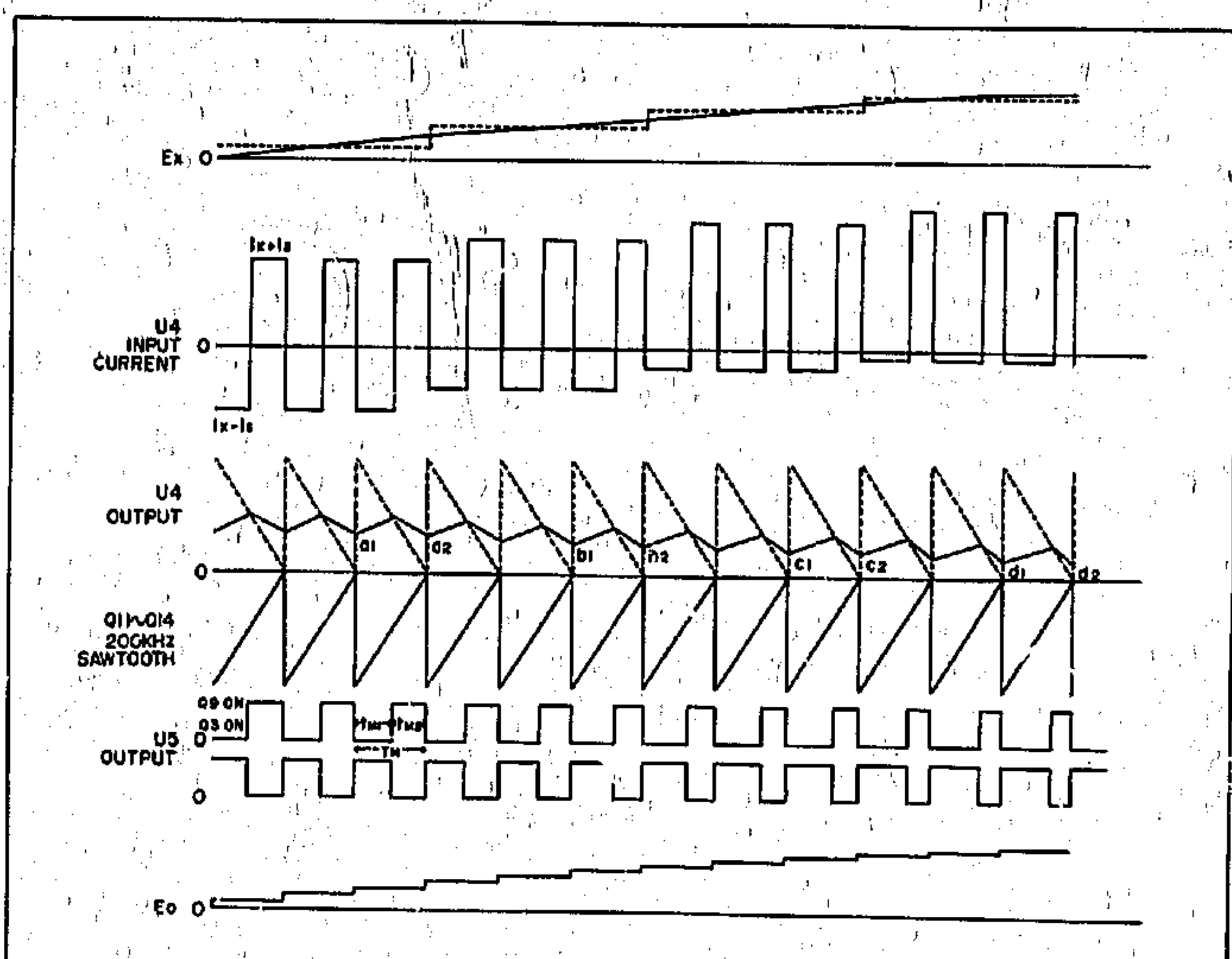


Figure 4-6. C-Side Multiplier Waveforms.

4-20. Since Integrator U7 is storing the portion integrated during prior period, it is necessary to cancel it during next period. This is accomplished by completing negative feed back path using R20 and Eo resulting from previous integration cycle.

4-21. Detector.

4-22. The Detector consists of three blocks, Summing Amplifier, C component Detector and Loss component Detector. The Summing Amplifier detects error signal +Δ1 (or −Δ2) at summing node and amplifies it to provide inputs to both Detectors. Both Detectors are identical except the C side has a 90° Phase Shifter.

4-23. The following description is for Cx side only. Figures 4-7 and 4-8 show block diagram and waveform for C side. Two amplified error signals 180° out of phase with each other are applied to FET switches Q39 and Q40, respectively. Q39 and Q40 are driven by signals of opposite phase, each of which is shifted 90° from Vx by 90° Phase Shifter U31. Then, Q39 and Q40 detect the 90° component and feed it into Integrator U27. In the process of advancing bridge balance, U27 integrates results of Q39 and Q40 output. U27 holds the value Ec when the bridge has balanced and maintains bridge balance by feeding back Ec to Multiplier M1.

4-24. The 90° Phase Shifter U31 produces an output 90° out of phase with Vx. U33C/D accepts U31 output and provides two complete symmetrical square waves of opposite phase to each other which change their states at each zero crossing point of U31 output. Outputs of U33C and U33D enable detection of 90° component of error current. The balance of in-phase component is detected by Loss side Synchronous Detector.

4-25. DVM SECTION.

4-26. Introduction.

4-27. The DVM section contains two main blocks, A-D Converter and Counter. A-D Converter employs pulse width modulation techniques. Figure 4-9 shows simplified block diagram of DVM section.

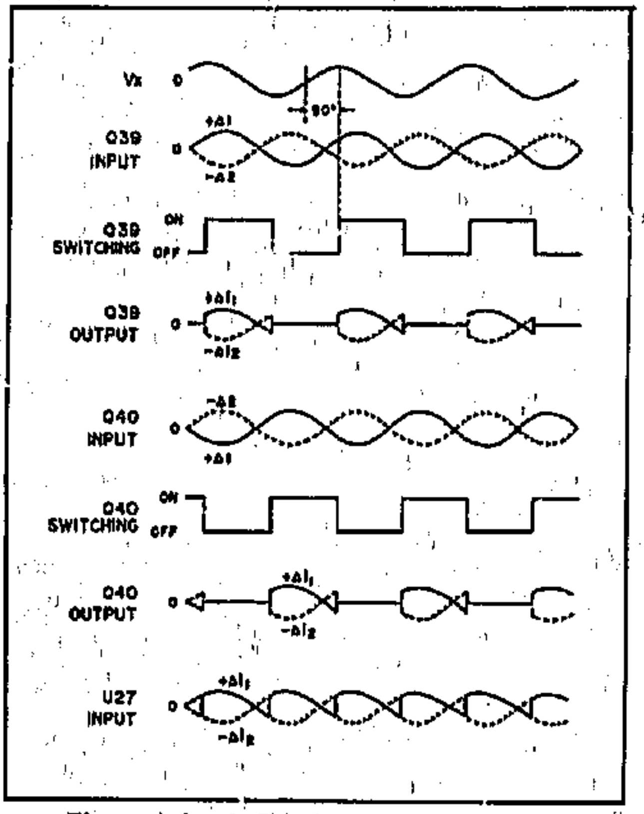


Figure 4-8. C-Side Detector Waveforms.

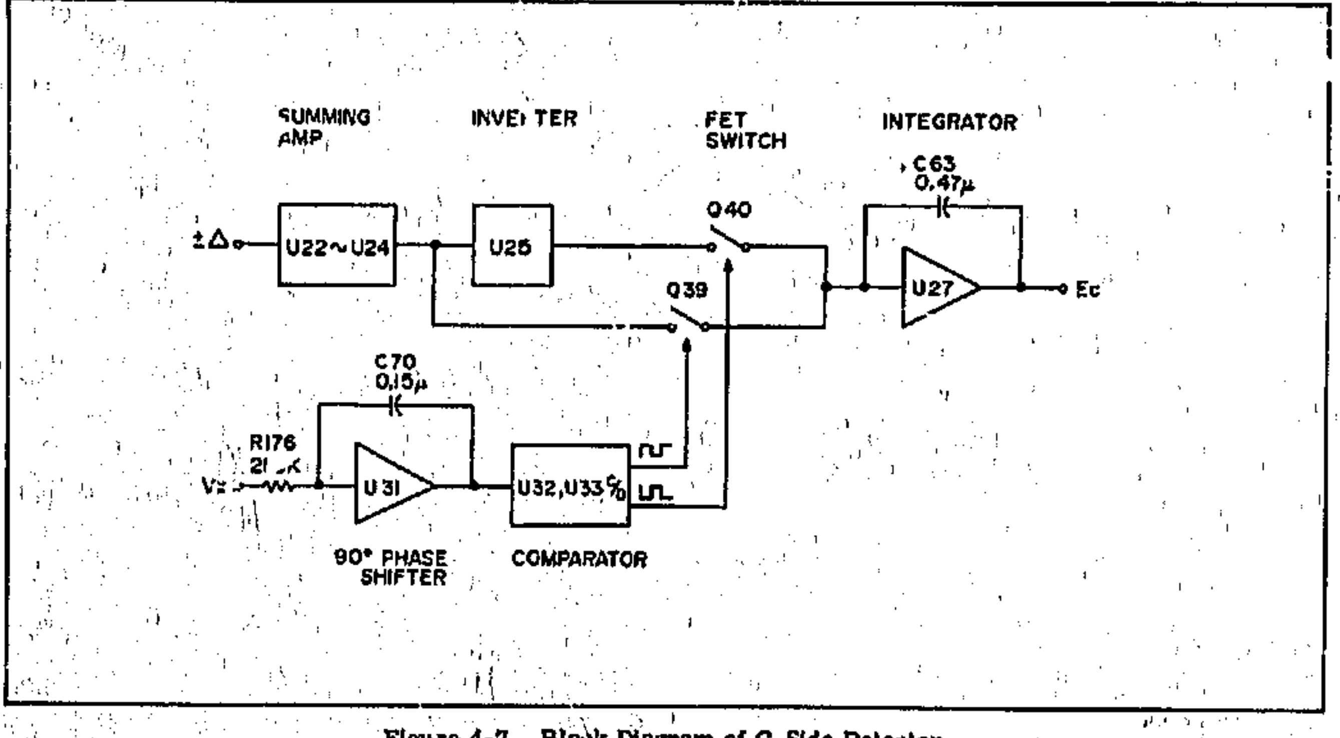


Figure 4-7. Block Diagram of C-Side Detector.

4-28. A-D Converter.

4-29. Pulse width modulation (PWM) used for analog-digital conversion, similar to that done in the Multiplier, is accomplished by modulating E_R (reference voltage) by E_{IN} (Input of DVM). A 60Hz clock signal E_{CL} is superimposed to reject 60Hz common mode interference. One of the differences between this circuit and Multiplier is that repetition rate of PWM is 60Hz rather than 200kHz.

4-30. Figure 4-10 shows block diagram of A-D Converter and Figure 4-11 is its waveforms. Integrator U2 input is sum of the three currents, I_{IN}, I_{CL} and I_R driven by three sources E_{IN} (input of DVM), E_R and E_{CL}, respectively, as shown. Now, assuming a time when all of three currents are positive, U2 output produces the most rapid negative going ramp in the positive domain and reaches zero level quickly. Here, Zero Comparator Q1 senses and provides two levels to turn Q7 off, Q8 on, which changes E_R polarity to minus. The sum of three currents is still positive, so U2 output continues to be a negative going ramp, but its slope rate is slower in the negative domain. After half period of Clock E_{CL}, E_{CL} changes the polarity to minus, then U2 input goes negative rapidly. U2 output turns into a rapid positive going ramp. Before long this ramp reaches zero level and E_R polarity is switched to plus by Q1. Since U2 input still negative, the output continues to be a slower positive going ramp in the positive domain. After one clock period passes, E_{CL} returns to its initial state. This completes one cycle. When this closed loop is just balanced, the current flowing into U2 as an input

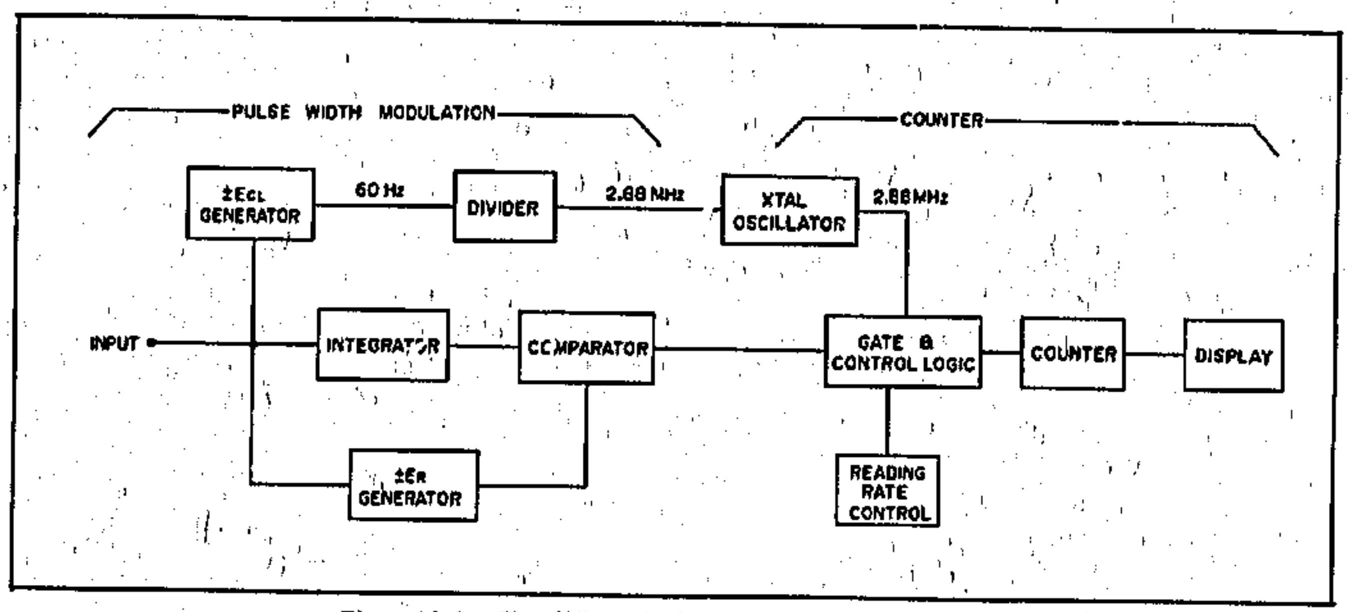


Figure 4-9. Simplified Block Diagram of DVM Section.

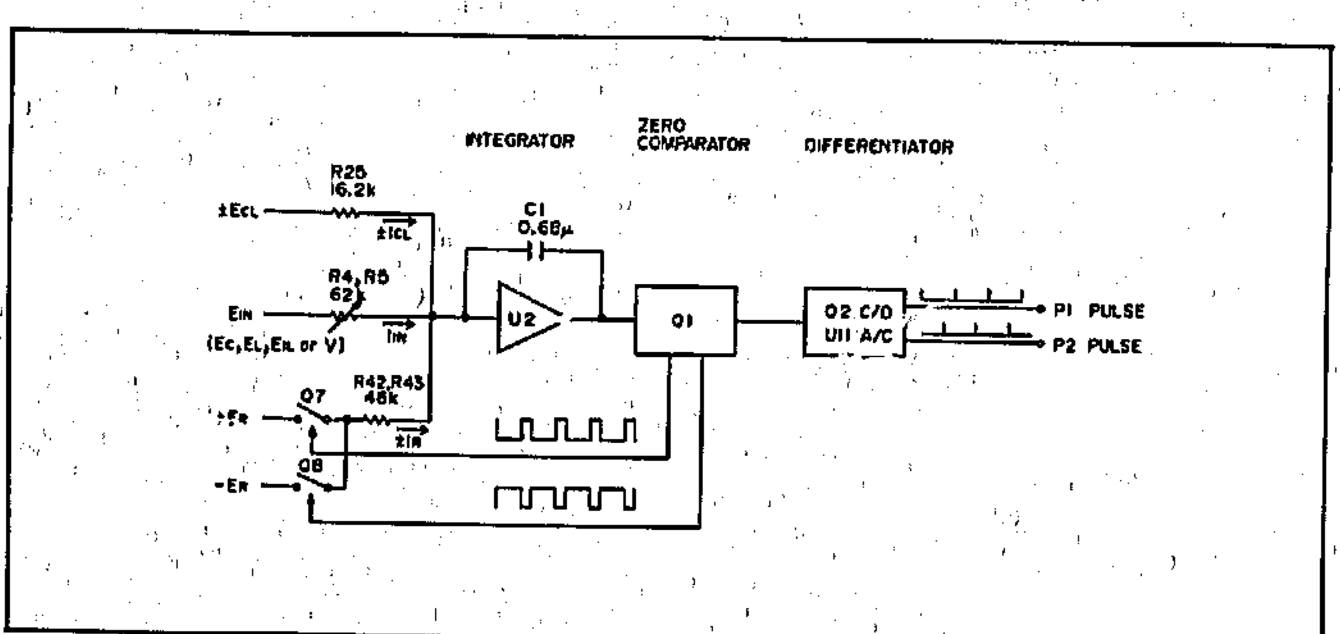


Figure 4-10. Block Diagram of A-D Converter.

during one clock period equals zero. Under these conditions, the following equation may be established:

$$E_{IN} = K5 \cdot E_R \cdot \frac{t_D1 - t_D2}{T_D}$$

$$= 2K5 \cdot E_R \cdot (\frac{T_D}{2} - t_D2) \qquad (11)$$

where, t_D1: on time of Q8
t_D2: on time of Q7
T_D: 60Hz clock period.
K5: constant

Equation (11) means that E_{IN} is proportional to the difference between $T_D/2$ and t_D2. Counter measures this difference.

Differentiator Q2C/D and U11A/C issues P1 and P2 pulses at the beginning of periods t_D1 and t_D2, respectively, to control gate of counter.

4-31. The following explains counter operation. Figure 4-12 shows Simplified Block Diagram and Figure 4-13 is Timing Chart of Counter. For positive DVM input, when reading rate is determined, Busy pulse which is approximately 80ms is fed from Rate Control U13 at beginning of each reading. Busy period is sufficient to allow logical operation for one reading. Simultaneously, the set pulse fed from Q12 determines initial setting by setting Decade Counter U27 to U31 to zero and F/F U15 and U17 to P1 Gate U11B enable and P2 Gate U14A disable, respectively. Under these conditions, P1 pulse then appears at P1 Gate U11B input and passes through U11B and changes F/F U15 state to open Clock Gate U10C. At this time, Clock U10A/B signal, 2.88MHz, is applied to ÷2 Counter U18 and again to Decade counter U 27 to U31.

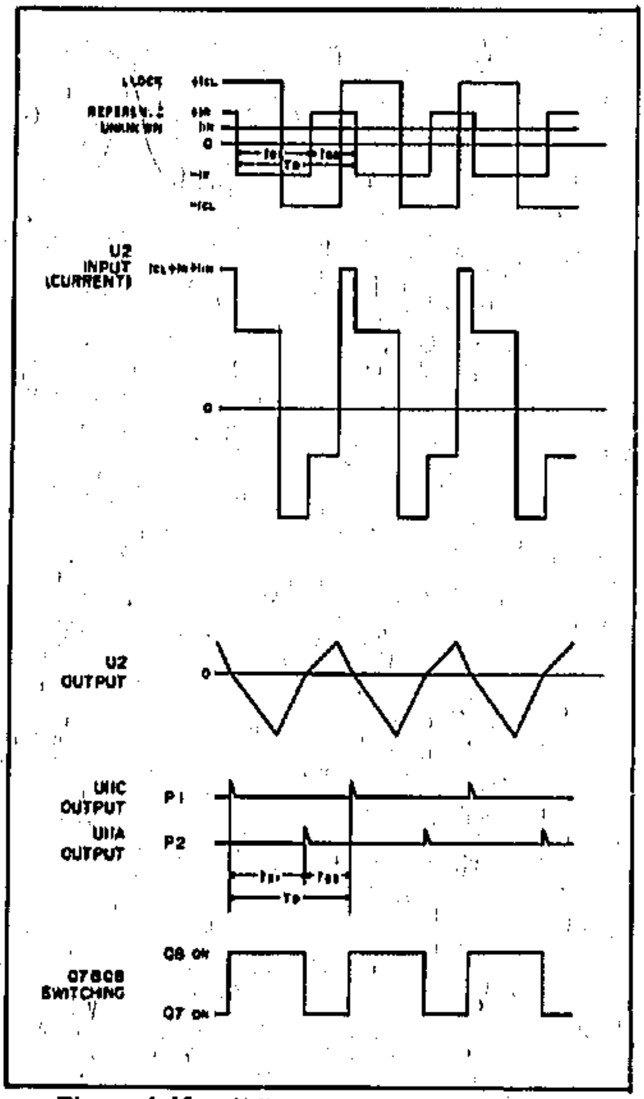


Figure 4-11. A-D Converter Waveforms.

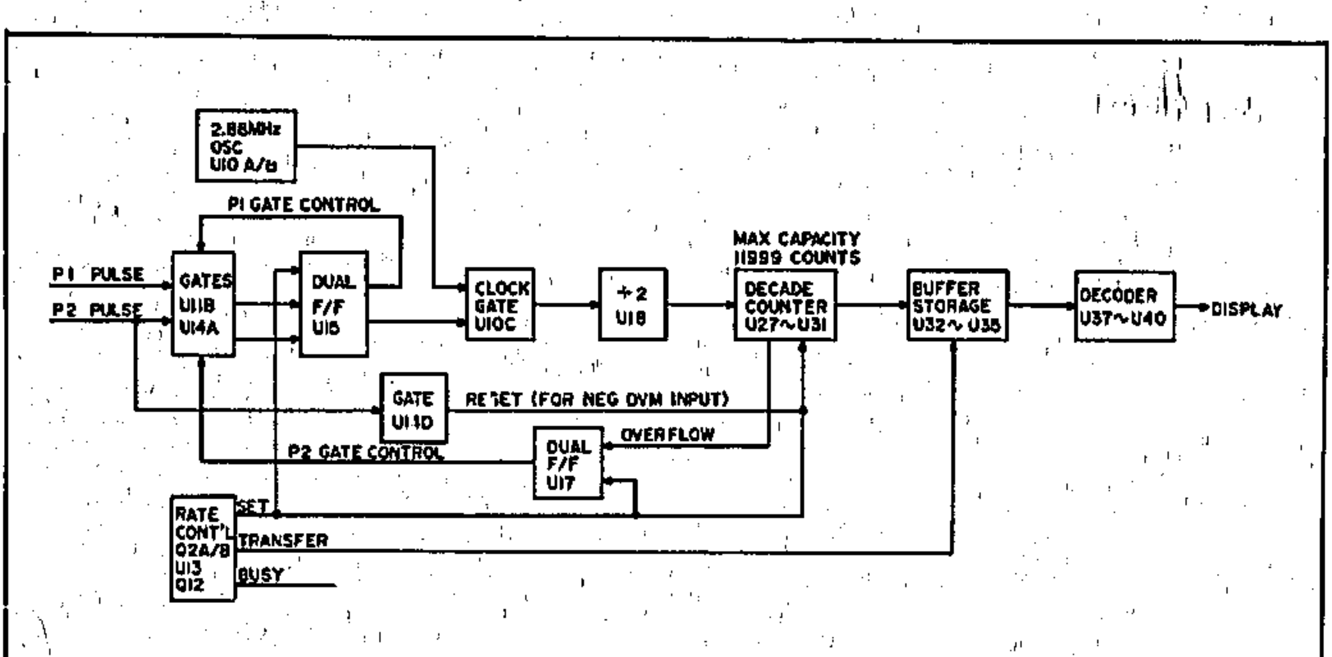


Figure 4-12. Simplified Block Diagram of Counter.

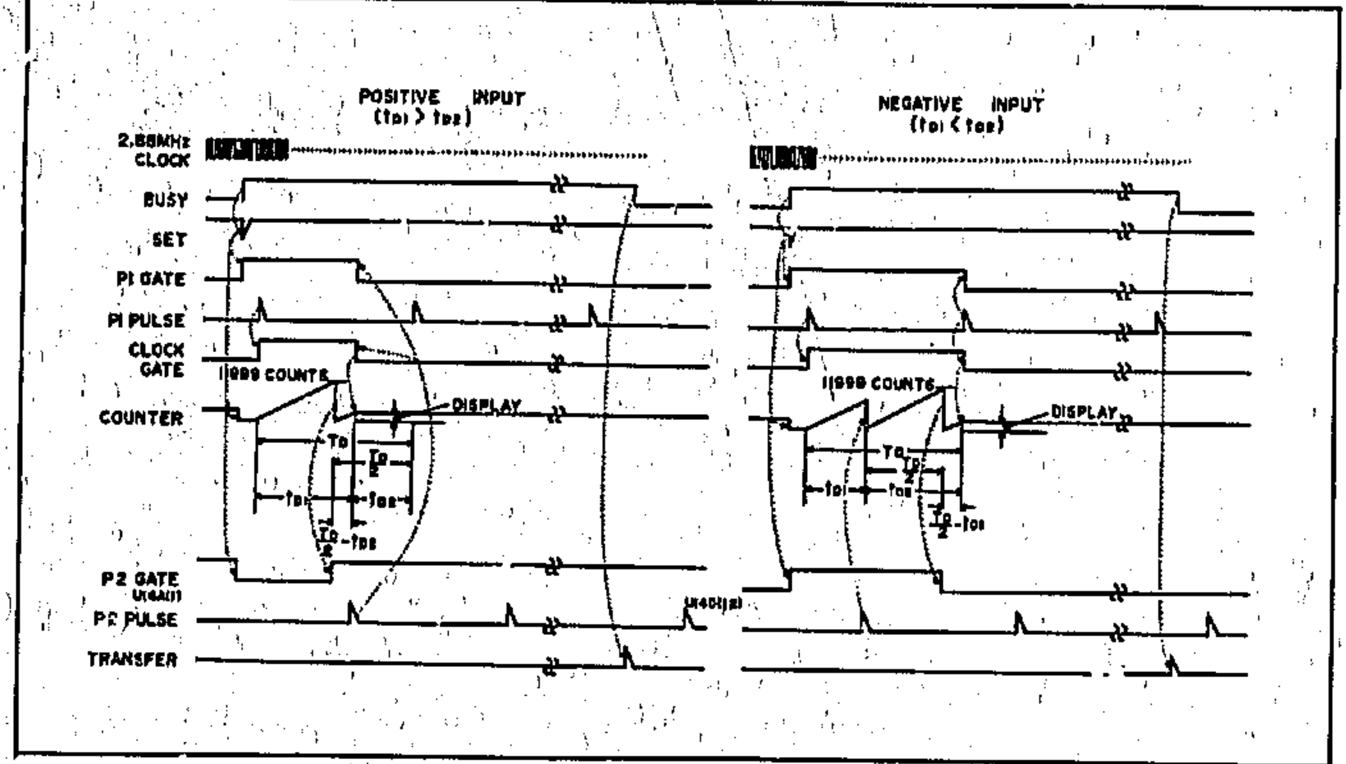


Figure 4-13. Counter Timing Chart.

Counter counts number of input pulses. Since P2 pulse occurs with a delay of at least half a period of 60Hz clock signal from P1 pulse occurrence (for positive DVM input), Counter U27 to U31 (with maximum counting capacity of 11999) overflows at $T_D/2$ from P1 pulse because the number of input pulses has just exceeded 11999 counts. At this moment, the Counter is reset by itself and provides overflow signal. This overflow signal changes F/F U17 states to open P2 Gate U14A. The Counter U27 to U31 again begins to count continuously from zero. Then P2 pulse is applied to P2 Gate U14A and changes F/F U15 state, which closes Clock gate U10C and P1 Gate U11B. The Counter holds the result which is proportional to $(T_D/2 - t_{D2})$ of equation ⑪ and represents DVM input E_{IN}. This result is sent to Buffer Storage U32 to U35. The data sent to Buffer Storage is transferred to Decoder (BCD to seven-segment) U37 to U40 by Transfer pulse issued at end of Busy period. This feeds new data to Decoder. At this point, the Counter goes into a waiting period and one reading sequence is completed when next set pulse is issued.

4-32. For negative DVM input, the difference from positive input is that P2 pulse occurs within half a period of 60Hz clock signal from P1 pulse occurrence. P1 pulse opens Clock Gate U10C and Counter U27 to U31 begins to count the number of input pulses. Since P2 pulse occurs before self-reset of Counter, P2 pulse takes route of Gate U14D to reset Counter to zero. The Counter again begins to count continuously, then is again reset to zero by itself after passing $T_D/2$ and again counts input pulses. After passing T_D from P1 pulse, the next P1 pulse is fed to F/F U15 to change U15 state and closes Clock Gate U10C and P1 Gate U11B. The Counter holds the result which is proportional to $(T_D/2 - t_{D1})$ and represents DVM input E_{IN}.

4-33. LEAKAGE CURRENT MEASUREMENT SECTION (OPTION 001).

4-34. Leakage Current Measurement Section mainly consists of two blocks, Bias Source and Detector as shown in Figure 4-14. Bias Source, having a dynamic range of over 0 to 100V, is a kind of series regulator with current limiter and applies bias voltage to unknown capacitor. Detector detects leakage current flow through unknown capacitor and converts it to a voltage.

4-35. When BIAS ON/OFF switch is set to ON, charging of unknown capacitor is begun. Charging rate is determined by time constant which is determined by protective resistor R_P, unknown capacitance Cx and unknown resistance Rx (which causes leakage). When the voltage V_B across unknown capacitor is very close to constant, changing current i_C is nearly zero and only leakage current I_L flows through unknown. This transition is shown in Figure 4-15. As shown in Figure 4-15, it takes at least 5τ until Ic is negligible. Under assumption that Ic is zero, output E_{IL} of Detector Amplifier is as follows:

$$E_{IL} = R_R \cdot I_L \qquad (12)$$

Equation ⑫ means that E_{IL} can represent I_L. DVM

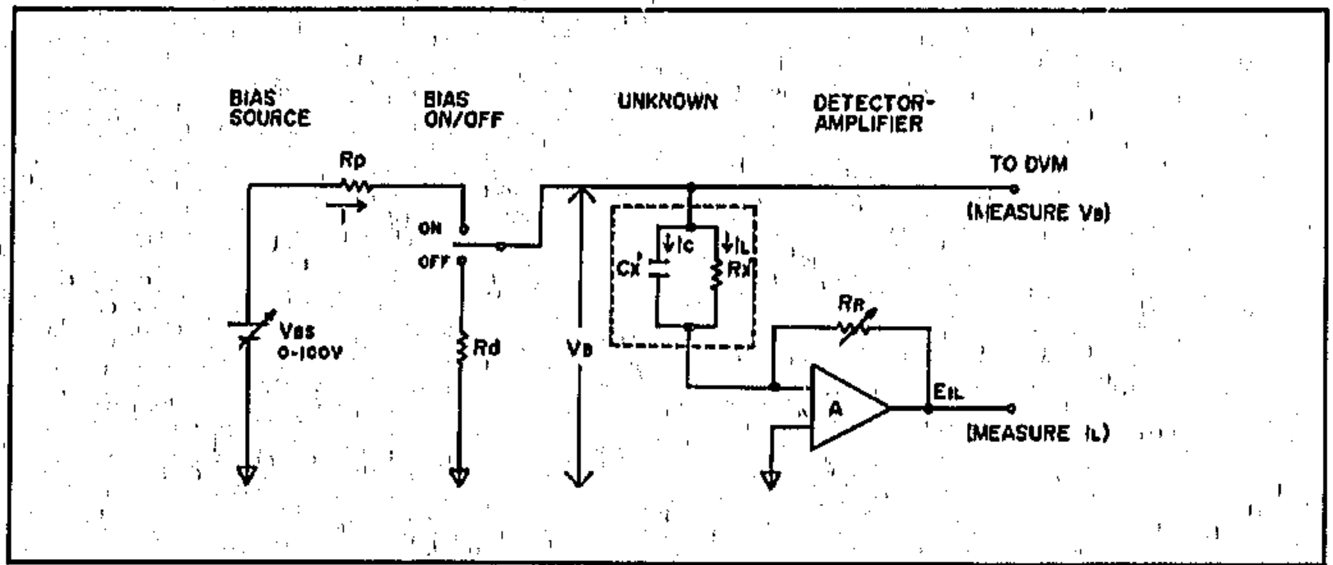


Figure 4-14. Simplified Block Diagram of I_L Measurement.

reads E_{IL} and displays I_L. Then, input of Detector-Amplifier is zero, so V_B itself is applied across unknown capacitor. DVM can also read bias voltage V_B. After measurement, BIAS ON/OFF switch is set to OFF and charge in unknown capacitor is discharged through discharge resistor R_d.

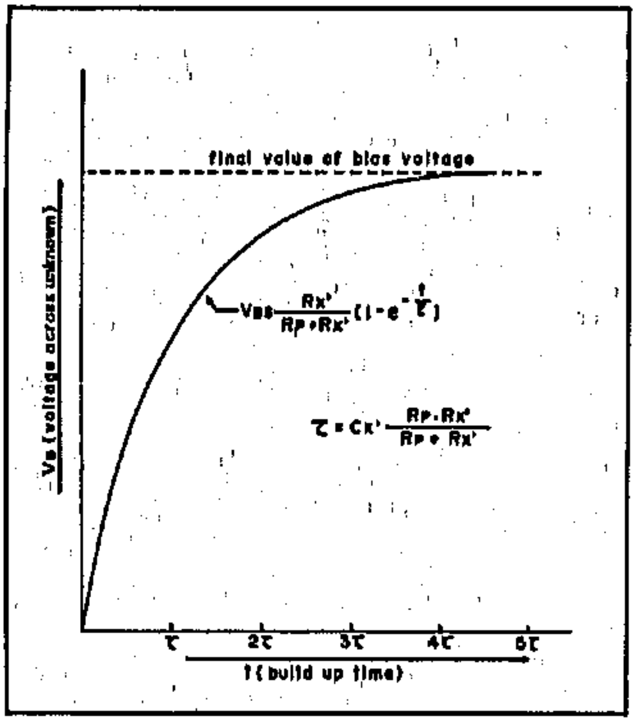


Figure 4-15. Build-up Curve.

Table 5-1. Required Test Equipment.

Instrument	Required Characteristics	Recommended Model or -hp- Part Number
Frequency Counter	Resolution: 0.1 sec	HP 5300A/5301A
AC Voltmeter	Range: 1mV to 1V Accuracy: ±3%	HP 403B
Standard Capacitors	10nF: ±0.02%	GR1409-L
	100nF: ±0.02%	GR1409-T
	1μF to 1F: 7 decade ranges	SOSHIN TM-520-C*
Precision Resistors	10MΩ: ±0.1%, 1/8W	-hp- P/N 0698-6194
	1MΩ: ±0.1%, 1/8W	-hp- P/N 0698-6369
	100kΩ: ±0.1%, 1/8W	-hp- P/N 0698-6358
	10kΩ: ±0.1%, 1/8W	-hp- P/N 0698-6360
	1kΩ: ±0.1%, 1/8W	-hp- P/N 0698-6362
	100Ω: ±0.1%, 1/8W	-hp- P/N 0698-6323
	10Ω: ±0.1%, 1/2W	-hp- P/N 0811-1988
	1Ω: ±0.1%, 2W	-hp- P/N 0811-2061
	.1Ω: ±0.1%, 2W	-hp- P/N 0811-3039
DC Standard	Voltage range: 1V to 1000V Accuracy: ±.01%	HP 740B
DC Digital Voltmeter	10V range, 1mV resolution Accuracy: ±0.04%	HP 34740A/34701A
Oscilloscope	Voltage range: .005 to 1V/div. Frequency range: 10MHz	HP 180A/1801A/1821A (10006B 10:1 probe)
Resistor	464kΩ 1% 0.5W	-hp- P/N 0698-3426

* SOSHIN TM-520-C provides 0.3μF to 1F in 14 position (1, 3 steps) and accuracy is ±1% (down to 0.1%) except 0.05% (down to 0.03%) for 0.3μF to 3μF at 120Hz, 23°C. Refer to TM-520-C instruction manual.

SECTION V
MAINTENANCE

5-1. INTRODUCTION.

5-2. This section contains information necessary to maintain the Model 4282A. The following paragraphs describe Performance Checks, Adjustment and Calibration Procedures and Troubleshooting Procedures.

5-3. REQUIRED EQUIPMENT.

5-4. Table 5-1 is a list of the equipment needed to properly maintain the Model 4282A. If the recommended model is not available, use any alternate that meets required specifications.

CAUTION

ONLY PERFORMANCE CHECKS ARE SHOULD BE DONE BY THE USER. ANY ADJUSTMENT, MAINTENANCE, AND REPAIR OF THE OPENED APPARATUS UNDER VOLTAGE SHOULD BE AVOIDED AS MUCH AS POSSIBLE AND, IF INEVITABLE, SHOULD BE CARRIED OUT ONLY BE A SKILLED PERSON WHO IS AWARE OF THE HAZARD INVOLVED.

5-5. PERFORMANCE CHECK.

5-6. The Performance Checks compare the Model 4282A with its specifications and can be used both for incoming and periodic inspection. Perform tests in order given. If instrument does not meet its performance specifications, refer to Adjustment and Calibration procedures in paragraph 5-22. The instrument's performance may be permanently recorded on the Performance Check Record located at end of this section.

5-7. Warm-up and Environment.

5-8. Before proceeding with Performance Checks or Adjustment and Calibration, allow at least 20 minutes warm-up for temperature stabilization.

5-9. The above checks should be done within an ambient temperature range of 18°C to 28°C.

5-10. Measuring Frequency Check.

5-11. The measuring frequency check, shown in Figure 5-1, requires a frequency counter (HP 5300A/5301A). Proceed as follows:

a. Set controls to -

5300A/5301A:

SAMPLE RATE .... full ccw (out of detent).
GATE 10s
WAVEFORM .... ∼
SENSITIVITY .... full cw

4282A:

FUNCTION C
C RANGE 10μF

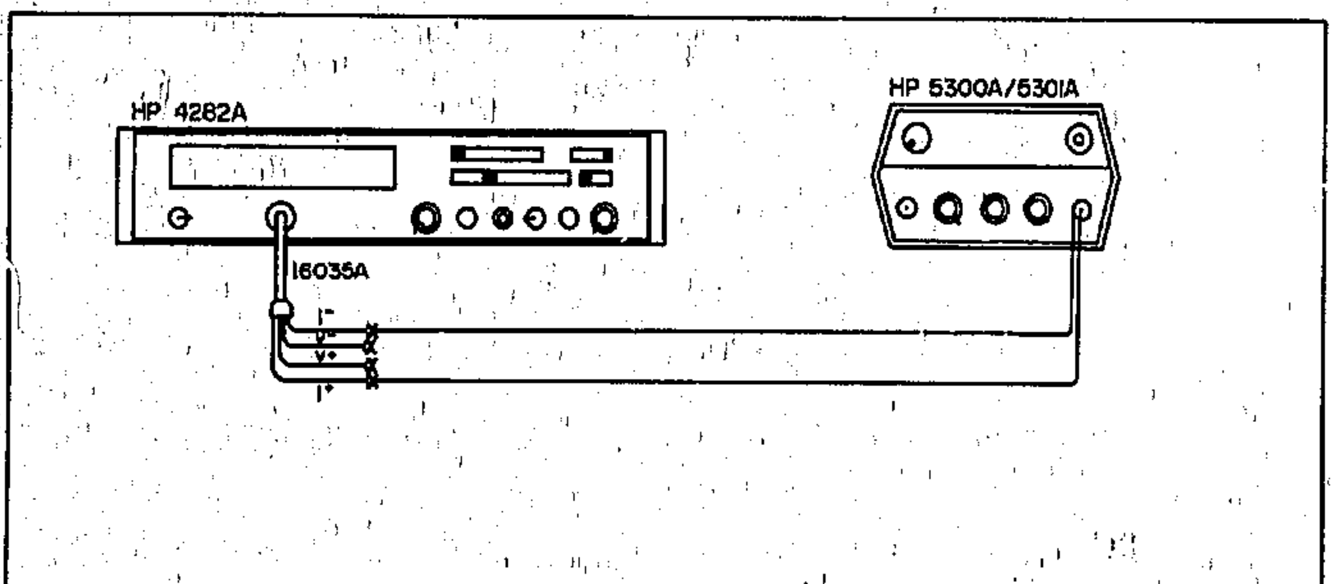


Figure 5-1. Measuring Frequency Check.

b. Connect 5300A/5301A to 4282A as shown in Figure 5-1.

c. Verify that measuring frequencies are within tolerance according to Table 5-2.

5-12. Measuring Voltage Check.

5-13. The measuring voltage check, shown in Figure 5-2, requires an ac voltmeter (HP 403B) and a decade step capacitor (SOSHIN TM-520-C) which covers range from 0.3μF to 1F. Proceed as follows:

a. Set controls to -

403B:

RANGE 1V

TM-520-C 1μF

4282A:

FUNCTION C
C RANGE 10mF
MEAS FREQ (Hz) 120
RATE .... full ccw

b. Connect 403B and SOSHIN TM-520-C to 4282A with Model 16035A Test Leads as shown in Figure 5-12.

Table 5-2. Measuring Frequency Accuracy.

MEAS FREQ (Hz)	Tolerance (Hz)
50*	49.3 to 50.7
60*	59.1 to 60.9
100	98.5 to 101.5
120	118.2 to 121.8

* 50Hz does not apply at 60Hz line operation and vice versa.

c. Verify that 403B reads less than 1Vrms.

d. Set 4282A C RANGE switch to 100mF, SOSHIN TM-520-C to 10mF and 403B RANGE switch to 100mV.

e. Verify that 403B reads less than 100mVrms.

f. Set 4282A C RANGE switch to 1F, SOSHIN TM-520-C to 100mF and 403B to 10mV.

g. Verify that 403B reads less than 10mVrms.

5-14. Capacitance Measurement Accuracy Check.

5-15. The capacitance measurement accuracy check, shown in Figure 5-3, requires standard capacitors GR 1409-L, GR 1409-T and SOSHIN TM-520-C (with certificate). Proceed as follows:

a. Set controls to -

4282A:

FUNCTION C
C RANGE 10nF
MEAS FREQ (Hz) 120
RATE .... full ccw

b. Connect Model 16036A Test Leads with two alligator-jaw clips to UNKNOWN connector.

c. Measure capacitance of 10nF and 100nF standard capacitors and verify that 4282A reads within tolerance according to Table 5-3.

d. Substitute Model 16035A Test Leads with four alligator clips for Model 16036A Test Leads.

e. Measure capacitances of 10μF to 1F in decade steps and verify that 4282A reads within tolerance according to Table 5-3.

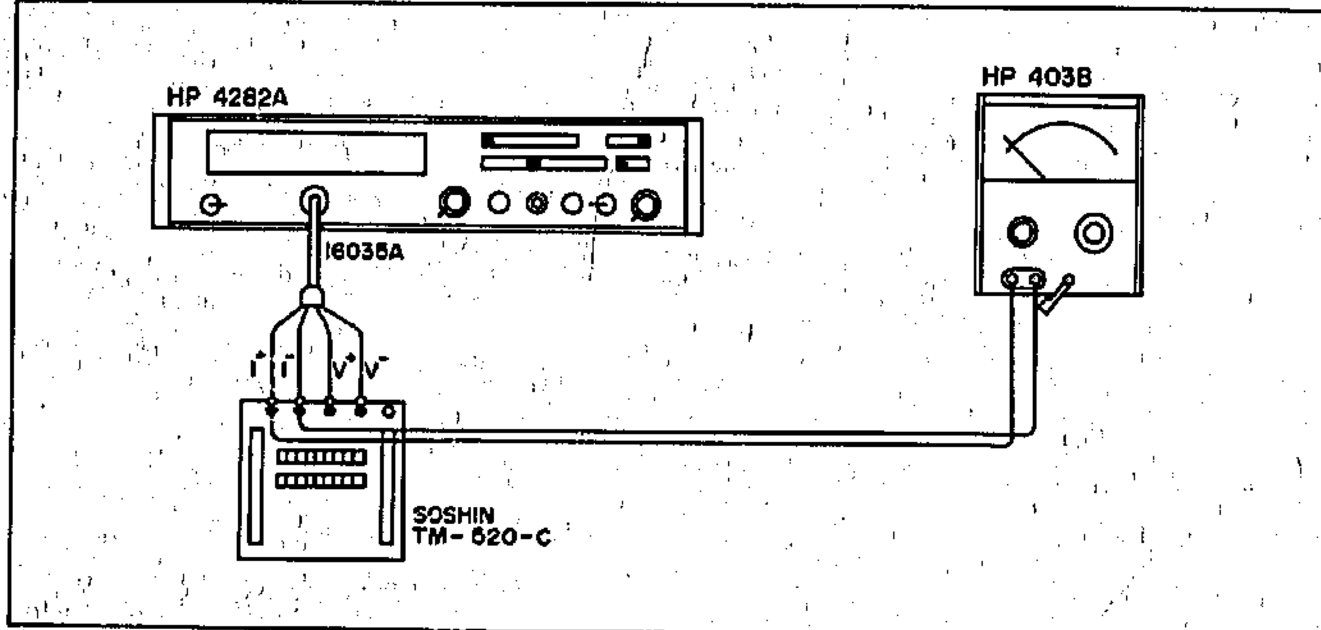


Figure 5-2. Measuring Voltage Check.

5-16. Loss Measurement Accuracy Check.

5-17. The loss measurement accuracy check (including dissipation factor and ohm-farad measurement accuracy check), shown in Figure 5-4, requires standard capacitors GR 1409-L, GR 1409-T and SOSHIN TM-520-C (with certificate) and resistors -hp- P/N 0698-0369, 1MΩ; 0698-6358, 100kΩ; 0698-6360, 10kΩ; 0698-6362, 1kΩ; 0698-6323, 100Ω; 0811-1968, 10Ω; 0811-2061, 1Ω and 0811-3039, .1Ω. Proceed as follows:

a. Set controls to -

4282A:

FUNCTION	D
C RANGE	10nF
MEAS FREQ (Hz)	120
RATE	full ccw

b. Build up standard impedances as shown in Figure 5-4(a).

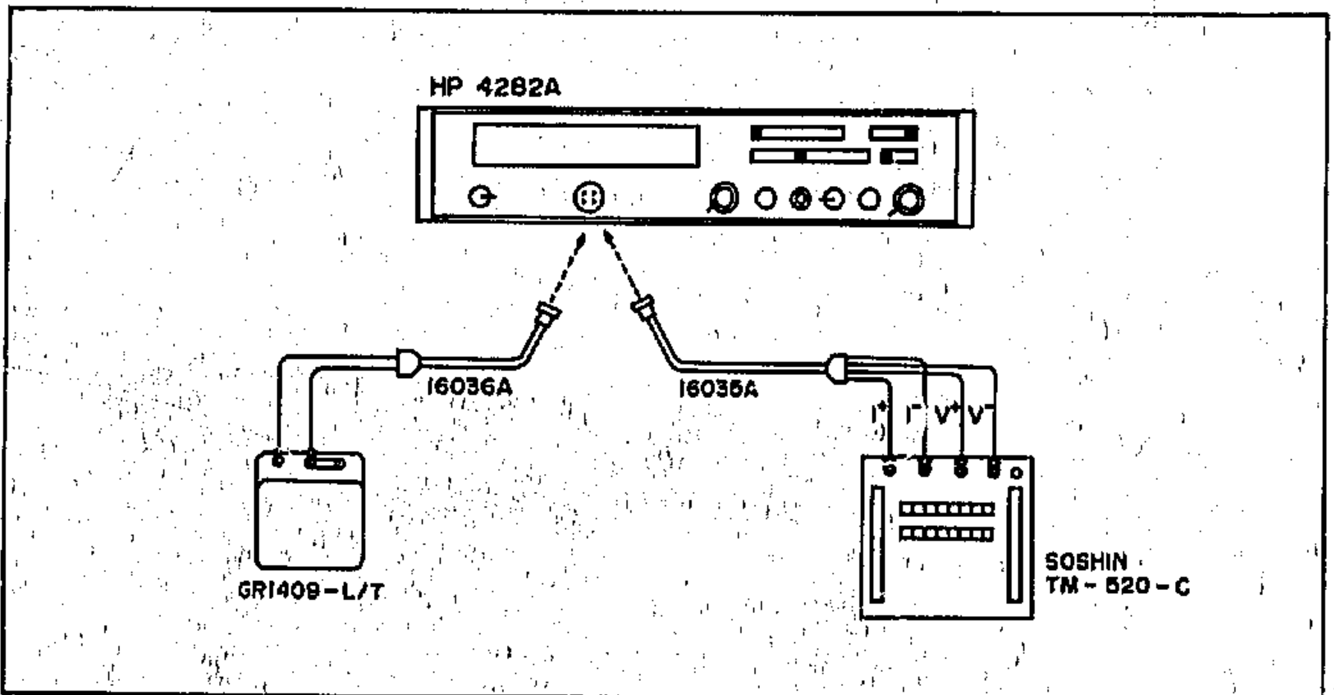


Figure 5-3. Capacitance Measurement Accuracy Check.

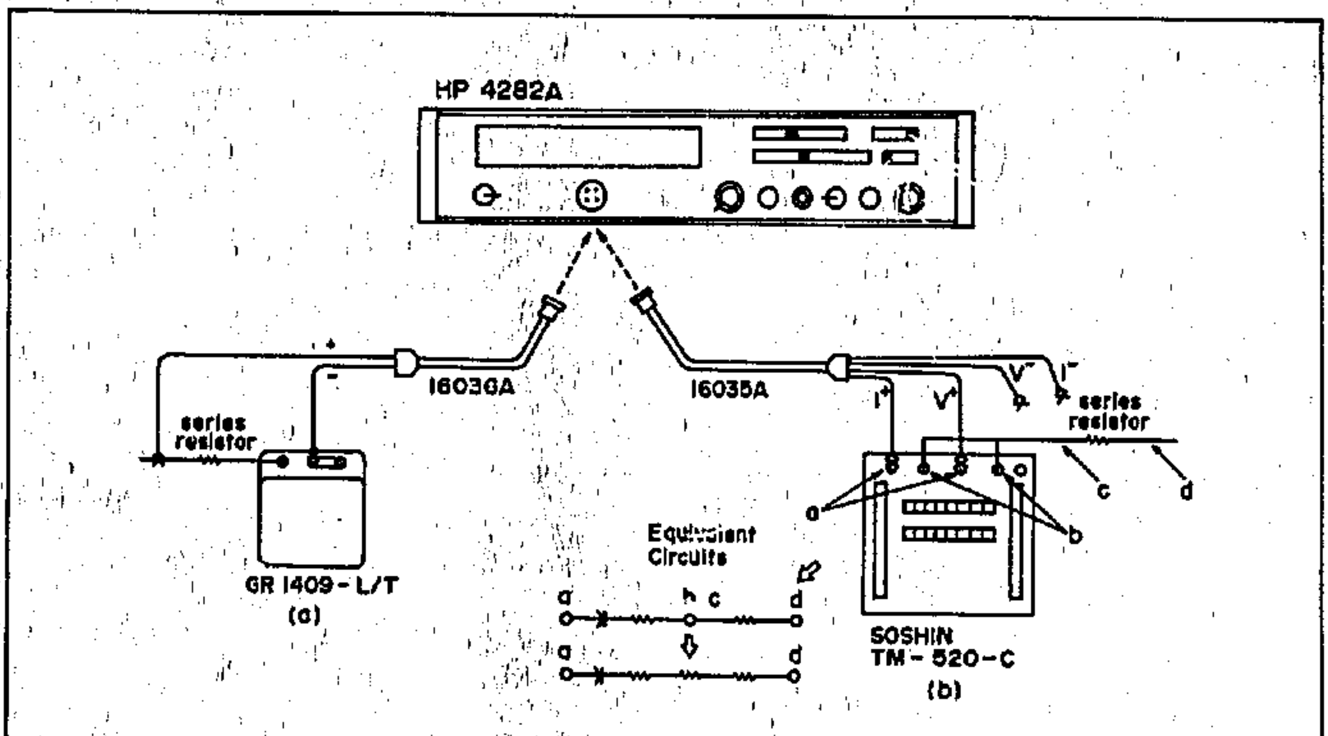


Figure 5-4. Loss Measurement Accuracy Check.

Table 5-3. Capacitance Measurement Accuracy.

Standard Capacitor*		4282A Settings: MEAS FREQ (Hz)	4282A Settings: C RANGE	Tolerance****	Test Leads
GR 1409-L	10nF	120	10nF	9.880 to 10.120nF	16036A
			100nF	9.85 to 10.15nF	
GR 1409-T	100nF			99.40 to 100.60nF	
			1µF	.0991 to .1009µF	
SOSHIN TM-520-C	1µF**	120, 100, 60***, 50***		.9955 to 1.0045µF	16035A
		120	10µF	.991 to 1.009µF	
	10µF			9.955 to 10.045µF	
			100µF	9.91 to 10.09µF	
	100µF			99.55 to 100.45µF	
			1mF	.0991 to .1009mF	
	1mF			.9955 to 1.0045mF	
			10mF	.985 to 1.015mF	
	10mF			9.895 to 10.105mF	
			100mF	9.80 to 10.20mF*****	
	100mF			98.00 to 102.00mF*****	
			1F	.0875 to .1125F*****	
	1F			.9650 to 1.0350F*****	

* Actual capacitance values are shown on certificate, whose deviation from nominal value should be added to each value in tolerance column.

** Verify that SOSHIN TM-520-C frequency response is flat through all four measurement frequencies.

*** 60Hz does not apply at 50Hz line operation and vice versa.

**** Tolerance depends upon only 4282A accuracy.

***** Certain considerations may be required for measurements on these ranges. Refer to paragraph 3-34.

Table 5-4. Loss Measurement Accuracy (1).

Standard Impedance	4282A Settings			Tolerance** (ΩF is in ΩmF)
	MEAS FREQ (Hz)	C RANGE	FUNCTION	
10nF - 1MΩ	120	10nF	D	7.09 to 7.99
		100nF		7.08 to 8.00
10nF - 100kΩ		10nF		.735 to .773
		100nF		.719 to .789
10nF - 10kΩ		10nF		.069 to .081
100nF - 100kΩ		100nF		7.26 to 8.82
			ΩF	9.65 to 10.35
	100		D	6.06 to 6.50
	60*			3.64 to 3.90
	50*			3.02 to 3.26
100nF - 10kΩ	120			.737 to .771
100nF - 1kΩ				.069 to .081

* 60Hz does not apply at 50Hz line operation and vice versa.

** Tolerance depends only upon 4282A accuracy.

c. Measure dissipation factor and ohm-farad with Model 16036A Test Leads according to Table 5-4, and verify that 4282A reads within tolerance.

d. Substitute Model 16035A Test Leads for Model 16036A.

e. Set 4282A to -

FUNCTION .... ΩF
C RANGE 1μF
MEAS FREQ (Hz) 120

f. Build up standard impedance using SOSHIN TM-520-C and 10kΩ resistor in a series connection as shown in Figure 5-4(b). Set SHOSHIN TM-520-C to 1μF.

g. Measure ohm-farad (ΩF) between points a and b as shown in Figure 5-4(b) and note display (ΩFab') in ΩmF.

h. Set FUNCTION switch to C and note display (Cab') in mF.

i. Set FUNCTION to ΩF.

j. Connnect I⁻ lead to point d and V⁻ lead to point c, respectively. Note display (ΩFac') in ΩmF.

k. Set FUNCTION switch to C and note display (Cac') in mF (connection is same as step j).

l. Set FUNCTION switch to ΩF.

m. Calibrate ohm-farad between points a and d as follows:

1) Derive ohm-farad of standard capacitor from dissipation factor denoted on certificate using following formula:

$\Omega Fab = D/2\pi f$ (in ΩmF)

where, ΩFab: ohm-farad value of standard capacitor.
D: dissipation factor denoted on certificate.
f: test frequency assigned on certificate.

2) Correct ohm-farad value between points a and c using following formula:

$\Omega Fac = \Omega Fab - \Omega Fab' + \Omega Fac'$

where, ΩFac: calibrated ohm-farad value between points a and c.
ΩFab: calculated value in (1) of step m.
ΩFab': displayed value of step g.
ΩFac': displayed value of step j.

Table 5-5. Loss Measurement Accuracy (2).

Standard Impedance		4282A C RANGE	Reference Ohm-Farad Value (in ΩmF)
Cs	Rs (Series Resistor)		
1µF	10kΩ	1µF & 10µF	ΩFad = ΩFac + Cad · Rs (Tolerance should be derived from Figure 1-3).
	1kΩ		
	100Ω		
10µF	1kΩ	10µF & 100µF	
	100Ω		
	10Ω		
100µF	100Ω	100µF and 1mF	
	10Ω		
	1Ω		
1mF	10Ω	1mF and 10mF	
	1Ω		
	.1Ω		
10mF	1Ω	10mF & 100mF	
	.1Ω		
100mF	.1Ω	100mF & 1F	
	0		
1F	0	1F	

Note: If above checks are satisfactory, Table 5-5 will verify D measurements accuracy for C Ranges.

3) Correct capacitance between points a and d using following formula:

Cad = Cs - Cab' + Cac' (in mF)

where, Cad: calibrated capacitance value between points a and d.
Cs: capacitance value given on certificate.
Cab': displayed value in step h.
Cac': displayed value in step k.

4) Establish standard ohm-farad using following formula:

ΩFad = ΩFac + Cad · Rs (in ΩmF)

where, ΩFad: established ohm-farad value between points a and d.
ΩFac: calibrated ohm-farad value between points a and c.
Cad: calibrated capacitance value in step m-3 between points a and d.
Rs: series resistance value in ohms (use nominal value).

Note

When using series resistors (Rs) below 1 ohm, it is necessary to calibrate total resistance [between points b and d shown in Figure 5-4(b)] including distributed resistance of corresponding leads.

n. Measure ΩFad and verify that 4282A reads within tolerance according to Figure 1-3, page 1-6.

o. Similarly, repeat steps e through n according to Table 5-5.

5-18. DC Voltage Measurement Accuracy Check.

5-19. The dc voltage measurement accuracy check, shown in Figure 5-5, requires dc standard (HP 740B). Proceed as follows:

a. Set controls to -

4282A:

FUNCTION V
DC BIAS RANGE .... EXT
DVM INPUT SELECTOR ... EXT
(rear panel)

740B:

FUNCTION .... STD
RANGE 1V
OUTPUT .... OFF

b. Connect 740B output to 4282A DVM INPUT connector on rear panel. Observe polarity.

c. Depress 740B OUTPUT push-button switch to turn ON.

d. Set 4282A DC BIAS RANGE to 10V and verify that 4282A reads within tolerance according to Table 5-6.

e. Set 740B for 10V output and check 4282A reading.

f. Set 4282A DC BIAS RANGE to 100V and check 4282A reading.

g. Set 740B for 100V output and check 4282A reading.

h. Set 4282A DC BIAS RANGE to EXT and check 4282A reading.

Table 5-6. DC Voltage Measurement Accuracy.

740B Output	4282A DC BIAS RANGE	Tolerance(V)
1V	10V	0.99 to 1.01
10V	10V	9.99 to 10.01
10V	100V	9.9 to 10.1
100V	100V	99.7 to 100.3
100V	EXT	99 to 101
600V	EXT	598 to 602

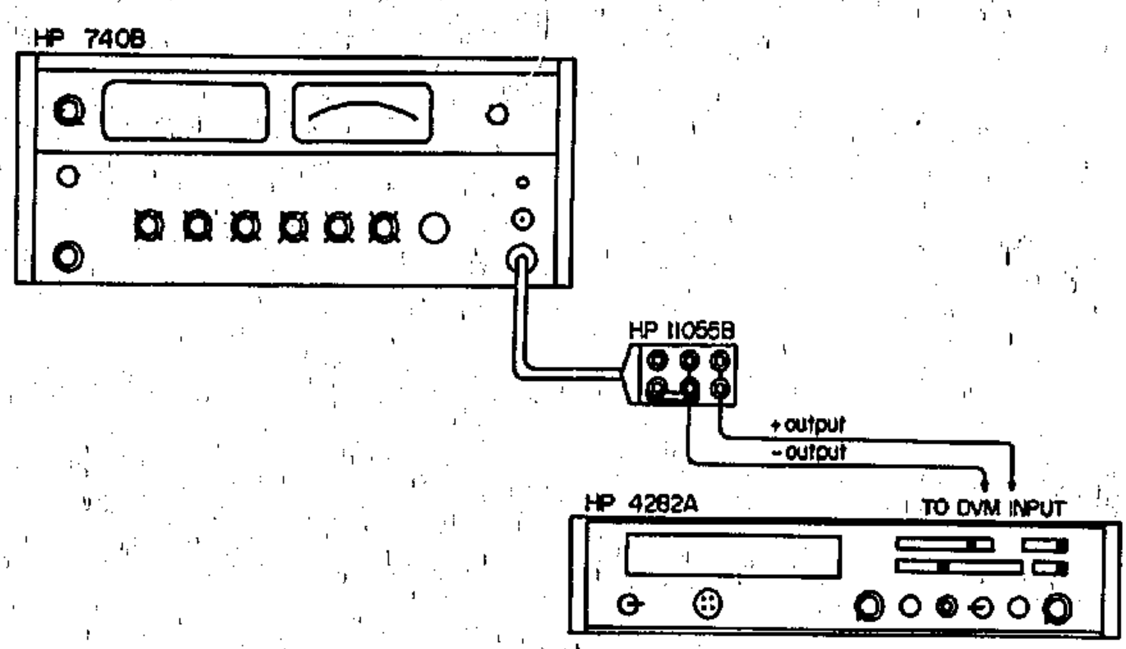


Figure 5-5. DC Voltage Measurement Accuracy Check.

i. Set 740B for 600V output and check 4282A reading.

CAUTION

DO NOT EXCEED 600V OR INSTRUMENT WILL BE DAMAGED.

j. Depress 740B OUTPUT push-button switch to turn output off and set 740B RANGE to 1V.

k. Set 4282A DC BIAS RANGE to 10V.

l. Change connection at 4282A DVM input terminal to check minus input.

m. Similarly, check according to steps c through j.

5-20. Leakage Current Measurement (Option 001) Accuracy Check.

5-21. The leakage current measurement (option 001) accuracy check, shown in Figure 5-6, requires resistors -hp- P/N 0698-6362, 1kΩ; 0698-6360, 10kΩ; 0698-6358, 100kΩ; 0698-6369, 1MΩ and 0698-8194, 10MΩ. Proceed as follows:

a. Set controls to -

4282A:

FUNCTION V
I_L RANGE 10mA
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0

b. Connect Model 16035A Test Leads to 4282A UNKNOWN connector and clip across 1kΩ resistor with 16035A current leads.

Note

Protect the two voltage leads.

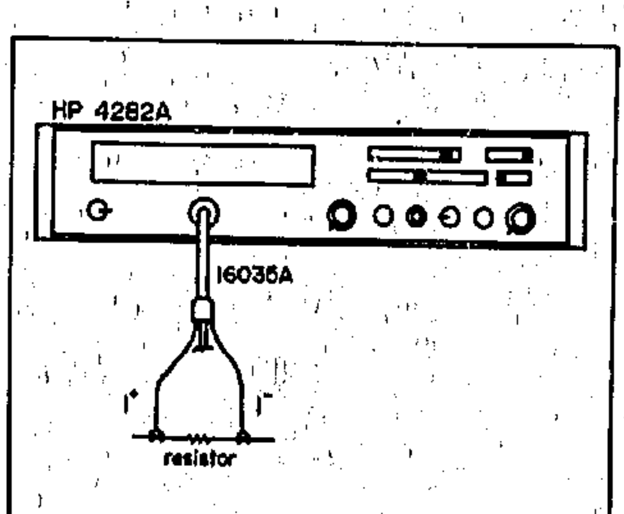


Figure 5-6. Leakage Current Measurement Accuracy Check.

c. Set 4282A DC BIAS ON-OFF switch to ON (ON lamp will light).

d. Apply 10V, as read from 4282A display, to 1kΩ resistor by turning DC BIAS control clockwise.

e. Set FUNCTION to I_L.

f. Verify that 4282A reads within tolerance according to Table 5-7.

g. Similarly, repeat steps a through f according to Table 5-7.

5-22. ADJUSTMENT AND CALIBRATION PROCEDURES.

5-23. The following adjustment and calibration procedures should be done only if performance checks indicate that instrument is not operating within its specifications. Be sure to complete all procedures in the order given, as several adjustments interact. Figure 5-12 shows location of internal adjustments (adjustments for A3 and A4 boards can be done from pattern side as is).

5-24. Instrument Cover Removal.

5-25. To remove either top or bottom covers, remove four screws securing cover to instrument. Slide cover approximately 1/2 inch to rear of instrument and lift free. To install cover, reverse procedure.

5-26. Initial Control Settings.

5-27. Initial control settings of instruments follow:

a. 4282A:

FUNCTION C
MEAS FREQ(Hz) 120
C RANGE.................... 10μF
RATE .... full ccw
DC BIAS ON/OFF .... OFF
DC BIAS control 0
DC BIAS RANGE 10V

b. Oscilloscope (HP 180A/1801A/1821A):

DISPLAY .... A
VOLT/DIV 1
POSITION .... center zero level
AC-GND-DC .... DC
TIME/DIV 5ms
SWEEP ....MAIN
SWEEP MODE .... AUTO
Trigger .... INT, +, DC

Note
Unless otherwise noted, use with 10:1 probe (10006B).

c. Digital Voltmeter (HP 34740A/34701A):

DCV 10

5-26. Power Supply Adjustment (A3).

5-27. The power supply requires dc digital voltmeter (HP 34740A/34701A) for adjustment. Proceed as follows:

a. Set ac line voltage to nominal voltage and complete line conversion of Power Line Module on rear panel. Connect Model 34740A/34701A Digital Voltmeter to +5V supply (refer to Figure 5-12).

b. Adjust A3R33 (+5V adj) for 34740A/34701A display of +5V ±0.2V (refer to Figure 5-12 and Table 5-8).

c. Similarly, adjust -5V, +15V and -15V power supplies according to Table 5-8.

Table 5-7. Leakage Current Measurement Accuracy.

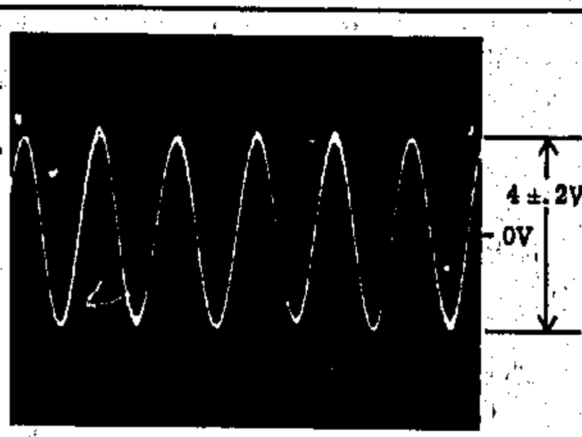
Resistor	Applied Voltage across Resistor	4262A I_L RANGE	Tolerance
1kΩ*	10V	10mA	9.77 to 10.23mA
10kΩ	10V	1mA	.977 to 1.023mA
100kΩ	10V	100μA	97.7 to 102.3μA
1MΩ	10V	10μA	9.77 to 10.23A**
10MΩ	10V	1μA	.960 to 1.040μA**

* Do not exceed 10V because 1kΩ resistor is marginal.

** Allow at least 20 seconds to verify.

Table 5-8. Power Supply Adjustment.

Power Supply	Adjusting Pot.	Tolerance(V)
+5V	A3R33	+4.8 to +5.2
-5V	A3R38	-4.8 to -5.2
+15V	A3R44	+14.7 to +15.3
-15V	A3R46	-14.7 to -15.3



1V/div., 5ms/div.

Figure 5-7. Oscillator Level at A1TP1.

5-30. DVM Calibration (A4).

5-31. The DVM adjustment uses a dc voltage standard (HP 740B). Proceed as follows:

a. Disconnect short wire at pin +10V IN on A2 board (see Figure 5-12).

b. Set 4262A to initial controls setting.

c. Ground pin +10V IN with short clip.

d. Adjust 4262A display for 0000* with A4R41 (Zero Adj).

e. Disconnect short clip and connect 740B between pin +10V IN and ground.

f. Set 740B controls for 10V output.

g. Adjust 4262A display for 10000* with A4R4 (Full-Scale Adj).

h. Disconnect 740B and resolder short wire removed in step a to pin +10V IN.

* Ignore decimal point and unit.

5-32. Oscillator Output Adjustment (A1).

5-33. The oscillator output adjustment uses an oscilloscope (180A/1801A/1821A). Proceed as follows:

a. Set 4262A and 180A/1801A/1821A to initial controls setting.

b. Connect oscilloscope to A1TP1 (see Figure 5-12) and adjust oscilloscope display for 4V ±0.3V peak to peak as shown in Figure 5-7 with A1R18 (Osc Level Adj) and A1R13 (Dist. Adj).

c. Disconnect oscilloscope.

5-34. Power Amplifier Offset Adjustment (A1).

5-35. The power amplifier offset adjustment requires an oscilloscope (HP 180A/1801A/1821A). Proceed as follows:

a. Set controls same as in paragraph 5-27 step a except set -

4262A:

FUNCTION V

180A/1801A/1821A:

VOLTS/DIV .... .005

b. Connect oscilloscope to A1TP2 (see Figure 5-12) and adjust dc level on oscilloscope for 0V with A1R29 (Power Amp Offset Null Adj).

c. Disconnect oscilloscope.

5-36. Common Mode Rejection Adjustment (A1).

5-37. The common mode rejection adjustment requires an oscilloscope (HP 180A/1801A/1821A).

a. Set controls to initial control settings except set -

180A/1801A/1821A:

VOLTS/DIV. . . .005 (without Model 10006B 10:1 probe)
Trigger .... EXT, +, DC (taken from A1TP1)

b. Connect Model 16035A Test Leads to fine wire as shown in Figure 5-8.

c. Connect oscilloscope to A1TP3 (see Figure 5-12) and adjust envelope for minimum (less than 15mV peak to peak) with A2R63 (CMR Adj) as shown in Figure 5-9.

d. Go to next adjustment as is.

5-38. C-Side Amplifier Offset (A1) and X100 Amplifier Zero (A2) Adjustments.

5-39. These adjustments require an oscilloscope (HP 180A/1801A/1821A). Proceed as follows:

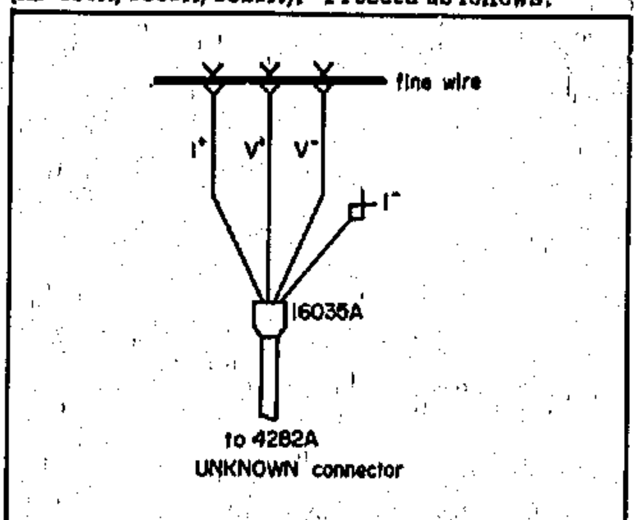
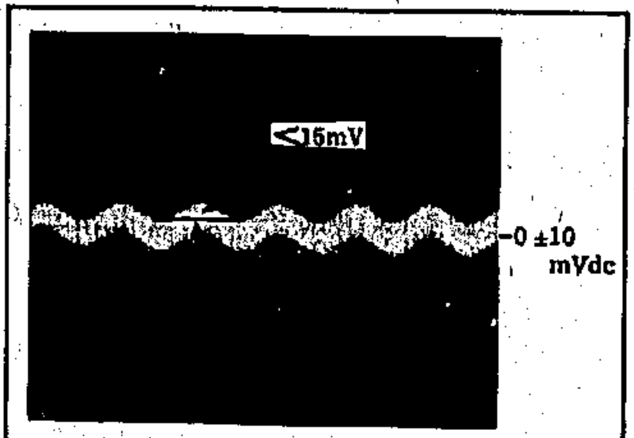


Figure 5-8. Connection for Common Mode Rejection Adjustment.



5mV/div., 5ms/div.

Figure 5-9. Minimized Common Mode Signal at A2TP3.

a. Settings and connections are exactly same as in previous adjustment.

b. Adjust dc level on oscilloscope to within 0 ±10 mV (2 divisions) with A1R64 (C-Amp Offset Null Adj).

c. Additionally, set controls to -

4282A:

FUNCTION V
C RANGE 1F

180A/1801A/1821A:

VOLTS/DIV .... .02
Trigger .... INT, -, DC

d. Connect oscilloscope to A2TP1.

e. Adjust dc level on oscilloscope for 0 ±0.2V (±1 division) with A2R6 (x10 Zero Adj).

f. Disconnect oscilloscope.

5-40. Multiplier Clock Frequency Adjustment (A2).

5-41. The multiplier clock frequency adjustment requires an oscilloscope (HP 180A/1801A/1821A). Proceed as follows:

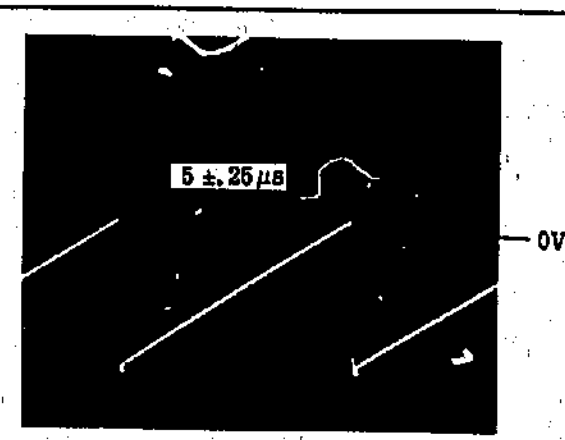
a. Set controls to initial control settings except set -

180A/1801A/1821A:

VOLTS/DIV 2
TIME/DIV 1μs
Trigger .... INT, -, DC

b. Connect oscilloscope to A2TP2 (see Figure 5-12) and adjust period of sawtooth on oscilloscope for 5 ±.25μs (5 ±.25 divisions) as shown in Figure 5-10 with A2R48 (Clock Adj.-- C side).

c. Remove oscilloscope and connect it to A2TP5 and similarly adjust period of sawtooth waveform with A2R130 (Clock Adj.-- Loss side).



2V/div., 1μs/div.

Figure 5-10. Multiplier Clock Waveform at A2TP2 and A2TP5.

d. Disconnect oscilloscope.

5-42. Multiplier Zero Adjustment (A2).

5-43. The multiplier zero adjustment requires an oscilloscope (HP 180A/1801A/1821A) and a standard capacitor (SOSHIN TM-520-C). Proceed as follows:

a. Set controls to initial control settings except set -

180A/1801A/1821A:

VOLTS/DIV. . . .005 (without Model 10006B 10:1 probe)
AC-GND-DC . . . . AC
Trigger . . . . EXT, +, DC (taken from A1TP1)

b. Connect standard capacitor SOSHIN TM-520-C with Model 16035A Test Leads and SOSHIN TM-520-C to 10μF.

c. Disconnect short jumper at pin LOOP (C side, see Figure 5-12) and reconnect it to pin GND.

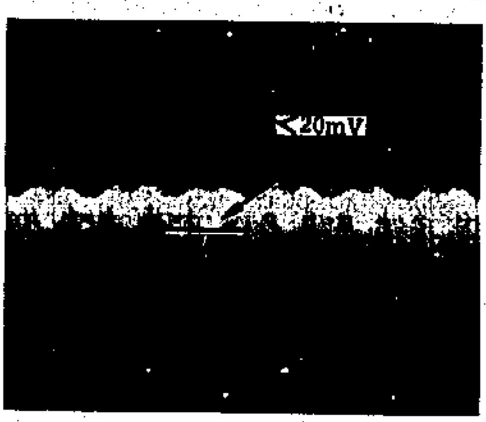
d. Connect oscilloscope to A2TP4 and adjust waveform on oscilloscope for minimum (less than 20mV -- 4 divisions peak to peak) as shown in Figure 5-11 with A2R11 (Zero Adj -- C side).

e. Reconnect short jumper to pin LOOP (C side).

f. Disconnect short jumper at pin LOOP (Loss side, see Figure 5-12) and connect it to pin GND (Loss side).

g. Connect oscilloscope to A2TP8 and adjust waveform on oscilloscope for minimum (less than 20mV peak to peak) with A2R84 (Zero Adj; Loss side).

h. Disconnect oscilloscope and reconnect short jumper to pin LOOP (Loss side).



5mV/div., 5ms/div.

Figure 5-11. Multiplier Zero Leakage at A2TP4 and A2TP8.

5-44. C and Loss Side Integrators Zero Adjustments (A2).

5-45. These adjustments require a dc digital voltmeter (HP 34740A/34701A), a 10μF standard capacitor (SOSHIN TM-520-C) and a 100Ω series resistor (-hp- P/N 0698-6323). Proceed as follows:

a. Set controls to initial control settings.

b. Construct an impedance consisting of a 10μF capacitor and a 100Ω resistor in a series connection as shown in Figure 5-4(b).

c. Connect impedance to UNKNOWN connector using Model 16035A Test Leads.

d. Connect 34740A/34701A to A2TP13 (see Figure 5-12).

e. Note 4282A and DVM display. Correct DVM offset.

f. Short pins x1 (see Figure 5-12) with shorting clip and note display.

g. Adjust 4282A and DVM displays to respective noted values with A2R166 (C Zero Adj.) and A2R167 (Loss Zero Adj.) Both adjustments interact.

h. Disconnect shorting clip.

i. Repeat steps e through g until each difference of display is within 2 counts for 4282A display and with 20 counts for DVM display between "open" and "short" test conditions.

j. Restore all connections.

5-46. Capacitance and Loss Calibration (A2).

5-47. This calibration uses a dc voltmeter (HP 34740A/34701A), a 10μF standard capacitor SOSHIN TM-520-C) and a 1kΩ series resistor (-hp- P/N 0698-6362). Proceed as follows:

a. Set controls to initial control settings.

b. Connect a 10μF standard capacitor to UNKNOWN connector with Model 16035A Test Leads.

c. Connect 34740A/34701A to A2TP13 (see Figure 5-12).

d. Set A2R101 (ϕ Adj -- Loss side) to midpoint.

e. Adjust 34740A/34701A display for 10·D volts ±20 counts (D is dissipation factor at 120Hz given in certificate) with A2R28 (ϕ Adj -- C side).

f. Adjust 4282A display for certified capacitance value (10μF) ±2 counts with A2R30 and A2R31 (C-Full Scale Adj, coarse and fine).

g. Change unknown to a 10μF standard capacitance and a 1kΩ resistor in a series connection. Paragraph 5-17 step f and Figure 5-4(b) show how to construct this impedance.

h. Measure dissipation factor between points a and b shown in Figure 5-4(b) and note 34740A display (Dab') in volts and 4282A display (Cab').

i. Change (only) connection of minus current lead to point d (minus voltage lead remains connected to point b). Note 34740A display (Dab") in volts and 4282A display (Cab").

j. Correct total dissipation factor (D$_T$) and capacitance (Cc) of impedance constructed in step g using following formula:

$$D_T = D + \frac{Dab'}{10} + \frac{Dab''}{10} + 753.8 \cdot Cc \cdot R$$

$$Cc = Cs - Cab' + Cab''$$

where,
- D_T: total dissipation factor at 120Hz.
- Cc: corrected capacitance value between points a and d.
- D: dissipation factor of 10μF standard capacitor at 120Hz (given on certificate).
- Dab': dissipation factor displayed in step h.
- Dab": dissipation factor displayed in step i.
- f: measuring frequency (120Hz).
- Cs: 10μF standard capacitance given on certificate.
- Cab': capacitance displayed in step h.
- Cab": capacitance displayed in step i.
- R: series resistor value of 1kΩ.

k. Change (only) connection of minus voltage lead to point d shown in Figure 5-4(b). Adjust 4282A display for corrected capacitance value (Cc) ±5 counts with A2R101 (θAdj -- Loss side) and 34740A/34701A display for D volts ±4 counts with A2R115 and A2R117 (Loss Full-Scale Adj, coarse and fine) alternately, a few times.

l. Repeat steps e through k a few times (skip steps h through j).

m. Disconnect 34740A/34701A.

5-48. Capacitance Linearity Adjustment (A2).

5-49. This adjustment uses a 10μF standard capacitor SOSHIN TM-620-C) and a 100Ω series resistor (-hp- P/N 0698-6323). Proceed as follows:

a. Set 4282A same as in previous adjustment.

b. Construct an impedance consisting of a 10μF capacitor and a 100Ω resistor in a series connection.

c. Connect the impedance to UNKNOWN connector using Model 16035A Test Leads.

d. Correct capacitance value (Cc') between points a and d [see Figure 5-4(b)]. Use paragraph 5-47, steps h, i and j for procedure (DVM is not required).

e. Set 4282A C RANGE to 100μF.

f. Adjust 4282A display for Cc' ±1 count with A2R11 (Zero Adj -- C side).

g. Set C RANGE to 10μF.

h. Adjust 4282A display for Cc' with A2R30 and A2R31 (C Full Scale Adj., coarse and fine).

i. Repeat steps e through h a few times.

5-51. This adjustment requires a 10nF capacitor (GR-1409-L) and a 200kΩ resistor (-hp- P/N 0698-3426). Proceed as follows:

a. Set 4282A same as previous adjustment except set C RANGE to 1μF.

b. Connect a 10nF capacitor and a 200kΩ resistor in series.

c. Connect unknown to 4282A with 16036A Test Leads.

d. Adjust A2R144 (Unbal Zero Adj) such that UNBALance annunciator just illuminates.

5-52. Low Capacitance Range Adjustment (A1).

5-53. This adjustment requires a 10nF standard capacitance (GR 1409-L), a 100kΩ resistor (-hp- P/N 0698-6358) and an oscilloscope (HP 180A/1801A/1821A). Proceed as follows:

a. Set controls to initial control settings except set -

4282A:

C RANGE 10nF

180A/1801A/1821A:

TIME/DIV 10ms
VOLTS/DIV .... .005
Trigger .... EXT, +, DC
(taken from A1TP1)

b. Connect 16036A Test Leads with two alligator-jaw clips to UNKNOWN connector and leave open.

c. Connect oscilloscope to A1TP4 (see Figure 5-12).

d. Adjust amplitude on oscilloscope for minimum (less than 20mV -- .4 divisions) with A1R83 (Stray Cap. Compen.).

e. Connect a 10nF capacitor to 16035A Test Leads and note 4282A display.

f. Change unknown to a 10nF capacitor and a 100kΩ resistor in a series connection.

g. Note 4282A display and adjust difference of two displays to within 10 counts with A1R104 (10nF Range Adj).

h. Repeat steps e through g a few times.

5-54. AGC Adjustment (A2).

5-55. The AGC Adjustment uses a 1μF standard capacitor (SOSHIN TM-520-C) and an oscilloscope (HP 180A/1801A/1821A). Proceed as follows:

a. Set controls to initial control settings except set -

4282A:

C RANGE 1μF

180A/1801A/1821A:

VOLTS/DIV 5

b. Set SOSHIN TM-520-C to 1μF and connect to 4282A with 16035A Test Lead.

c. Connect oscilloscope to A2TP1 (see Figure 5-12).

d. Adjust amplitude on oscilloscope for 20V ±1V peak to peak with A2R72 (AGC Adj).

e. Disconnect oscilloscope.

5-56. High Capacitance Ranges Adjustment (A1, A2).

5-57. This adjustment uses a standard capacitor (SOSHIN TM-520-C). Proceed as follows:

a. Set 4282A to initial control settings except set C RANGE to 1mF.

b. Set SOSHIN TM-520-C to 1mF.

c. Connect 16035A Test Leads to UNKNOWN connector.

d. Twist two current leads with each other (at least five times) and also twist the two voltage leads together (see paragraph 3-34) and connect to SOSHIN TM-520-C.

e. Adjust 4282A display for certified 1mF capacitance value with A1R120 (1mF Range Adj).

f. Set 4282A C RANGE and SOSHIN TM-520-C to 10mF.

g. Adjust 4282A display for certified 10mF capacitance value with A2R88 (10mF RANGE Adj).

h. Set 4282A C RANGE and SOSHIN TM-520-C to 1F.

i. Adjust 4282A display for certified 1F capacitance value with A2R10 (1F Full Scale Adj).

5-58. Adjustment for Leakage Current Measurement Board Option 001 (A7).

5-59. This adjustment uses a 10kΩ resistor (-hp- P/N 0698-6360). Proceed as follows:

a. Set controls to -

4282A:

FUNCTION .... I_L
I_L RANGE 1mA
RATE .... full ccw
DC BIAS RANGE 10V
DC BIAS ON OFF .... ON
DC BIAS control 0

34740A/34701A:

DCV 10V

b. Do not connect Test Leads to UNKNOWN connector.

c. Connect 34740A/34701A to A7TP2 and adjust 34740A/34701A display for 0 ±2mV (±2 counts) with A7R24 (Offset Adj 1).

Note

Observe 34740A/34701A zero volts reading.

d. Change 34740A/34701A connection to A7TP3 and adjust display for 0 ±10mV (±10 counts) with A7R31 (Offset Adj 2).

e. Connect 16035A Test Leads to UNKNOWN connector.

f. Connect a 10kΩ resistor between plus and minus current leads.

Note

Protect the two voltage leads.

g. Connect 34740A/34701A to plus current lead and chassis ground.

h. Adjust 34740A/34701A display for 10.000V with DC BIAS control. Correct DVM offset.

i. Change 34740A/34701A connection to A7TP3 and adjust 34740A/34701A display for 10.000V ±0.050V with A7R27 (Full-Scale Adj).

j. Restore all original settings and connections.

5-60. TROUBLESHOOTING.

5-61. This portion of Section V contains information and procedures designed to assist in the isolation of malfunctions. The information presented is based on a systematic analysis of the instrument circuits and, if followed, will minimize troubleshooting time.

5-62. Guidelines.

5-63. Before troubleshooting the 4282A, observe the following guidelines:

a. Perform the adjustments outlined in paragraphs 5-22 through 5-57. Some apparent malfunctions can be corrected by these adjustments or the inability to obtain correct adjustment will often reveal the source of trouble.

b. Check for burned or loose components, loose connections or any other obvious condition that might be a source of trouble.

5-64. Reference Settings.

5-65. Three sets of reference settings are provided for helping to isolate various troubles. They are called Reference Settings "C", Reference Settings "V" and Reference Settings "I_L", which symbolize capacitance measurements, dc voltage measurements and leakage current measurements, respectively. These settings follow. They are also listed on each troubleshooting tree page to be used in combination with trees. "Normal Display" shown for each setting applies to a 4282A whose adjustments have been completed. Therefore, a 4262A whose display is out of tolerance slightly, may not be faulty but merely out of adjustment.

Reference Settings "C":

FUNCTION C
C RANGE 1μF
MEAS FREQ (Hz) 100
RATE .... full ccw
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... 1μF (SOSHIN TM-520-C) plus 1.47kΩ (-hp- P/N 0757-1078) in series. Use 16035A Test Lead.

- Normal Display -

Capacitance ... .9900 to 1.0100 (in μF)
Dissipation factor . .904 to .944
Ohm-farad .... 1.45 to 1.49 (in ΩmF)
Rate annunciator .... flashing
Other annunciators .... off

Reference Settings "V":

FUNCTION V
C/I_L RANGE .....does not apply
MEAS FREQ .....does not apply
RATE .... full ccw
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN ....does not apply
DVM INPUT SELECTOR ... EXT (on rear panel)
DVM INPUT .... apply +10V ±.1% (on rear panel)

- Normal Display -

Voltage .... 9.90 to 10.10 (in V)
Rate annunciator .... flashing
Other annunciator .... off

Reference Settings "I_L":

FUNCTION .... I_L
I_L RANGE 1mA
MEAS FREQ .....does not apply
RATE .... full ccw
UNKNOWN ..... 10kΩ (-hp- P/N 0698-6360) connected between plus and minus current leads.
DC BIAS RANGE 10V
DC BIAS ON OFF .... ON
DC BIAS control ...., set to 10V read from display when FUNCTION set to V.

- Normal Display -

Leakage Current 0.970 to 1.030 (in mA)
Rate annunciator .... flashi
Other annunciators ... off (exc dc bias ON lam

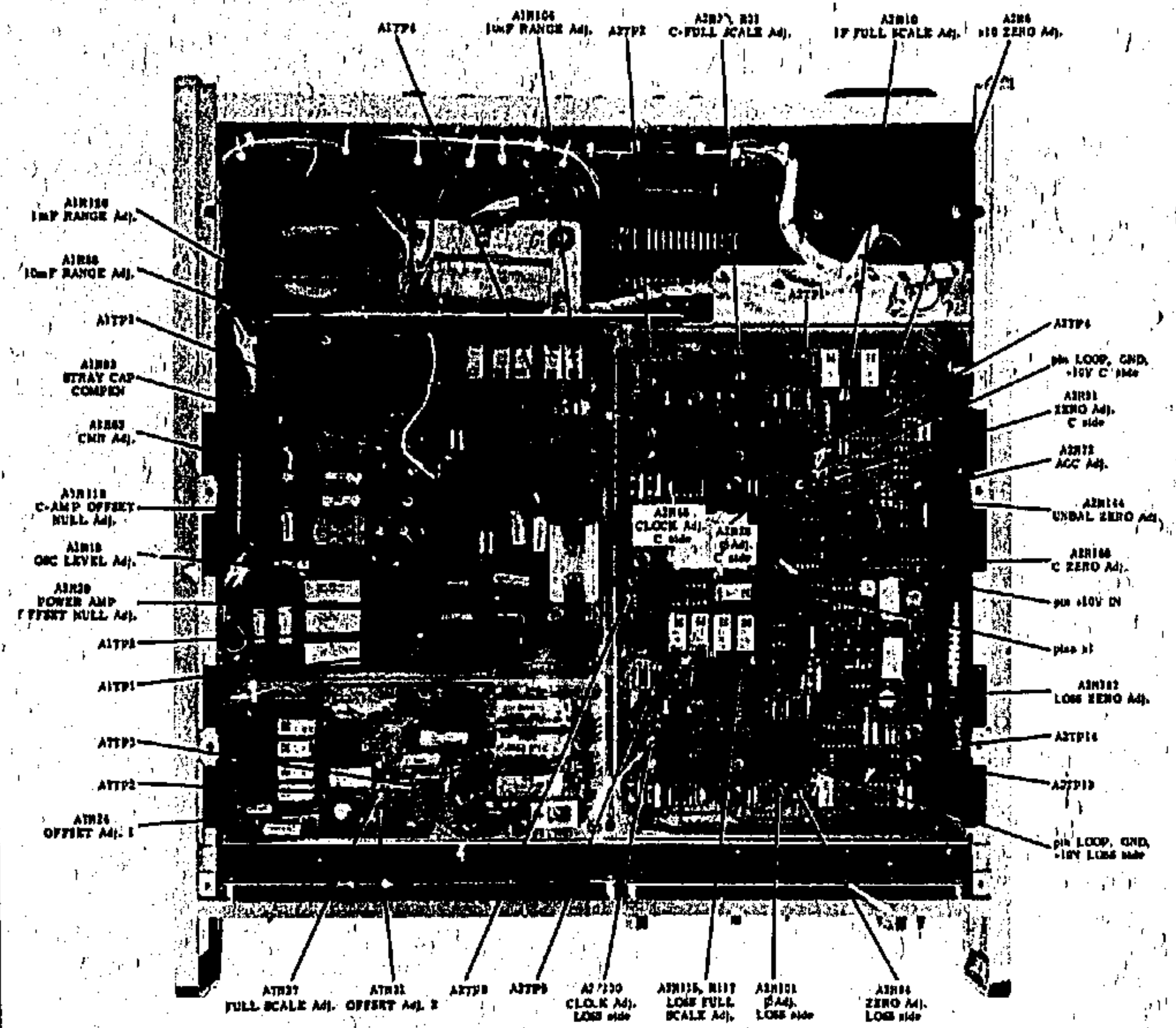
5-66. Troubleshooting Trees.

5-67. The General Troubleshooting Tree Figure 5-13 is useful for making a preliminary diagnosis of trouble location. It, in turn, will refer you to other, specific area, troubleshooting trees. Troubleshooting trees to which specific reference settings have been assigned are, namely: "Function Control" (Figure 5-22), "C and I_L Range Control" (Figure 5-23 and 5-24) and "Unit and Decimal Point" (Figure 5-25). The trees are especially designed for easy trouble isolation. For troubles on ranges other than those in sample trees, use above format and proceed similarly.

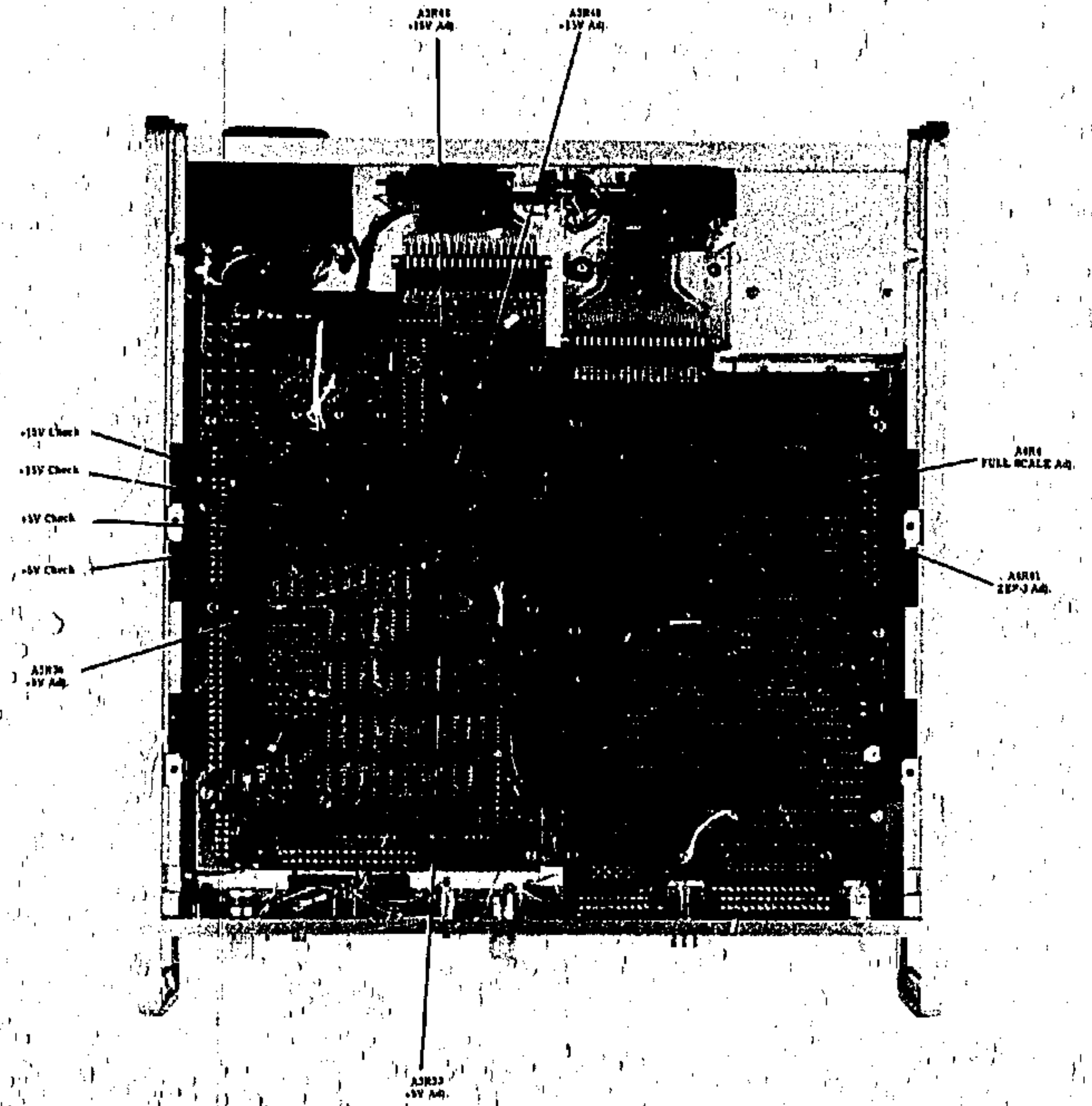
5-68. All waveforms shown in troubleshooting trees are taken using Model 10000B 10:1 probe. Vertical scale used is given below each photo. "0V" at right is zero reference level of related waveforms. See test point locations on facing pages of troubleshooting trees.

5-69. Troubleshooting trees are located on fold-outs at end of this section. When entering a troubleshooting tree, always start at the point labeled "START". Do not attempt to start in the middle of a tree.

5-70. Since troubleshooting trees may not cover all troubles encountered, refer to schematics and descriptions provided on facing page of each schematic and Section IV Theory of Operation in unusual situations.

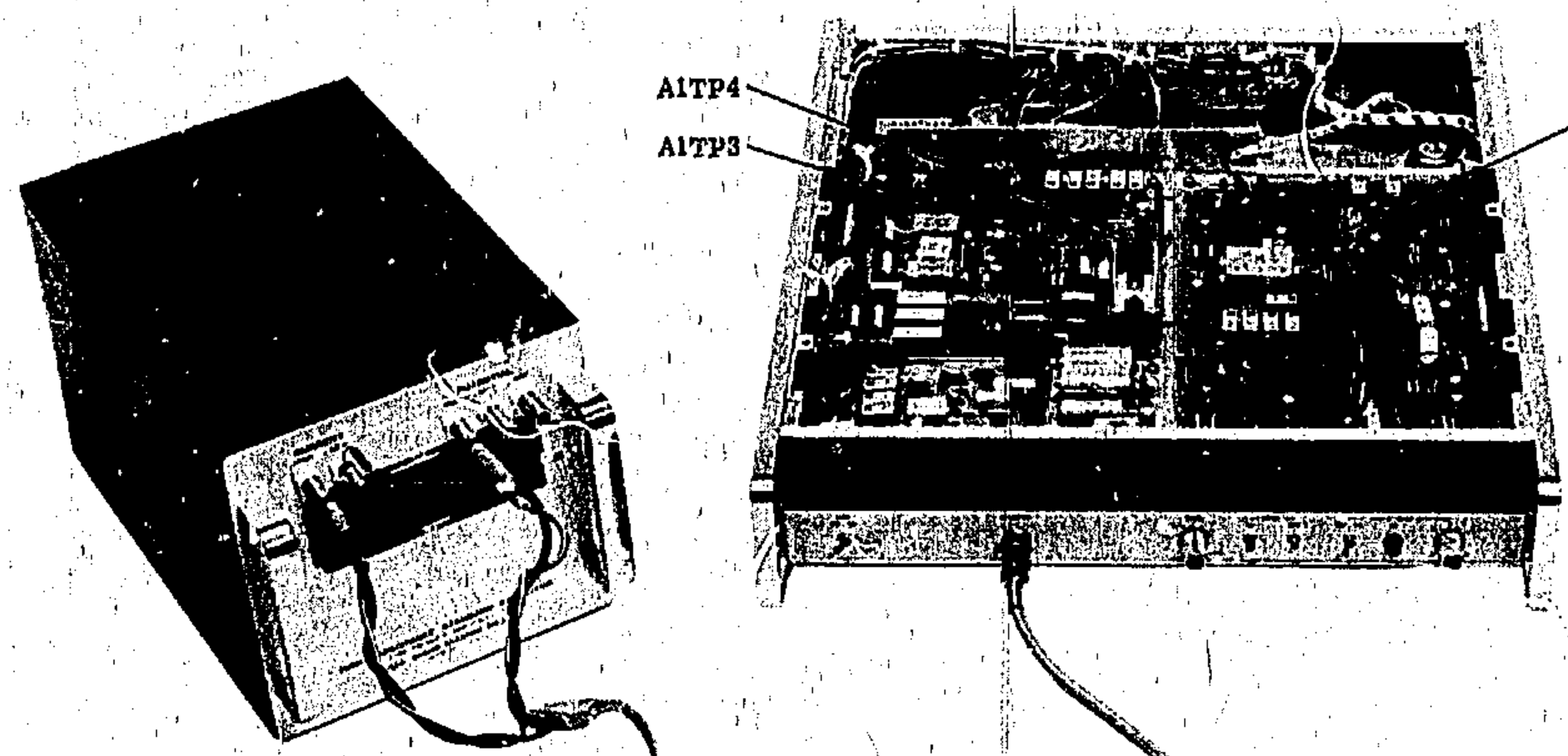


TOP VIEW



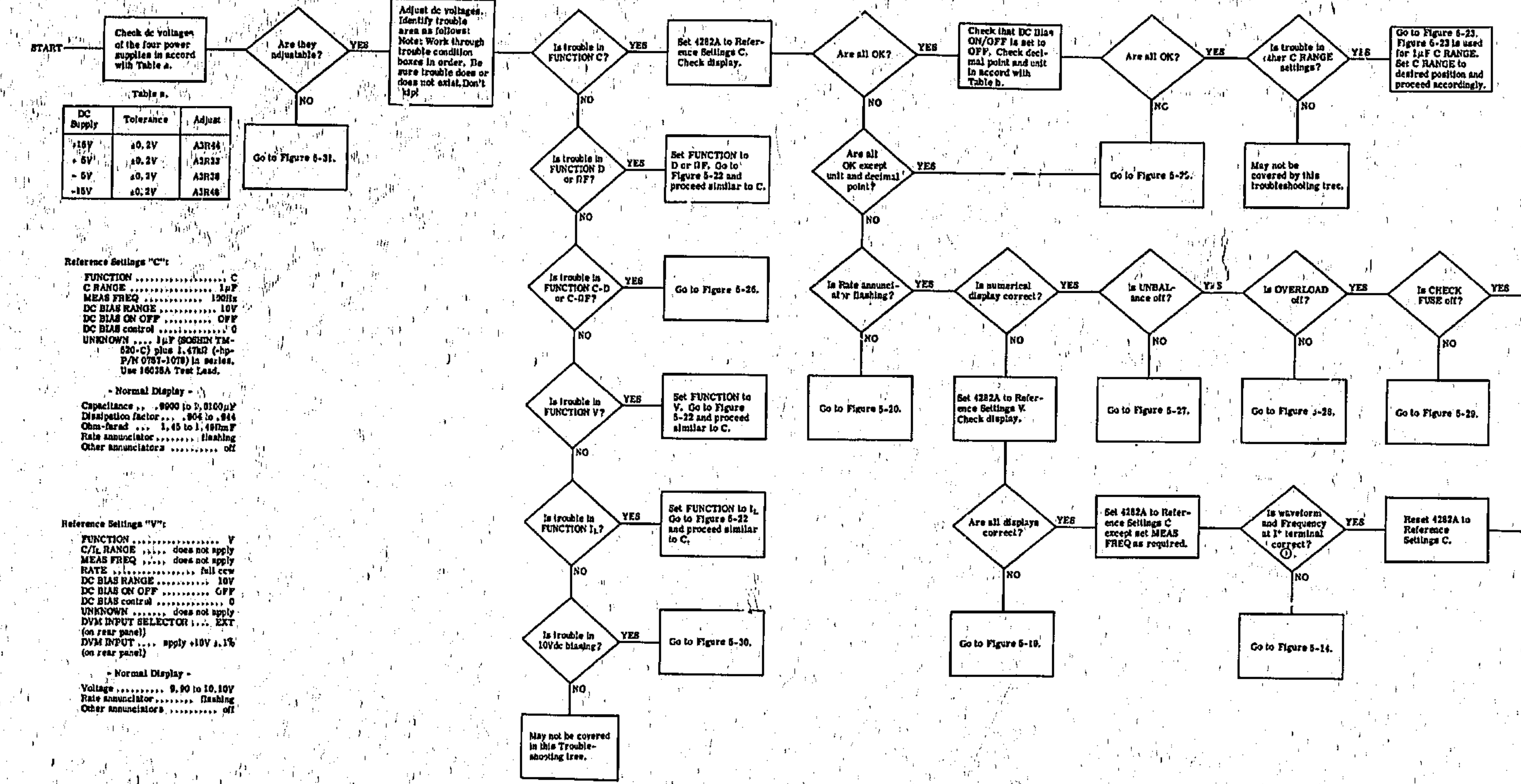
BOTTOM VIEW

Figure 5-12. Adjustments and Test Point Locations.



SEE INSIDE

Figure 5-12
Adjustments and Test Point Location



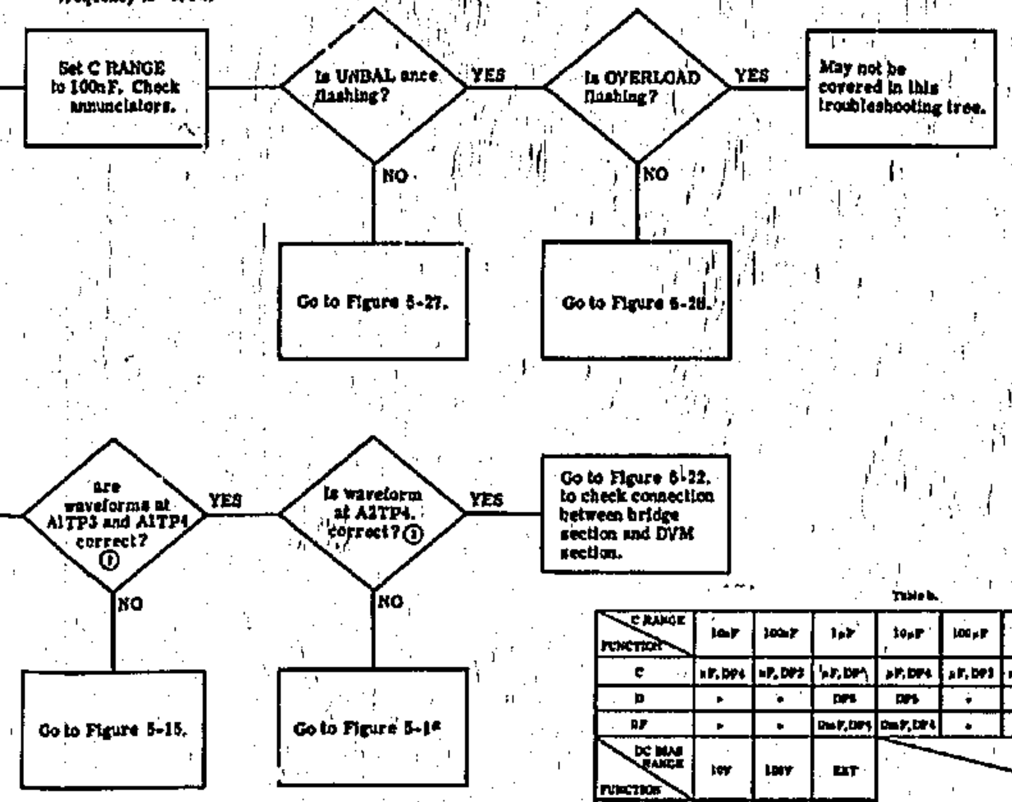


Table a.

DC Supply	Tolerance	Adjust
+15V	±0.2V	A3R44
+ 5V	±0.2V	A3R33
- 5V	±0.2V	A3R38
-15V	±0.2V	A3R48

Reference Settings "C":

FUNCTION C
C RANGE 1µF
MEAS FREQ 100Hz
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... 1µF (SOSHIN TM-520-C) plus 1.47kΩ (-hp- P/N 0757-1078) in series. Use 16035A Test Lead.

- Normal Display -

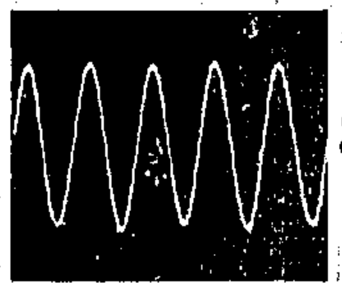
Capacitance ... .9900 to 1.0100µF
Dissipation factor ... .904 to .944
Ohm-farad ... 1.45 to 1.49ΩmF
Rate annunciator .... flashing
Other annunciators .... off

Reference Settings "V":

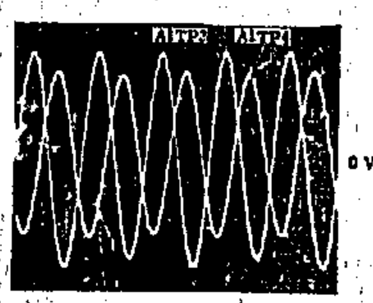
FUNCTION V
C/IL RANGE ...... does not apply
MEAS FREQ ...... does not apply
RATE .... full ccw
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... does not apply
DVM INPUT SELECTOR ..... EXT (on rear panel)
DVM INPUT .... apply +10V ±.1% (on rear panel)

- Normal Display -

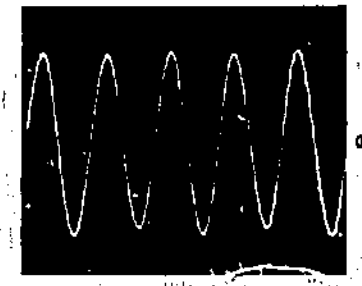
Voltage .... 9.90 to 10.10V
Rate annunciator .... flashing
Other annunciators .... off



1 0.5V/div. 5ms/div.



2 2V/div. 5ms/div.



3 2V/div. 5ms/div.

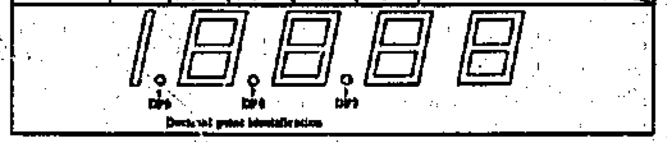
Note: This shows waveform when measuring frequency is 100Hz. At other measuring frequencies, use above for amplitude reference. Tolerance of each measuring frequency is 1.5%.

Table b.

FUNCTION \ C RANGE	10nF	100nF	1µF	10µF	100µF	1mF	10mF	100mF	1F
C	nF, DP4	nF, DP3	µF, DP5	µF, DP4	µF, DP3	mF, DP5	mF, DP4	mF, DP3	F, DP5
D	*	*	DP5	DP5	*	*	*	*	*
DF	*	*	ΩmF, DP5	ΩmF, DP4	*	*	*	*	*

FUNCTION \ DC BIAS RANGE	10V	100V	EXT
V	V, DP4	V, DP3	kV, DP5

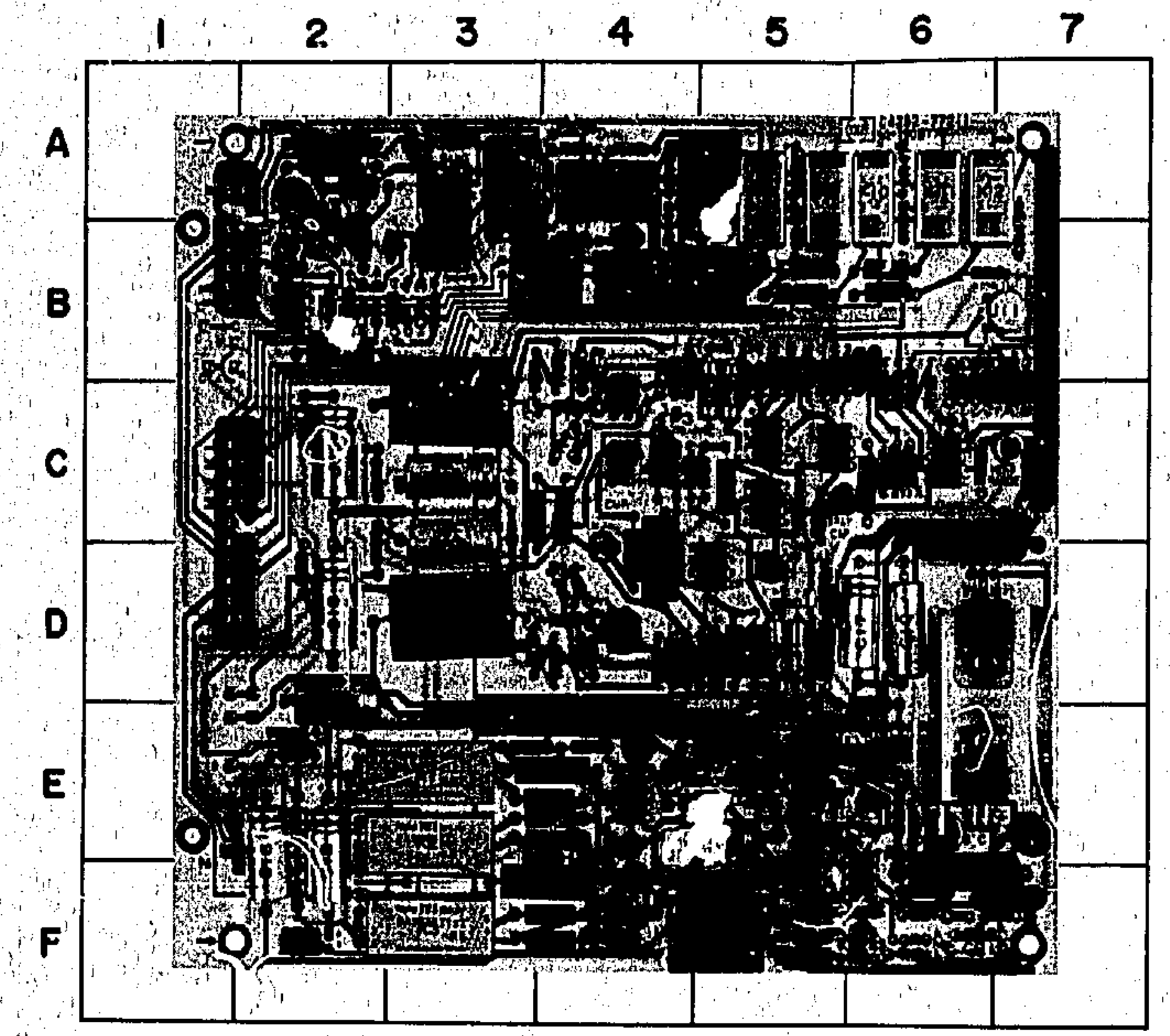
FUNCTION \ IL RANGE	1µA	10µA	100µA	1mA	10mA
IL	µA, DP5	µA, DP4	µA, DP3	mA, DP5	mA, DP4



Decimal point identification

Figure 5-13

Troubleshooting Tree - General



TEST POINTS LOCATOR

Test Point No.	Grid Loc.	Test Point No.	Grid Loc.
A1TP1	F-4	A1TP3	C-4
A1TP2	E-6	A1TP4	C-6

PARTS LOCATOR

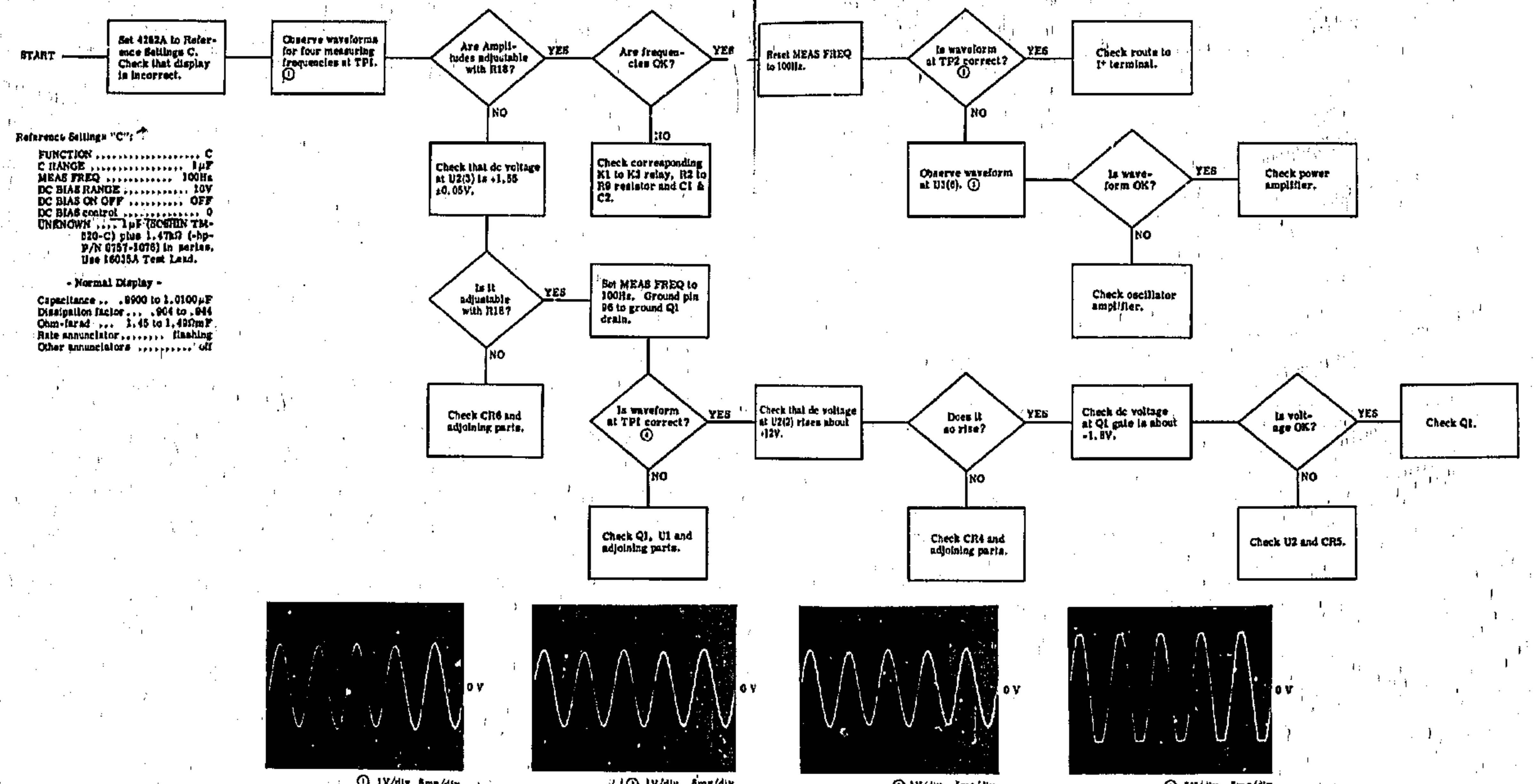
Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	F-5	C14	C-2	CR8	F-6	K3	F-3	Q10	A-2	R12	E-5	R25	E-6	R38	A-2	R51	E-2
C2	F-5	C15	C-3	CR9	F-6	K4	A-3			R13	F-4	R26	E-5	R39	B-2	R52	D-2
C3	E-5	C16	E-2	CR10	F-6	K5	A-3	R1	F-2	R14	E-4	R27	E-6	R40	B-2	R53	D-2
C4	E-5	C17	D-6	CR11	B-2			R2	E-4	R15	E-4	R28	F-6	R41	B-3		
C5	F-5	C18	D-2	CR12	A-2	Q1	E-4	R3	E-4	R16	E-4	R29	E-6	R42	B-2	U1	F-4
C6	E-5	C19	C-3	CR13	B-3	Q2	E-5	R4	F-4	R17	E-5	R30	E-6	R43	B-3	U2	E-4
C7	E-5			CR14	B-3	Q3	F-6	R5	F-5	R18	E-4	R31	F-6	R44	E-5	U3	F-5
C8	F-7	CR1	E-2	CR15	B-2	Q4	E-6	R6	E-4	R19	E-4	R32	F-6	R45	E-6	U4	F-6
C9	B-2	CR2	E-2	CR16	B-2	Q5	E-7	R7	E-4	R20	F-6	R33	F-6	R46	E-2	U5	B-2
C10	D-5	CR3	F-2	CR50	F-2	Q6	E-6	R8	F-4	R21	F-6	R34	D-6	R47	E-2		
C11	E-5	CR4	E-5	CR51	F-2	Q7	D-6	R9	F-4	R22	F-5	R35	B-2	R48	C-2	XA1	B-1
C12	E-2	CR5	E-3			Q8	B-2	R10	E-4	R23	F-5	R36	E-2	R49	C-2	XA2	C-1
C13	E-2	CR6	E-5	K1	E-3	Q9	B-2	R11	E-4	R24	F-6	R37	A-2	R50	E-1		
		CR7	F-5	K2	E-3												

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C20	C-3	CR14	B-3	CR35	B-6	K5	A-3	R55	A-4	R71	D-4	R96	B-7	R112	B-5	U11	B-7
C21	D-4	CR17	C-4	CR36	B-6	K6	A-4	R56	C-4	R72	D-4	R97	B-7	R113	B-5	U12	C-6
C22	C-5	CR18	C-4	CR37	B-6	K7	A-5	R57	C-3	R83	C-5	R98	B-6	R114	D-5	U13	C-5
C23	D-3	CR19	B-4	CR38	B-6	K8	A-5	R58	B-4	R84	C-5	R99	B-6	R115	D-5	U14	C-5
C24	D-5	CR20	B-4	CR39	B-7	K9	A-5	R59	B-4	R85	B-5	R100	B-6	R116	D-5	U15	D-6
C25	D-5	CR21	C-4	CR40	B-7	K10	A-6	R60	C-4	R86	B-5	R101	B-6	R117	D-5		
C26	B-6	CR22	C-4	CR41	C-6	K11	A-6	R61	D-4	R87	B-5	R103	C-6	R118	D-5	XA1	B-1
C27	B-6	CR23	D-4	CR42	C-6	K12	A-7	R62	D-4	R88	A-3	R104	C-7	R119	B-4		
C28	C-6	CR24	D-4	CR43	A-4			R63	D-4	R89	B-4	R105	C-7	R120	B-4		
C29	C-5	CR25	D-4	CR44	B-4	Q11	D-5	R64	B-4	R90	B-4	R106	C-6				
C30	C-5	CR26	D-4	CR45	B-5	Q12	D-5	R66	C-4	R91	B-5	R107	B-5	U6	C-4		
C31	D-5	CR27	D-4	CR46	B-5	Q13	D-5	R67	D-5	R92	B-5	R108	A-4	U7	C-4		
C32	D-5	CR28	D-4	CR47	A-6			R68	C-5	R93	B-5	R109	C-4	U8	D-4		
C33	D-5	CR33	D-5	CR48	B-6	R43	B-3	R69	D-4	R94	B-6	R110	B-5	U9	C-5		
		CR34	D-5	CR49	B-7	R54	A-4	R70	D-3	R95	B-6	R111	B-5	U10	C-5		

SEE INSIDE

Figure 5-13
Troubleshooting Tree - General

A1 Test Point Locations under Fold.



Reference Settings "C":

FUNCTION C
C RANGE 1µF
MEAS FREQ 100Hz
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... 1µF (SOSHIN TM-520-C) plus 1.47kΩ (-hp- P/N 0757-1076) in series. Use 16035A Test Lead.

- Normal Display -

Capacitance .. .9900 to 1.0100µF
Dissipation factor ... .904 to .944
Ohm-farad ... 1.45 to 1.49ΩmF
Rate annunciator .... flashing
Other annunciators .... off

① 1V/div. 5ms/div.

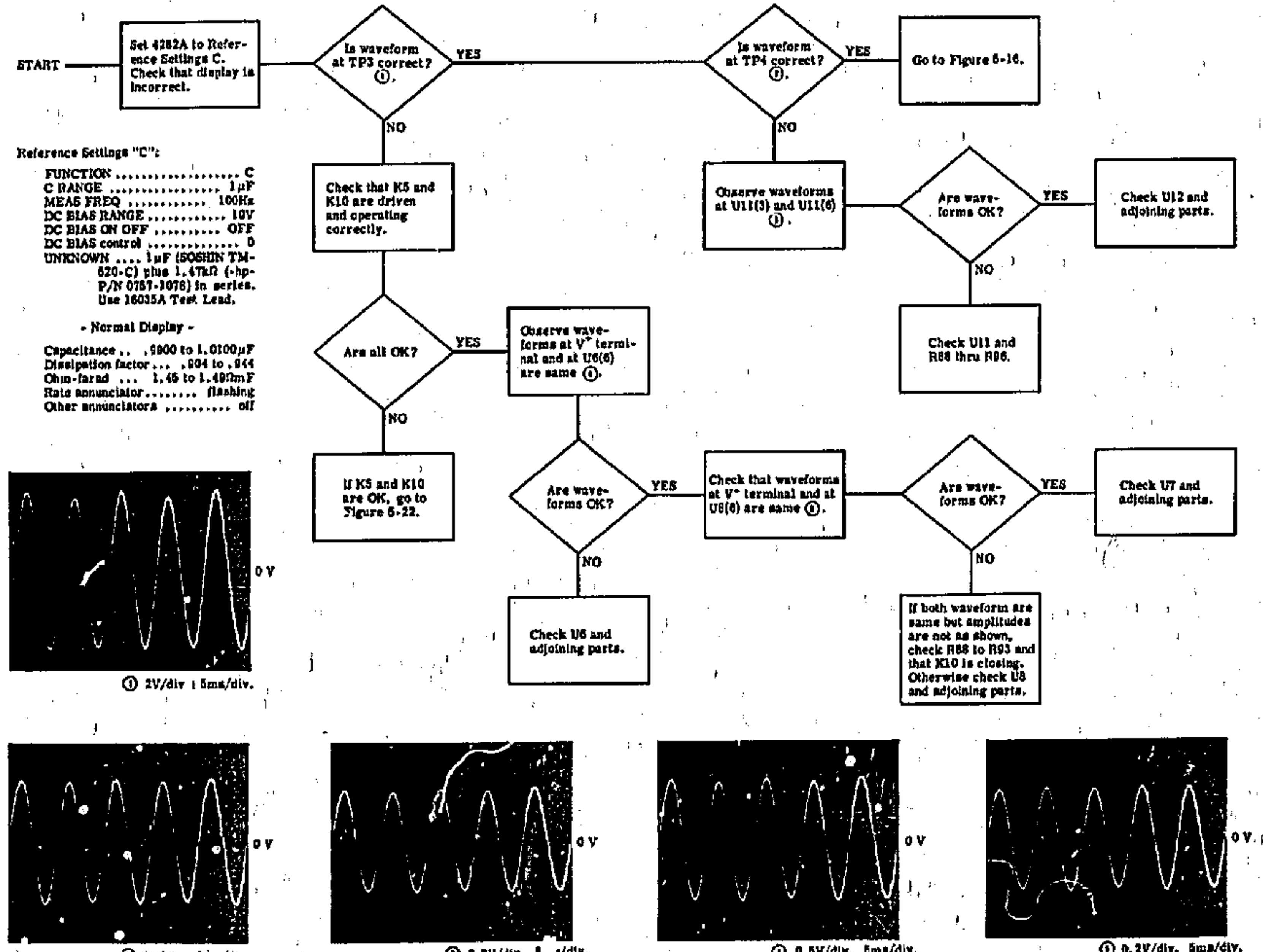
Note: This shows waveform when measuring frequency is 100Hz. At other measuring frequencies, use above for amplitude reference. Tolerance of each measuring frequency is ±1.5%.

② 1V/div. 5ms/div.

③ 1V/div. 5ms/div.

④ 5V/div. 5ms/div.

Figure 5-14. Troubleshooting Tree - Oscillator (A1).



Reference Settings "C":

FUNCTION C
C RANGE 1µF
MEAS FREQ 100Hz
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... 1µF (SOSHIN TM-520-C) plus 1.47kΩ (-hp- P/N 0757-1076) in series. Use 16035A Test Lead.

- Normal Display -

Capacitance .. .9900 to 1.0100µF
Dissipation factor ... .904 to .944
Ohm-farad ... 1.45 to 1.49ΩmF
Rate annunciator .... flashing
Other annunciators .... off

① 2V/div 5ms/div.

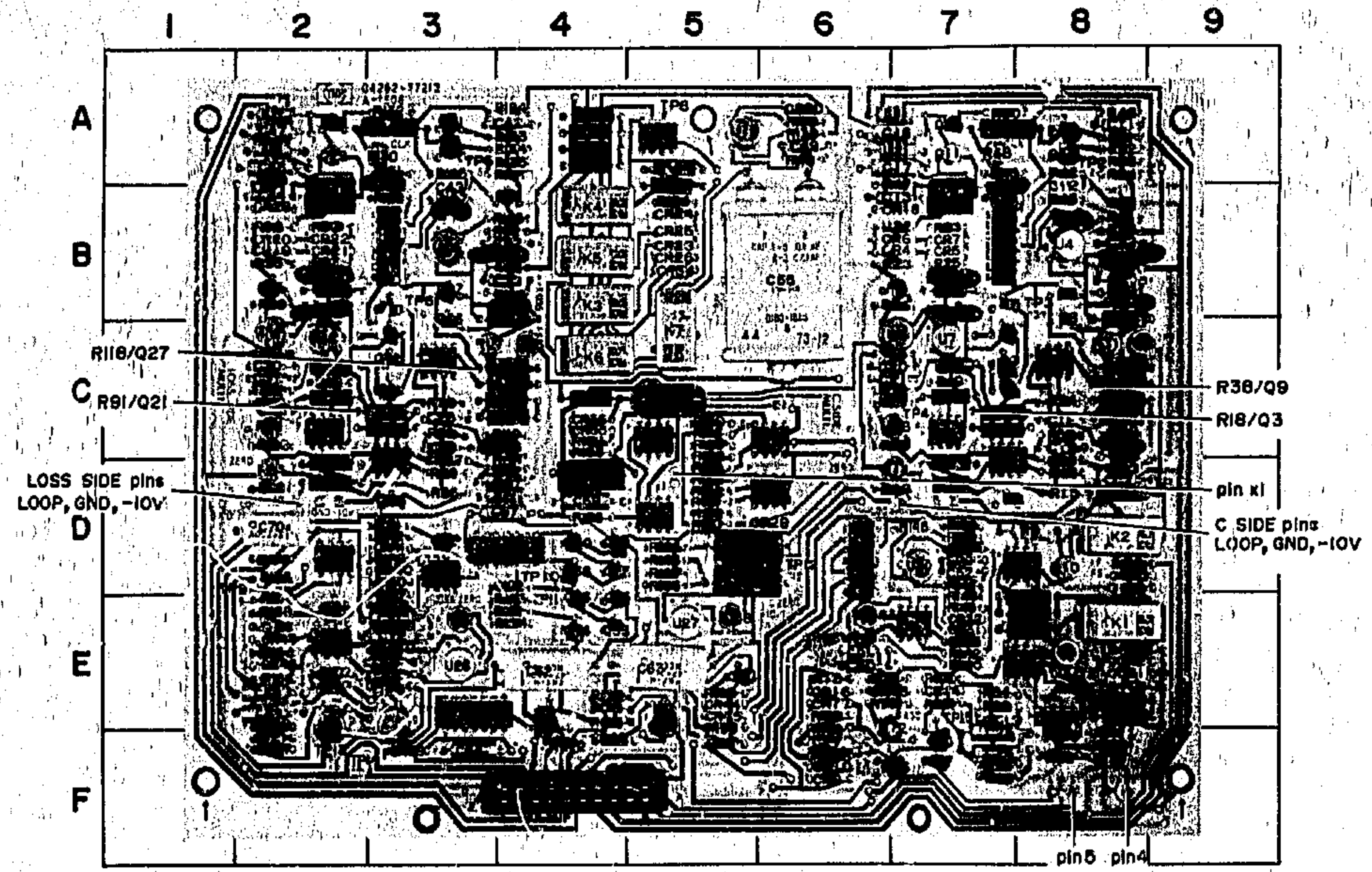
② 2V/div. 5ms/div.

③ 0.2V/div. 5 s/div.

④ 0.5V/div. 5ms/div.

⑤ 0.2V/div. 5ms/div.

Figure 5-15. Troubleshooting Tree - C and Loss Side Amplifiers (A1).



TEST POINTS LOCATOR

Test Point No.	Grid. Loc.	Test Point No.	Grid. Loc.
A2TP1	D-6	A2TP8	A-5
A2TP2	A-8	A2TP9	D-2
A2TP3	B-8	A2TP10	D-4
A2TP4	C-7	A2TP11	D-4
A2TP5	A-3	A2TP12	D-6
A2TP6	B-3	A2TP13	F-2
A2TP7	C-2	A2TP14	F-3

PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	E-8	Q4	C-7	R39	C-8
C2	D-7	Q5	C-7	R40	B-8
C3	B-7	Q6	C-6	R41	B-8
C4	C-7	Q7	B-6	R42	B-8
C5	B-7	Q8	B-8	R43	A-8
C6	B-8	Q9	B-8	R44	B-8
C7	D-8	Q10	B-8	R45	B-8
C8	C-8	Q11	A-7	R46	B-7
C9	B-8	Q12	A-7	R47	B-6
C10	B-8	Q13	A-8	R48	A-7
C11	A-8	Q14	A-8	R49	B-7
C12	B-8	Q15	E-7	R50	A-7
C13	B-8	Q16	F-6	R51	A-8
C14	B-7	Q17	F-7	R52	A-8
C15	A-7			R53	A-8
C16	A-6	R1	E-8	R54	C-8
C17	A-6	R2	D-8	R55	C-6
C18	C-8	R3	E-8	R56	B-8
C19	C-8	R4	E-8	R57	C-8
C20	C-6	R5	E-8	R58	C-6
C21	C-6	R6	E-8	R59	B-8
C22	B-8	R7	D-8	R60	F-8
C23	B-8	R8	E-8	R61	E-8
C24	D-8	R9	D-7	R62	F-8
C25	E-7	R10	D-8	R63	F-8
C26	F-7	R11	D-6	R64	E-7
C27	E-6	R12	D-6	R65	E-7
		R13	D-7	R66	F-7
CR1	E-8	R14	D-7	R67	E-7
CR2	E-8	R15	D-8	R68	F-7
CR3	D-8	R16	D-8	R69	E-7
CR4	B-6	R17	C-7	R70	E-6
CR5	B-7	R18	C-7	R71	E-6
CR6	B-6	R19	C-7	R72	E-6
CR7	B-7	R20	C-7	R73	E-6
CR8	C-8	R21	B-7	R74	E-6
CR9	F-6	R22	B-6	R75	E-6
CR10	F-6	R23	B-6	R76	F-6
CR11	E-8	R24	B-6		
CR12	E-8	R25	B-7	T1	B-7
CR13	E-7	R26	B-6		
CR14	E-7	R27	C-6	U1	E-7
CR15	E-6	R28	C-6	U2	D-7
CR16	E-6	R29	C-6	U3	C-8
CR17	E-6	R30	C-8	U4	B-8
CR18	B-6	R31	C-8	U5	B-7
		R32	C-8	U6	C-7
K1	E-8	R33	D-8	U7	C-7
K2	D-8	R34	C-8	U8	C-7
		R35	D-8	U10	E-8
Q1	D-7	R36	C-8		
Q2	B-7	R37	C-8	XA1	F-4
Q3	C-7	R38	C-8		

SEE INSIDE

Figures 5-14 and 5-15
Troubleshooting Tree - Oscillator (A1)
Troubleshooting Tree - C and Loss side Amplifiers (A1)

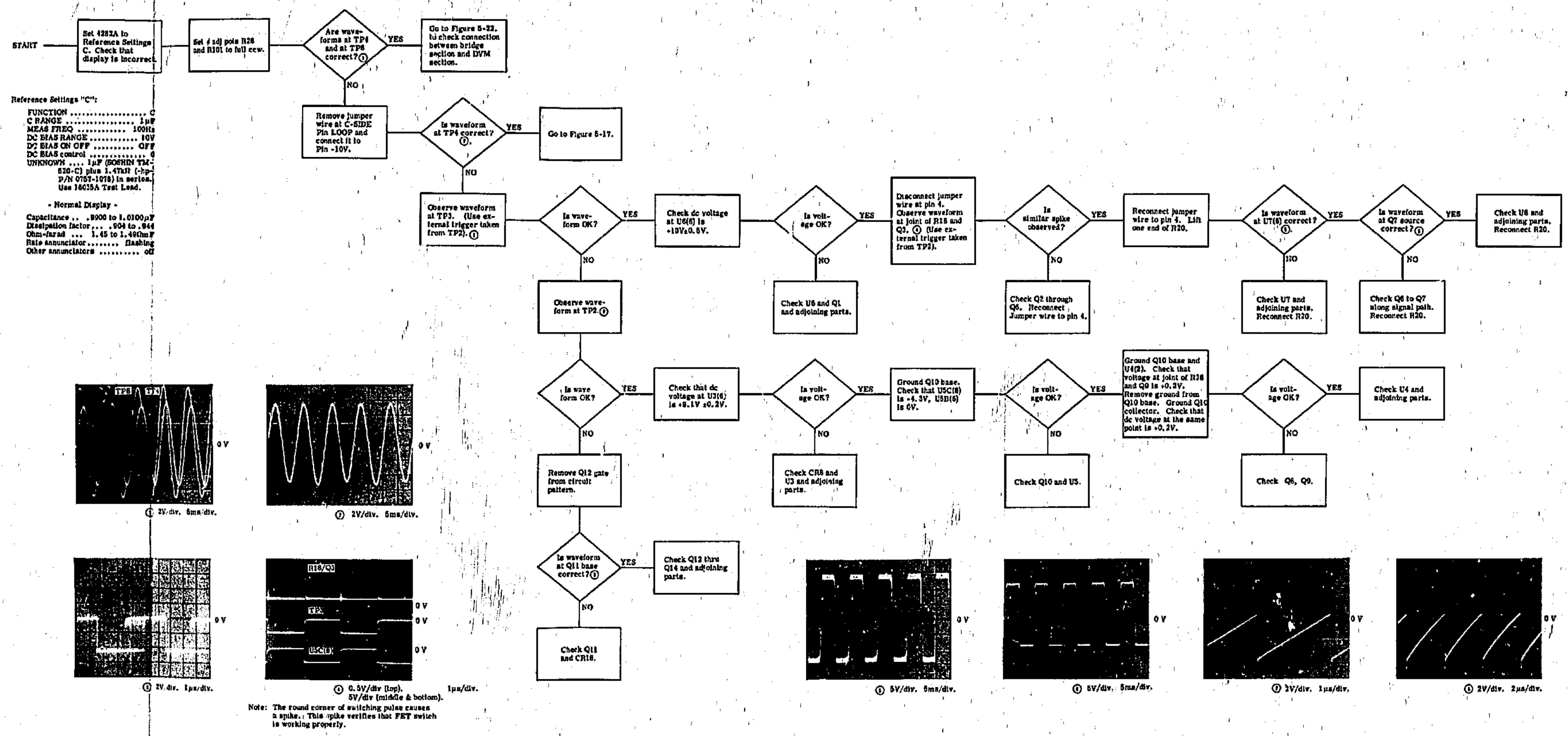
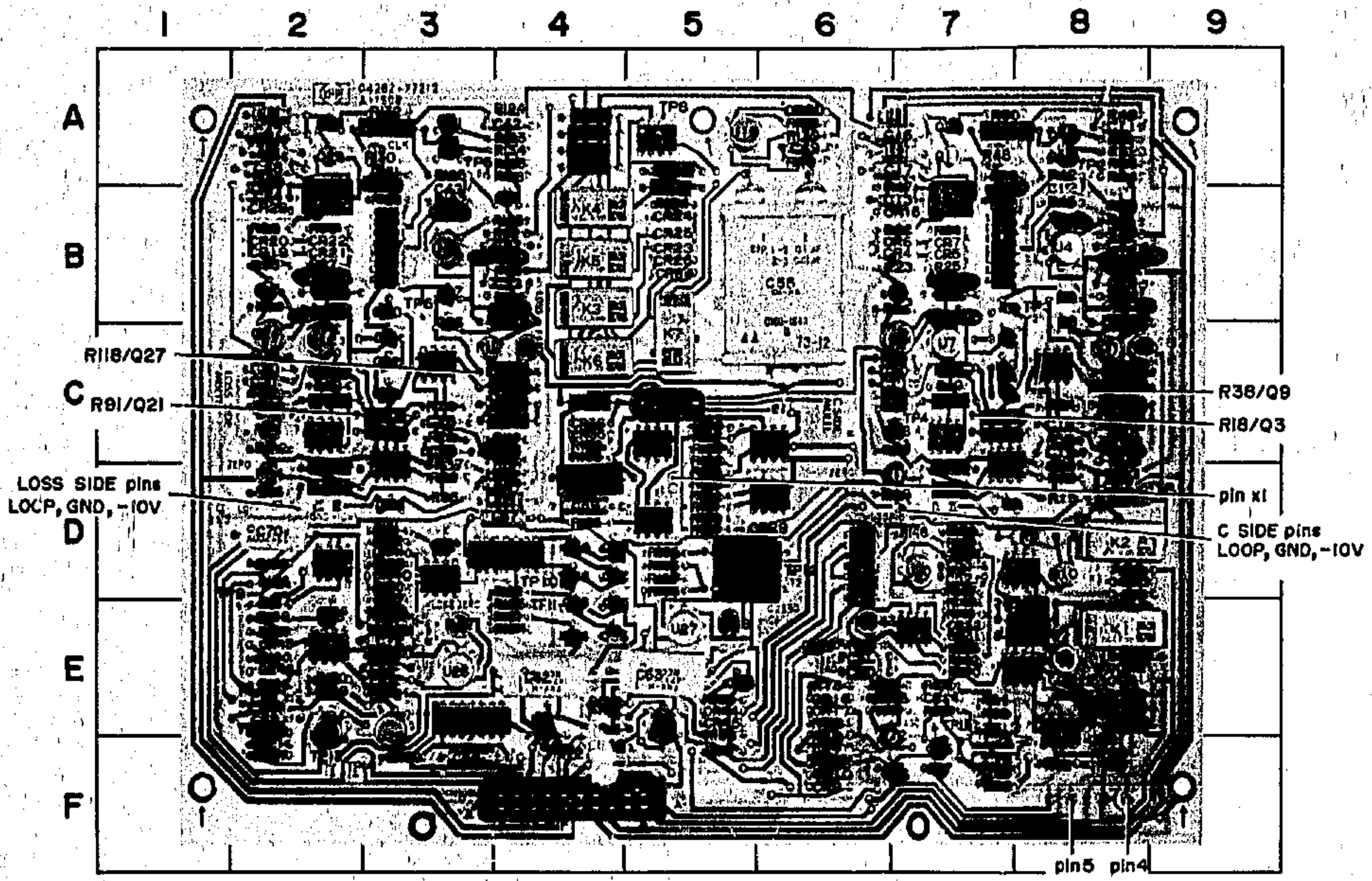


Figure 5-16

Troubleshooting Tree - C Side Multiplier (A2)



TEST POINTS LOCATOR

Test Point No.	Grid. Loc.	Test Point No.	Grid. Loc.
A2TP1	D-8	A2TP8	A-5
A2TP2	A-8	A2TP9	D-2
A2TP3	B-8	A2TP10	D-4
A2TP4	C-7	A2TP11	D-4
A2TP5	A-3	A2TP12	D-6
A2TP6	B-3	A2TP13	F-2
A2TP7	C-2	A2TP14	F-3

PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C28	C-3	Q19	D-3	R115	C-4
C29	C-3	Q20	B-3	R116	C-4
C30	C-2	Q21	C-3	R117	C-3
C31	C-2	Q22	C-3	R118	C-4
C32	B-4	Q23	C-3	R119	C-4
C33	B-4	Q24	C-2	R120	B-4
C34	C-2	Q25	B-2	R121	C-4
C35	B-2	Q26	B-3	R122	B-4
C36	B-2	Q27	B-3	R123	B-4
C37	D-4	Q28	B-4	R124	A-4
C38	C-4	Q29	A-2	R125	A-3
C39	B-4	Q30	A-2	R126	A-4
C40	B-3	Q31	A-3	R127	B-3
C41	B-4	Q32	A-3	R128	B-3
C42	A-4			R129	B-2
C43	B-3	R77	E-5	R130	A-3
C44	B-2	R78	C-3	R131	A-3
C45	B-3	R79	C-3	R132	A-3
C46	A-3	R80	C-2	R133	A-4
C47	A-2	R81	C-2	R134	A-4
C48	A-2	R82	B-4	R135	A-4
C49	A-6	R83	B-4	R136	D-5
C50	E-6	R84	D-2	R137	D-5
C51	E-6	R85	D-3	R138	A-6
C52	D-7	R86	D-2	R139	A-6
C53	D-7	R87	D-2	R140	E-7
C54	E-6	R88	C-2	R141	E-6
		R89	D-3	R142	E-7
CR19	B-2	R90	C-3	R143	E-7
CR20	B-2	R91	C-3	R144	E-6
CR21	B-2	R92	C-2	R145	E-7
CR22	B-2	R93	C-2	R146	D-7
CR23	B-5	R94	B-2	R147	D-7
CR24	B-5	R95	B-2	R148	D-7
CR25	B-5	R96	B-2	R149	D-7
CR26	B-5	R97	B-2	R150	D-7
CR27	C-3	R98	B-2		
CR28	B-2	R99	B-2	T2	B-2
CR29	D-5	R100	C-2		
CR30	A-6	R101	C-2	U11	C-3
CR31	E-7	R102	C-2	U12	C-2
CR32	E-7	R103	E-5	U13	C-2
CR33	D-7	R104	B-5	U14	A-5
		R105	A-4	U15	C-3
K3	B-4	R106	A-4	U16	B-3
K4	B-4	R107	A-4	U17	B-3
K5	B-4	R108	A-4	U18	E-7
K6	C-4	R109	B-5	U19	A-5
		R110	A-6	U20	D-7
L3	A-2	R111	A-5	U21	D-6
L4	A-2	R112	C-4		
		R113	C-4	XA1	F-4
Q18	E-5	R114	C-4		

SEE INSIDE

Figure 5-16
Troubleshooting Tree - C Side Multiplier (A2)

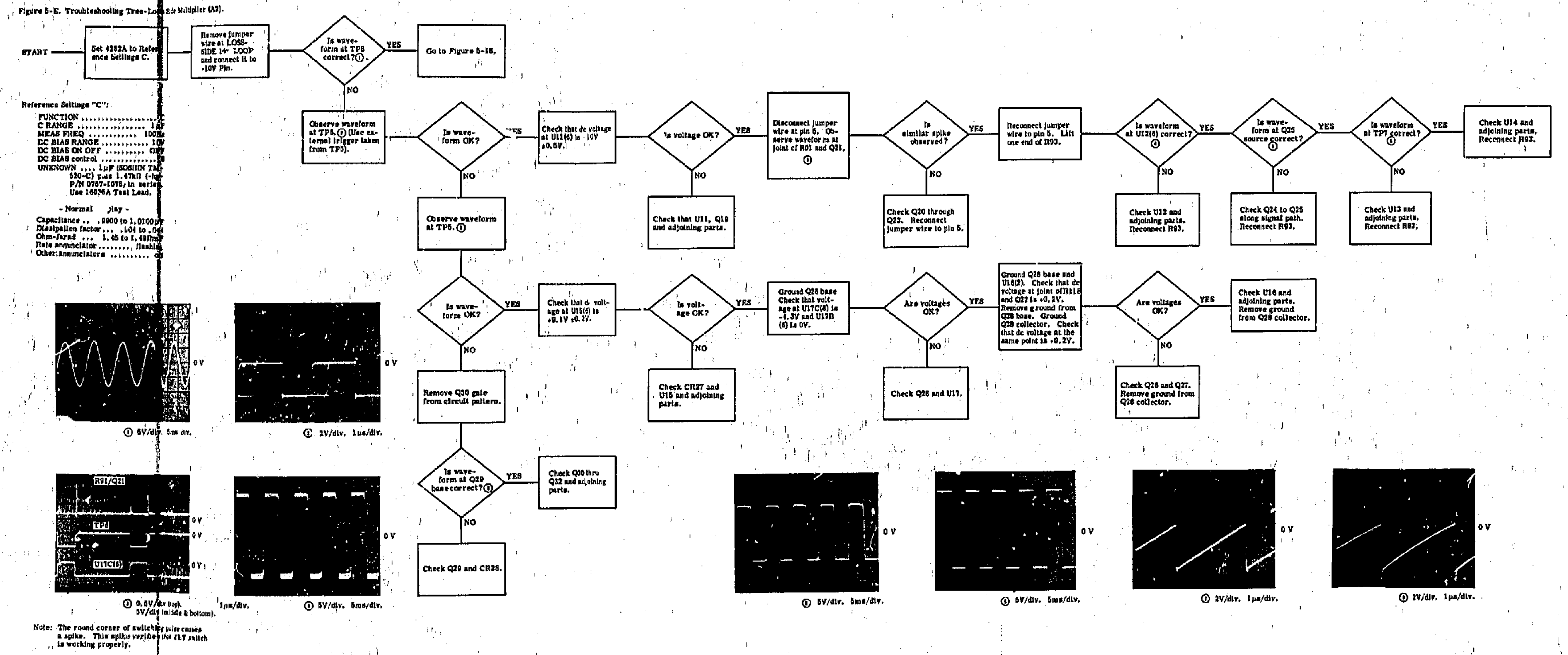
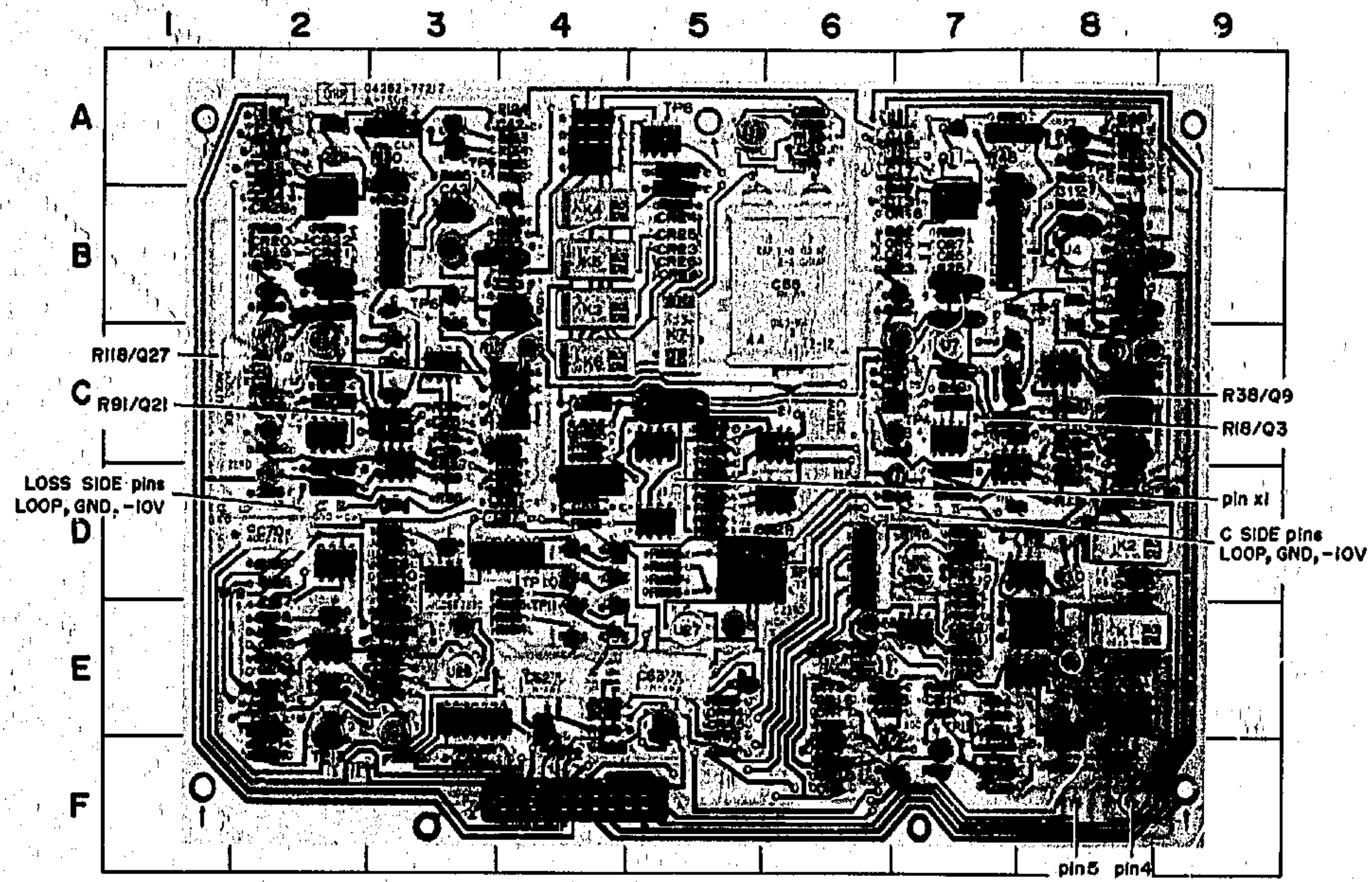


Figure 5-17

Troubleshooting Tree - Loss Side Multiplier (A2)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C55	B-6	Q35	D-4	R179	E-3
C57	C-5	Q36	D-4	R180	D-3
C58	D-4	Q37	D-4	R181	D-3
C59	D-4	Q38	D-4	R182	D-3
C60	D-5	Q39	D-4	R183	D-3
C61	D-5	Q40	D-4	R184	E-4
C62	E-4	Q41	E-4	R185	D-4
C63	E-5	Q42	D-3	R186	E-2
C64	E-3	Q43	E-2	R187	D-3
C65	E-3			R188	E-2
C66	E-3	R151	C-4	R189	E-2
C67	D-4	R152	C-4	R190	E-2
C68	E-2	R153	C-4	R191	E-4
C69	E-2	R154	C-5	R192	D-4
C70	D-2	R155	D-4	R193	E-5
C71	D-3	R156	C-5	R194	E-4
C72	D-3	R157	C-5	R195	E-4
		R158	C-5	R196	E-4
CR34	B-5	R159	D-5		
CR35	C-4	R160	D-5	U22	C-5
CR36	C-4	R161	D-5	U23	D-5
CR37	E-2	R162	D-5	U24	C-6
CR38	E-2	R163	D-5	U25	D-6
CR39	E-3	R164	D-5	U26	E-3
CR40	D-3	R165	D-5	U27	E-5
CR41	D-3	R166	D-5	U28	E-2
CR42	E-2	R167	E-3	U29	E-3
CR43	E-2	R168	E-5	U30	E-3
CR44	E-5	R169	E-2	U31	D-2
CR45	E-5	R170	E-2	U32	D-3
CR46	E-4	R171	E-2	U33	D-4
		R172	E-4	U34	E-2
K7	C-5	R173	E-4	U35	E-5
		R174	E-3		
L5	D-4	R175	E-3	XA1	F-4
		R176	D-2		
Q33	E-4	R177	D-2		
Q34	E-4	R178	D-2		

TEST POINTS LOCATOR

Test Point No.	Grid. Loc.	Test Point No.	Grid. Loc.
A2TP1	D-8	A2TP8	A-5
A2TP2	A-8	A2TP9	D-2
A2TP3	B-8	A2TP10	D-4
A2TP4	C-7	A2TP11	D-4
A2TP5	A-3	A2TP12	D-6
A2TP6	B-3	A2TP13	F-2
A2TP7	C-2	A2TP14	F-3

SEE INSIDE

Figure 5-17
Troubleshooting Tree - Loss Side Multiplier (A2)

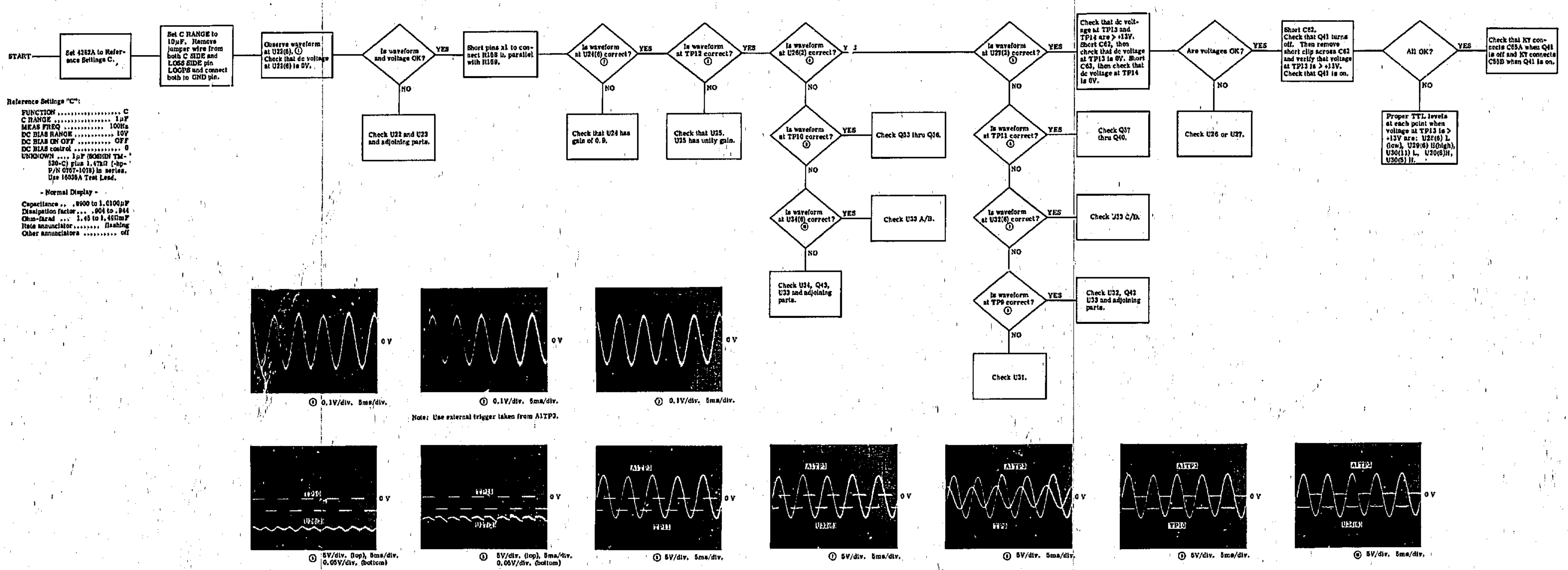
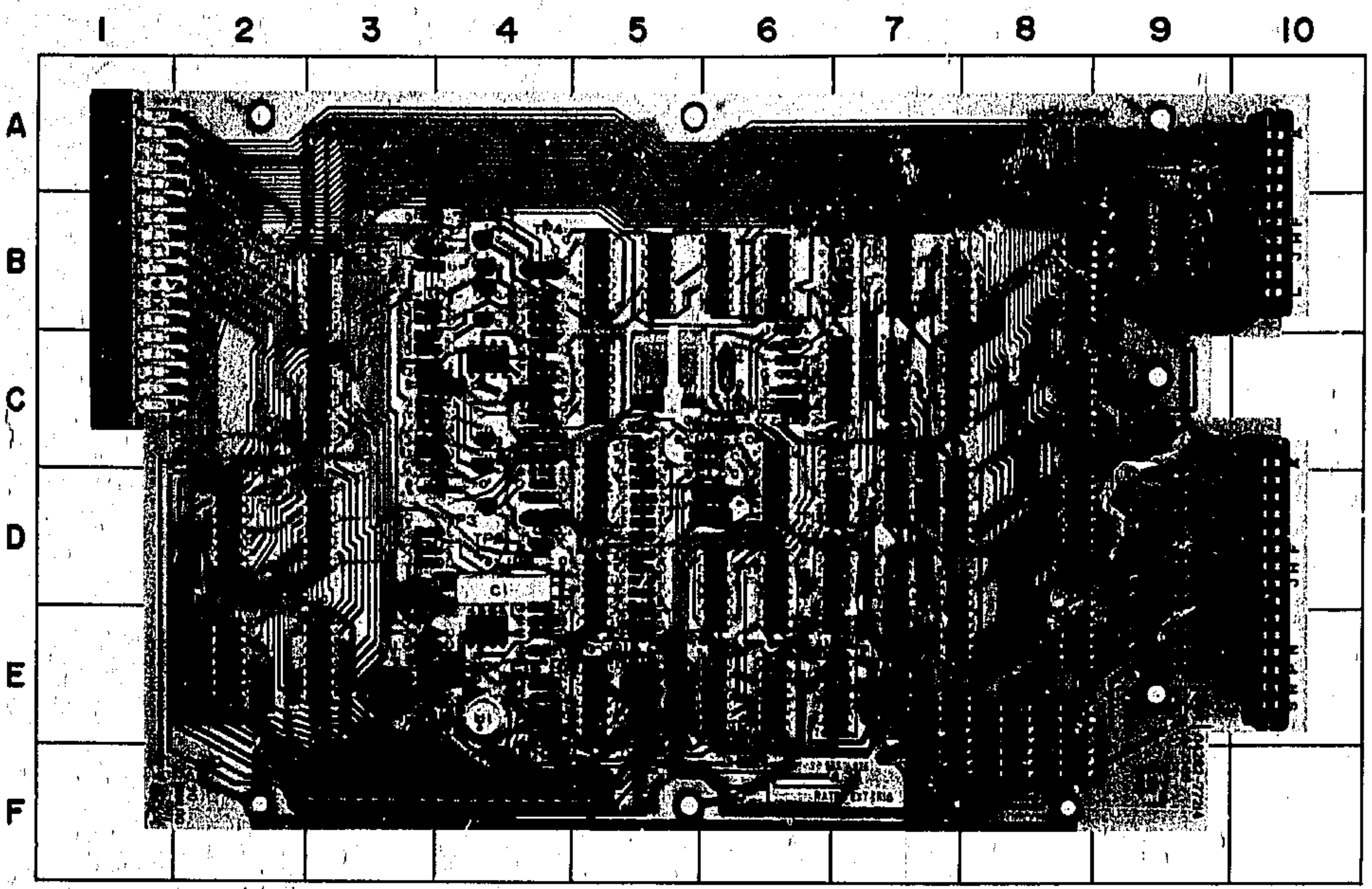


Figure 5-18

Troubleshooting Tree - Null Detector (A2)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	D-4	R1	E-4	R34	C-6
C2	D-4	R2	E-4	R35	C-6
C3	E-5	R3	E-4	R36	C-6
C4	E-5	R4	E-3	R37	C-6
C5	C-6	R5	E-4	R38	D-4
C6	C-6	R6	E-4	R39	E-4
C7	B-4	R7	D-4	R40	D-4
C8	D-4	R8	D-4	R41	D-3
C9	D-4	R9	D-5	R42	E-4
C10	C-4	R10	D-5	R43	D-4
C11	C-4	R11	D-6	R44	C-4
		R12	E-5	R45	C-4
CR1	E-4	R13	E-5	R46	C-4
CR2	E-4	R14	D-5	R47	C-4
CR3	E-4	R15	E-5	R48	C-4
CR4	E-4	R16	D-5	R49	C-4
CR5	D-4	R17	E-5	R50	C-4
CR6	B-4	R18	E-5	R51	C-4
CR7	B-4	R19	E-4	R52	D-4
CR8	C-4	R20	E-4	R53	D-4
CR9	C-4	R21	C-4		
CR10	D-4	R22	C-4	U1	E-4
CR11	E-4	R23	B-4	U2	E-4
		R24	C-4	U3	C-4
Q1	D-5	R25	D-4	U4	C-5
Q2	E-5	R26	C-4	U5	B-5
Q3	B-4	R27	C-4	U6	B-5
Q4	B-4	R28	C-4	U7	B-6
Q5	B-4	R29	C-4	U8	B-6
Q6	B-4	R31	C-4	U9	B-7
Q7	C-4	R32	B-4	U10	C-7
Q8	C-4	R33	B-4		
Q9	D-4			XA3	F-3
				Y1	C-5

TEST POINTS LOCATOR

Test Point No.	Grid. Loc.	Test Point No.	Grid. Loc.
A4TP1	B-4	A4TP8	E-5
A4TP2	D-4	A4TP9	E-6
A4TP3	D-4	A4TP10	E-6
A4TP4	B-4	A4TP11	D-6
A4TP5	E-6	A4TP12	D-6
A4TP6	D-6	A4TP13	C-6
A4TP7	D-5	A4TP14	C-7

SEE INSIDE

Figure 5-18

Troubleshooting Tree - Null Detector (A2)

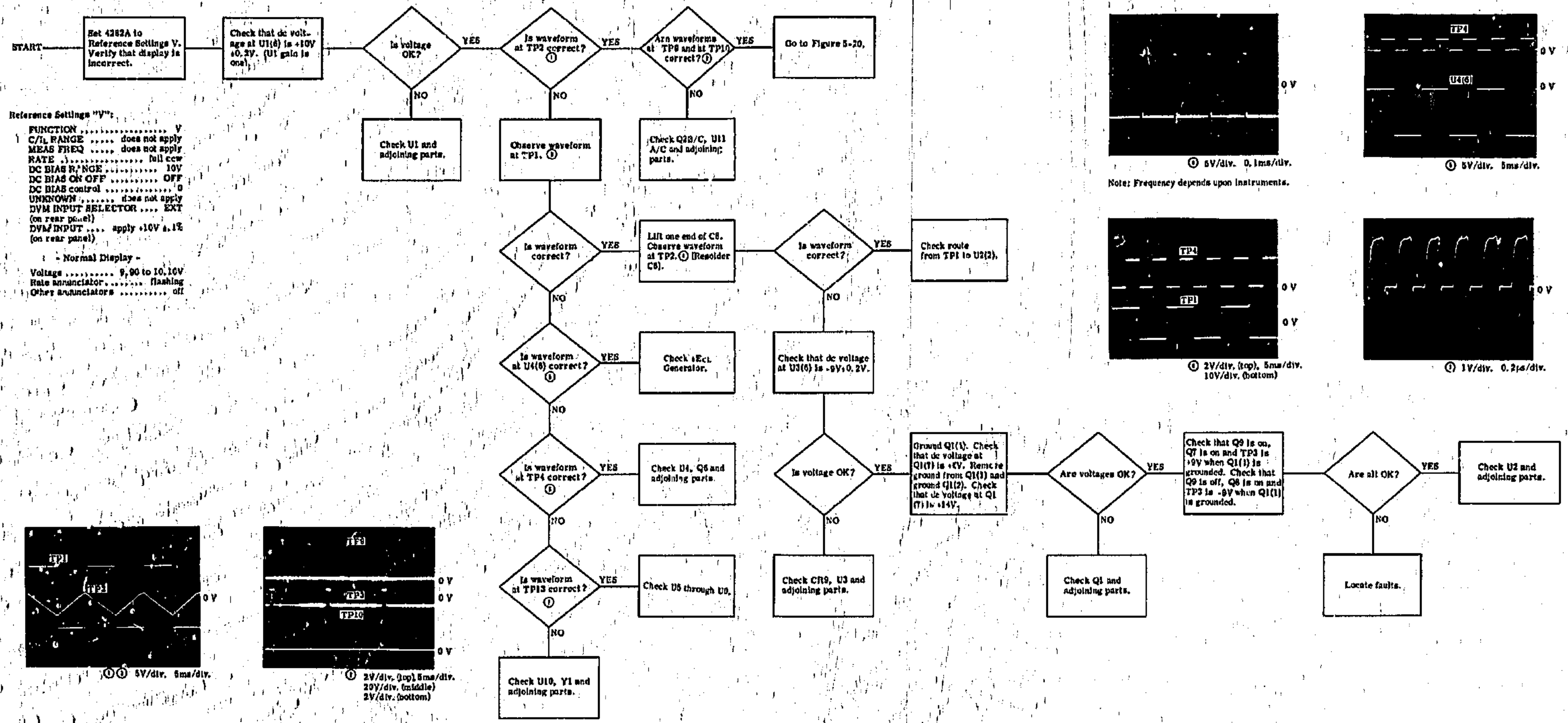
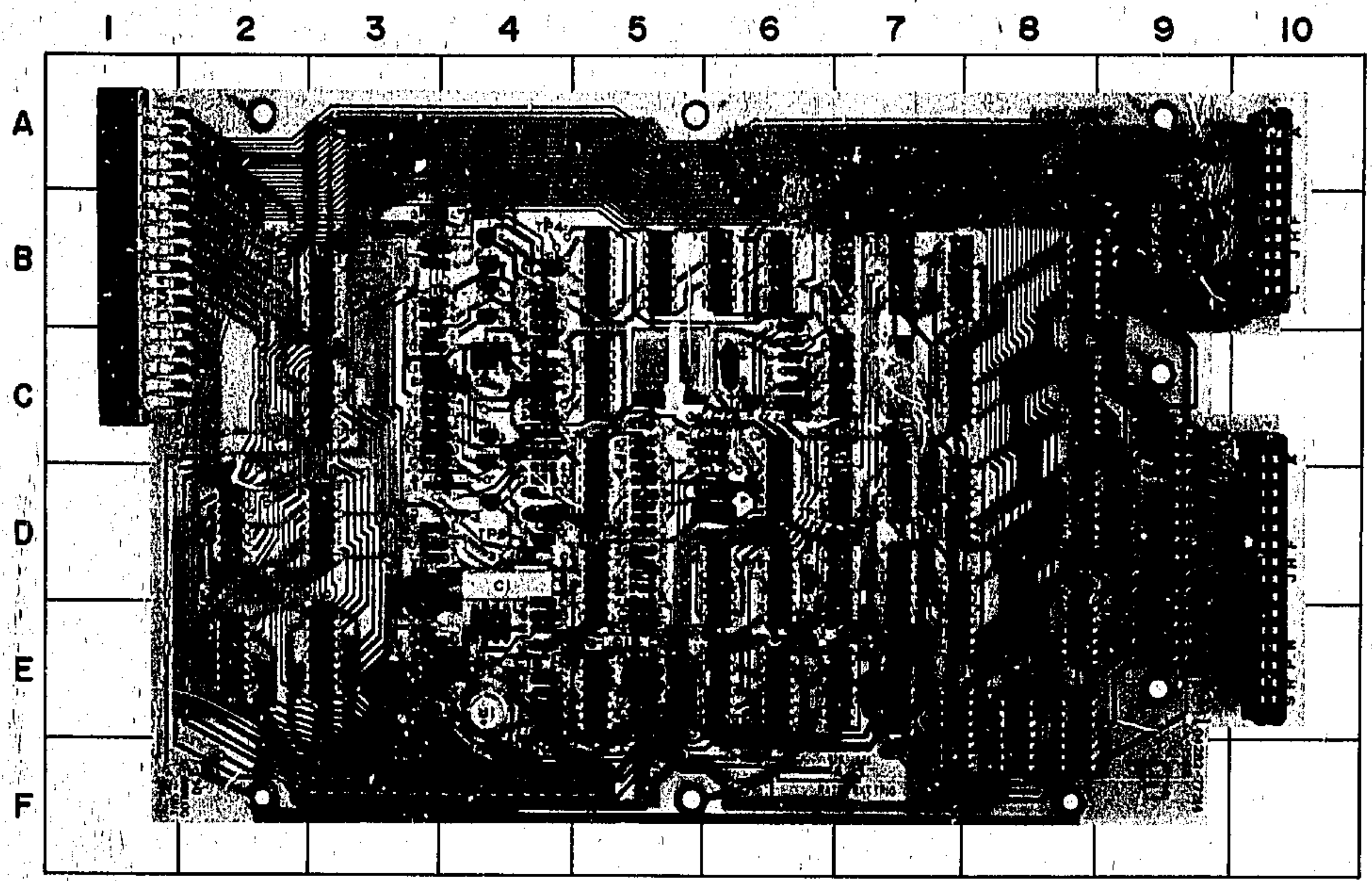


Figure 5-19
Troubleshooting Tree - PWM (A4)



PARTS LOCATOR

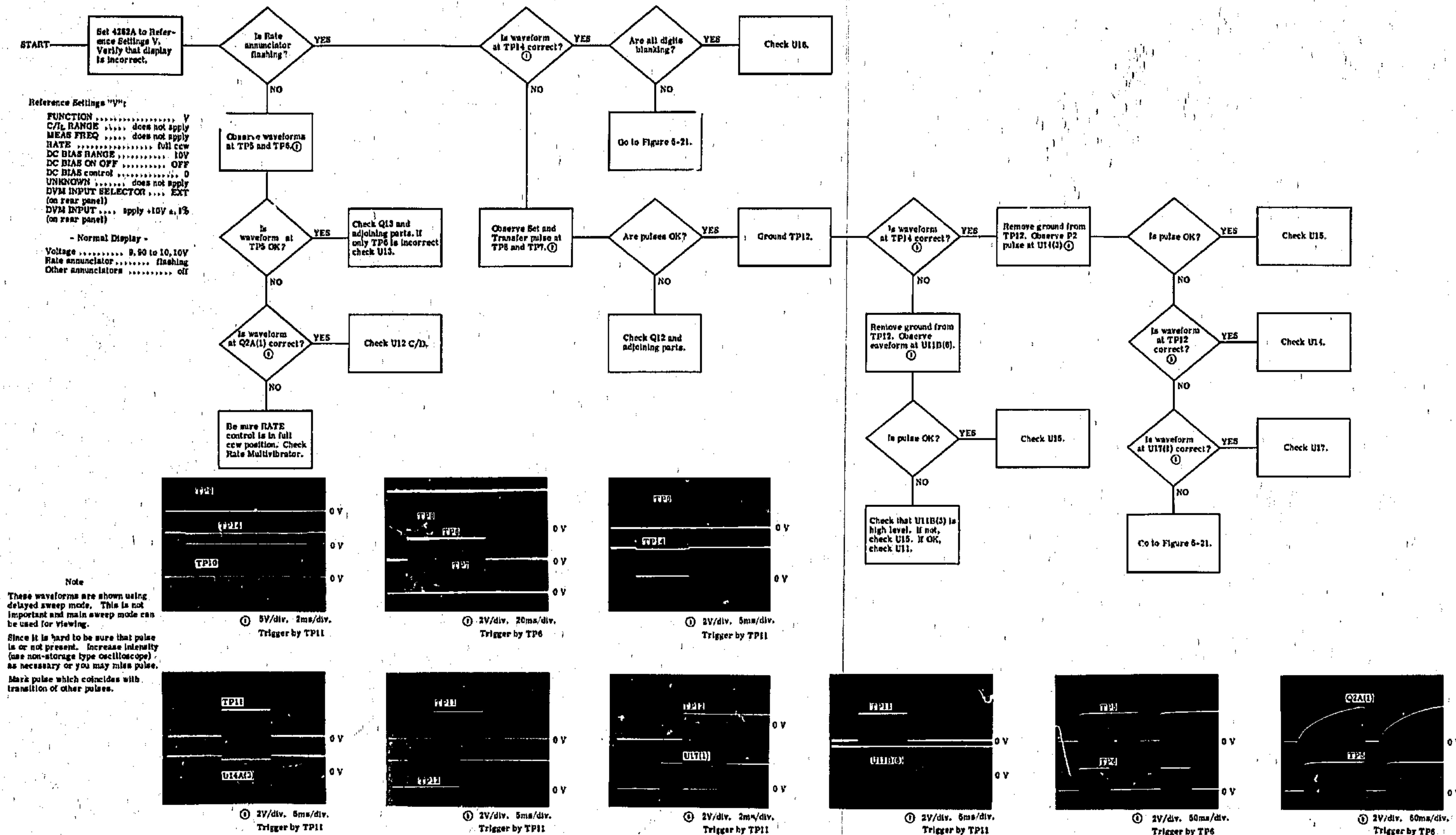
Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C12	C-6	R54	D-6	R74	B-9
C13	C-6	R55	C-6	R75	B-9
C14	C-6	R56	E-4	R104	F-6
C15	E-5	R57	E-4	R105	B-9
C16	E-4	R58	E-4	U10	C-7
C17	D-6	R59	E-4	U11	E-6
C18	D-6	R60	D-5	U12	D-6
C19	D-6	R61	C-5	U13	D-6
C20	E-7	R62	C-5	U14	E-7
C21	E-6	R63	D-5	U15	E-6
C22	D-7	R64	D-5	U16	D-6
		R65	C-5	U17	D-7
CR11	F-4	R66	D-5	U18	D-7
		R67	D-5	U19	E-8
Q2	E-5	R68	D-5	U20	E-8
Q12	D-5	R69	C-6	U21	B-3
Q13	A-9	R70	E-7		
Q14	B-9	R71	E-6	XA1	B-10
Q15	B-9	R72	B-4	XA2	D-10
Q16	B-9	R73	E-9	XA3	F-3
Q17	B-9			XA4	B-1

TEST POINTS LOCATOR

Test Point No.	Grid. Loc.	Test Point No.	Grid. Loc.
A4TP1	B-4	A4TP8	E-5
A4TP2	D-4	A4TP9	E-6
A4TP3	D-4	A4TP10	E-6
A4TP4	B-4	A4TP11	D-6
A4TP5	E-6	A4TP12	D-6
A4TP6	D-6	A4TP13	C-6
A4TP7	D-5	A4TP14	C-7

SEE INSIDE

Figure 5-19
Troubleshooting Tree - PWM (A4)



Reference Settings "V":

FUNCTION V
C/I_L RANGE ...... does not apply
MEAS FREQ ...... does not apply
RATE .... full ccw
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... does not apply
DVM INPUT SELECTOR .... EXT
(on rear panel)
DVM INPUT .... apply +10V ±.1%
(on rear panel)

- Normal Display -

Voltage .... 9.90 to 10.10V
Rate annunciator .... flashing
Other annunciators .... off

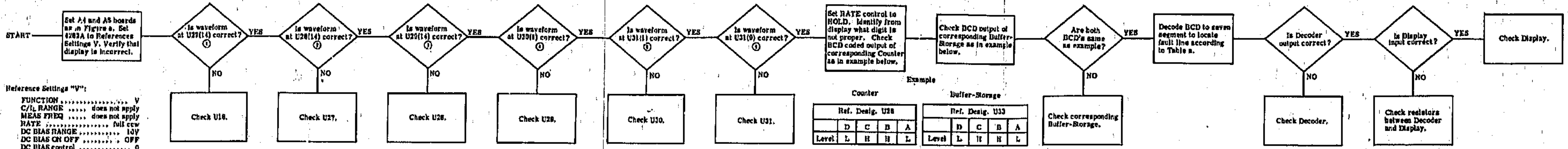
Note

1. These waveforms are shown using delayed sweep mode. This is not important and main sweep mode can be used for viewing.
2. Since it is hard to be sure that pulse is or not present. Increase intensity (use non-storage type oscilloscope) as necessary or you may miss pulse.
3. Mark pulse which coincides with transition of other pulses.

Figure 5-20
Troubleshooting Tree - Control Logic (A4)

Figure a.

Figure 5-21. Troubleshooting Tree-Counter/Buffer Storage/Decoder/Display (A4, A5).

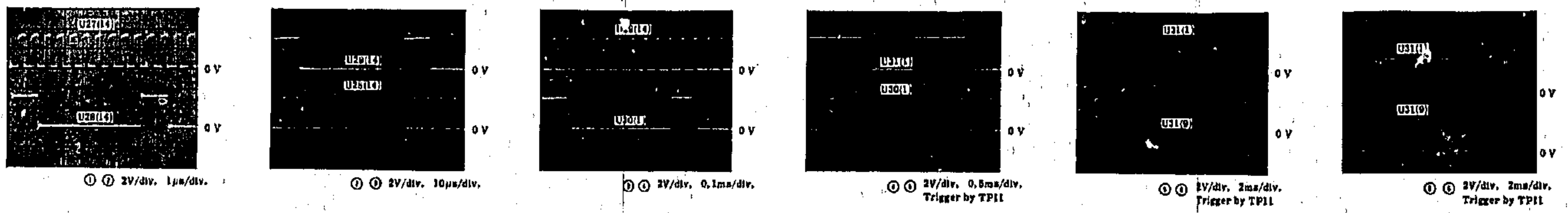


Reference Settings "V":

FUNCTION V
C/L RANGE ...... does not apply
MEAS FREQ ...... does not apply
RATE .... full ccw
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... does not apply
DVM INPUT SELECTOR ..... EXT
(on rear panel)
DVM INPUT ..... apply +10V ±.1%
(on rear panel)

\- Normal Display -

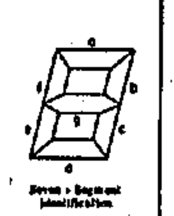
Voltage .... 9.90 to 10.10V
Rate annunciator .... flashing
Other annunciators .... off



Note: End state of U31(1) depends upon DVM input variation.

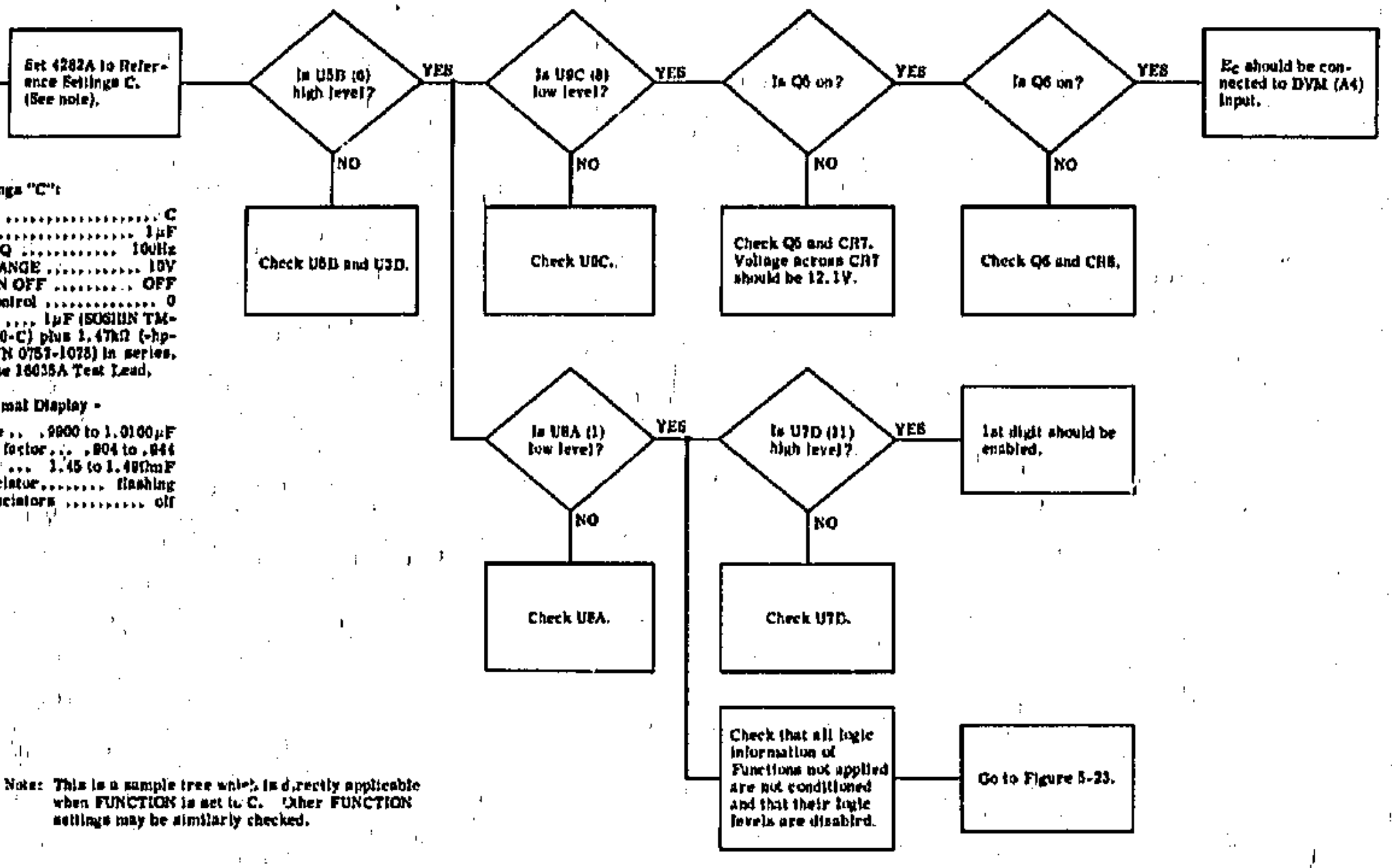
Table a.

	BCD coded input				Seven - Segment output						
	D	C	B	A	a	b	c	d	e	f	g
1	L	L	L	H	H	L	L	H	H	H	H
2	L	L	H	L	L	L	H	L	L	H	L
3	L	L	H	H	L	L	L	L	H	H	L
4	L	H	L	L	H	L	L	H	H	L	L
5	L	H	L	H	L	H	L	L	H	L	L
6	L	H	H	L	L	H	L	L	L	L	L
7	L	H	H	H	L	L	L	H	H	H	H
8	H	L	L	L	L	L	L	L	L	L	L
9	H	L	L	H	L	L	L	H	H	L	L
0	L	L	L	L	L	L	L	L	L	L	H



Note: Input is high (H) true and output is low (L) true.

Figure 5-21. Troubleshooting Tree - Counter/Buffer Sotrage/Decoder/Display (A4, A5).



Reference Settings "C":

FUNCTION C
C RANGE 1μF
MEAS FREQ 100Hz
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... 1μF (SOSHIN TM-520-C) plus 1.47kΩ (-hp- P/N 0757-1078) in series. Use 16035A Test Lead.

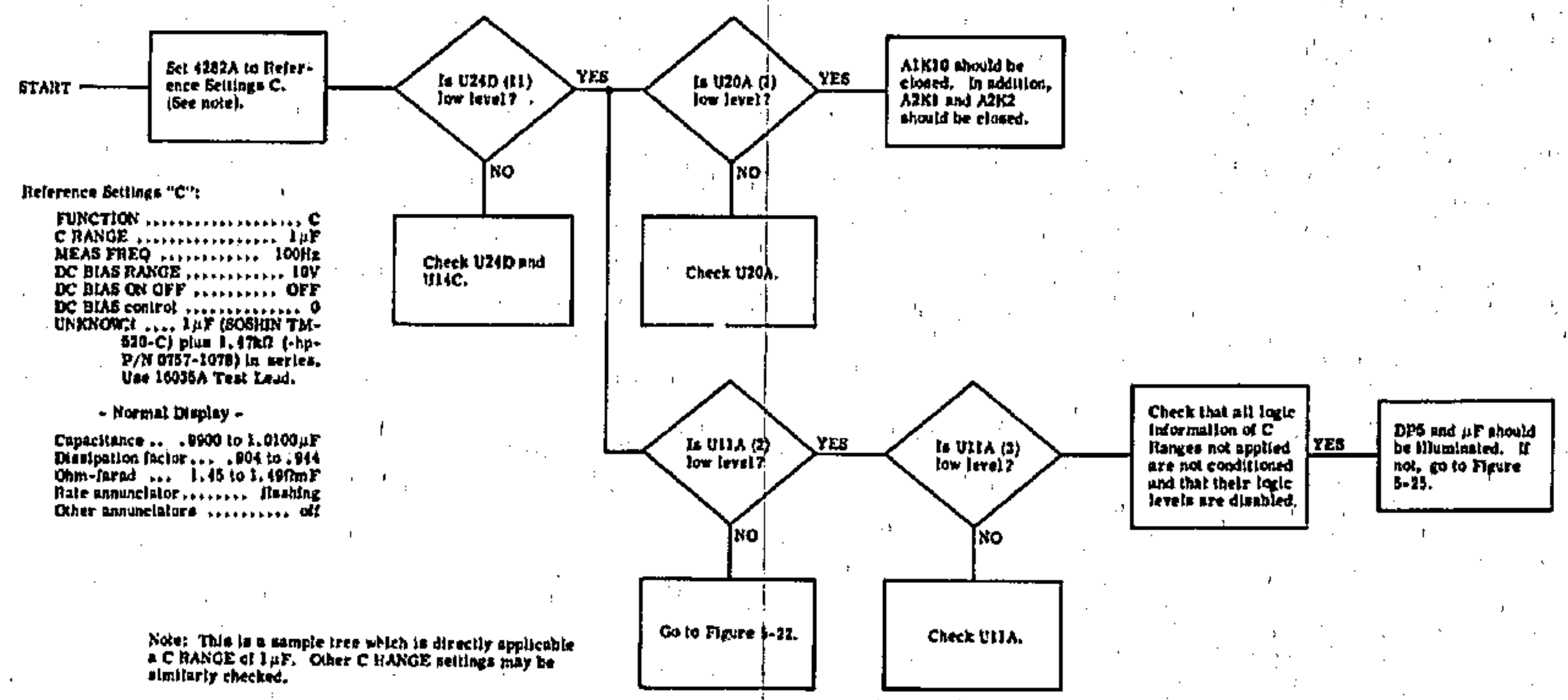
\- Normal Display -

Capacitance .... .9900 to 1.0100μF
Dissipation factor .... .904 to .944
Ohm-farad .... 1.45 to 1.490mF
Rate annunciator .... flashing
Other annunciators .... off

Note: This is a sample tree which is directly applicable when FUNCTION is set to C. Other FUNCTION settings may be similarly checked.

Figure 5-22. Troubleshooting Tree - Function Control (A3).

SEE INSIDE



Reference Settings "C":

FUNCTION C
C RANGE 1μF
MEAS FREQ 100Hz
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... 1μF (SOSHIN TM-520-C) plus 1.47kΩ (-hp- P/N 0757-1078) in series. Use 16035A Test Lead.

\- Normal Display -

Capacitance .... .9900 to 1.0100μF
Dissipation factor .... .904 to .944
Ohm-farad .... 1.45 to 1.490mF
Rate annunciator .... flashing
Other annunciators .... off

Note: This is a sample tree which is directly applicable to C RANGE of 1μF. Other C RANGE settings may be similarly checked.

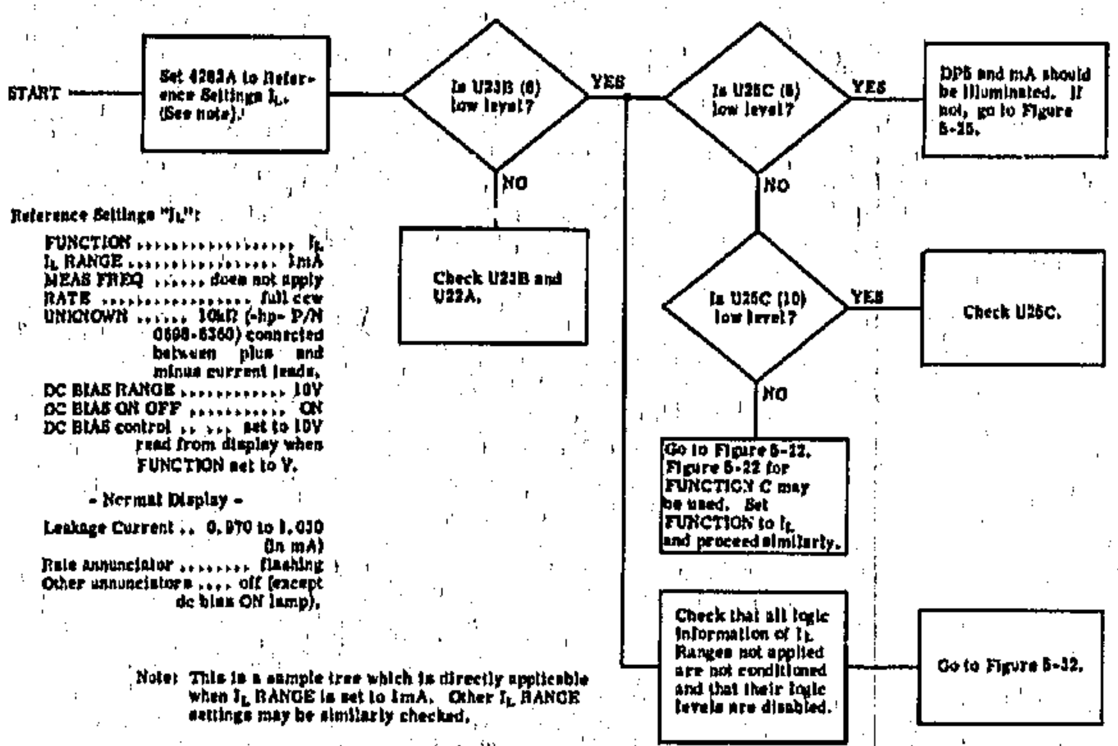
Figure 5-23. Troubleshooting Tree - C Range Control (A3).

Figure 5-20

Troubleshooting Tree - Control Logic (A4)

Figures 5-21 to 5-23

Troubleshooting Tree - Counter/Buffer Storage/Decoder/Display (A4, A5)
Troubleshooting Tree - Function Control (A3)
Troubleshooting Tree - C Range Control (A3)



Reference Settings "I_L":

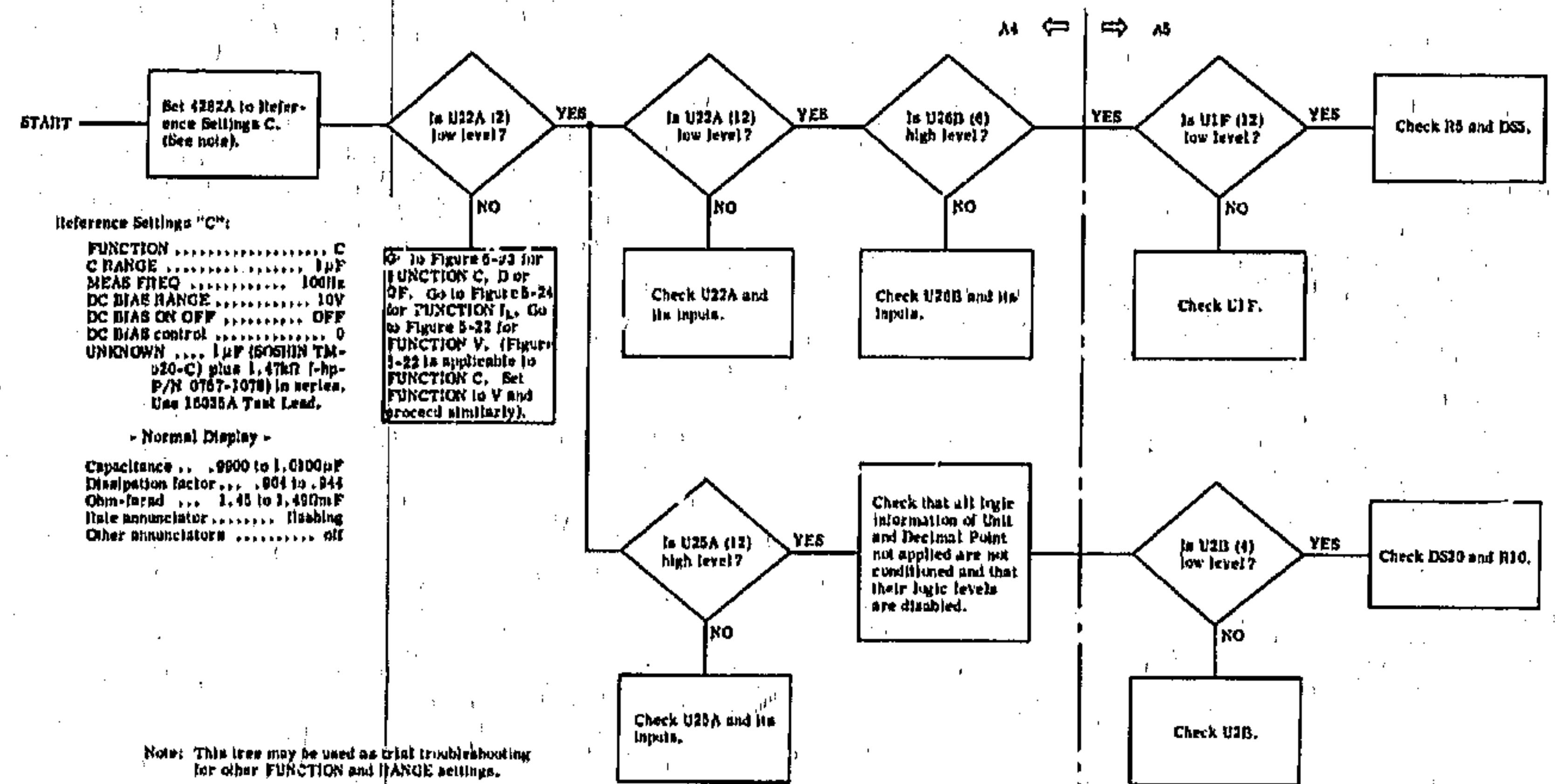
FUNCTION .... I_L
I_L RANGE 1mA
MEAS FREQ ...... does not apply
RATE .... full ccw
UNKNOWN ...... 10kΩ (-hp- P/N 0698-6360) connected between plus and minus current leads.
DC BIAS RANGE 10V
DC BIAS ON OFF .... ON
DC BIAS control ..... set to 10V read from display when FUNCTION set to V.

- Normal Display -

Leakage Current .. 0.970 to 1.030 (in mA)
Rate annunciator .... flashing
Other annunciators .... off (except dc bias ON lamp).

Note: This is a sample tree which is directly applicable when I_L RANGE is set to 1mA. Other I_L RANGE settings may be similarly checked.

Figure 5-24. Troubleshooting Tree - I_L Range Control (A3).



Reference Settings "C":

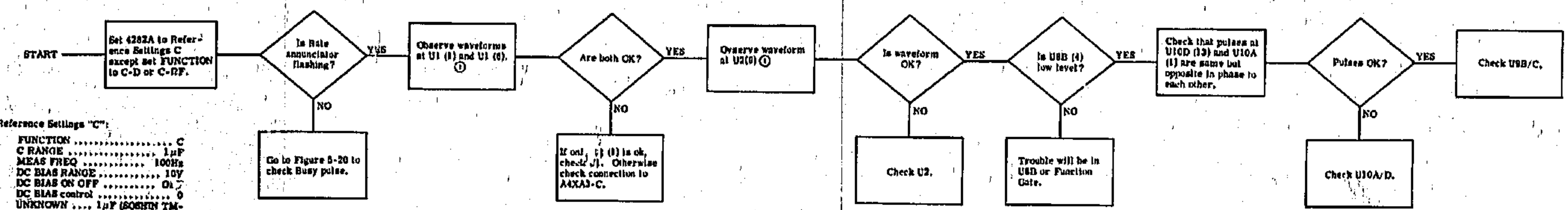
FUNCTION C
C RANGE 1µF
MEAS FREQ 100Hz
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... 1µF (SOSHIN TM-520-C) plus 1.47kΩ (-hp- P/N 0757-1078) in series. Use 16035A Test Lead.

- Normal Display -

Capacitance .. .9900 to 1.0100µF
Dissipation factor ... .904 to .944
Ohm-farad ... 1.45 to 1.490mF
Rate annunciator .... flashing
Other annunciators .... off

Note: This tree may be used as trial troubleshooting for other FUNCTION and RANGE settings.

Figure 5-25. Troubleshooting Tree - Unit and Decimal Point (A4, A5).

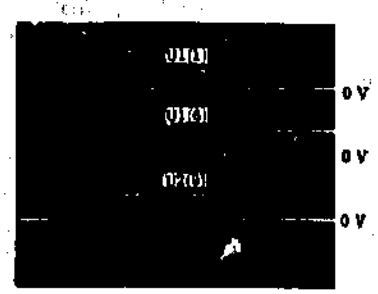


Reference Settings "C":

FUNCTION C
C RANGE 1µF
MEAS FREQ 100Hz
DC BIAS RANGE 10V
DC BIAS ON OFF .... OFF
DC BIAS control 0
UNKNOWN .... 1µF (SOSHIN TM-520-C) plus 1.47kΩ (-hp- P/N 0757-1078) in series. Use 16035A Test Lead.

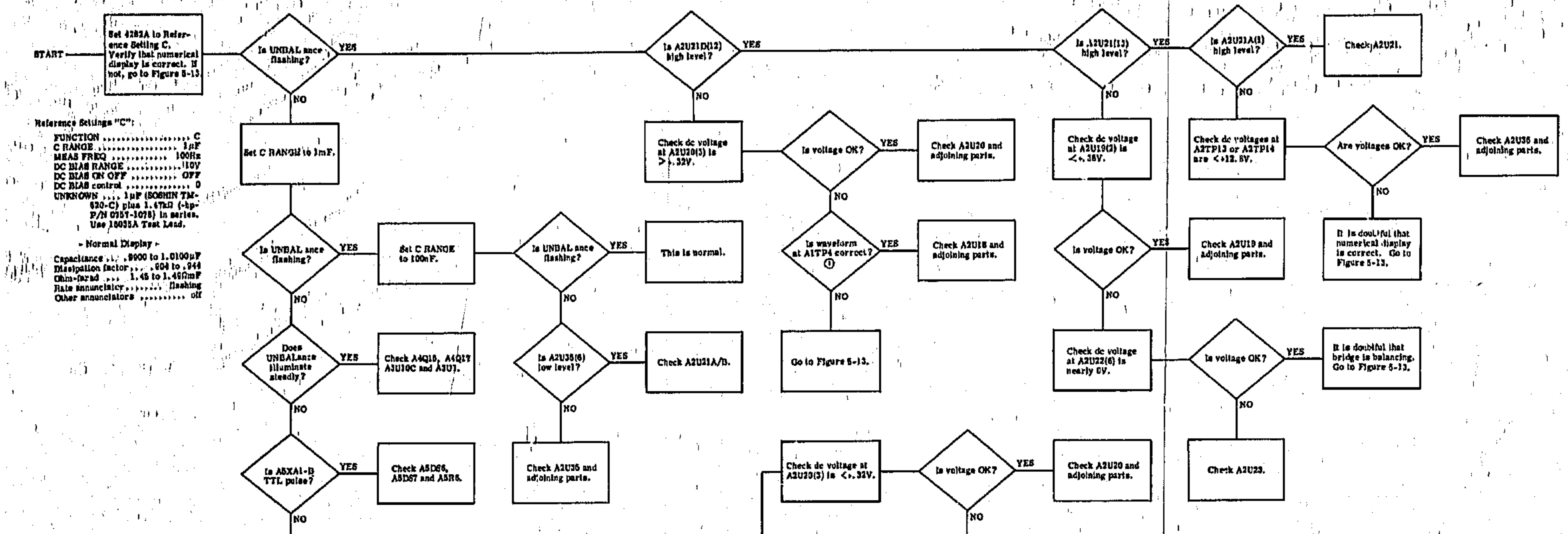
- Normal Display -

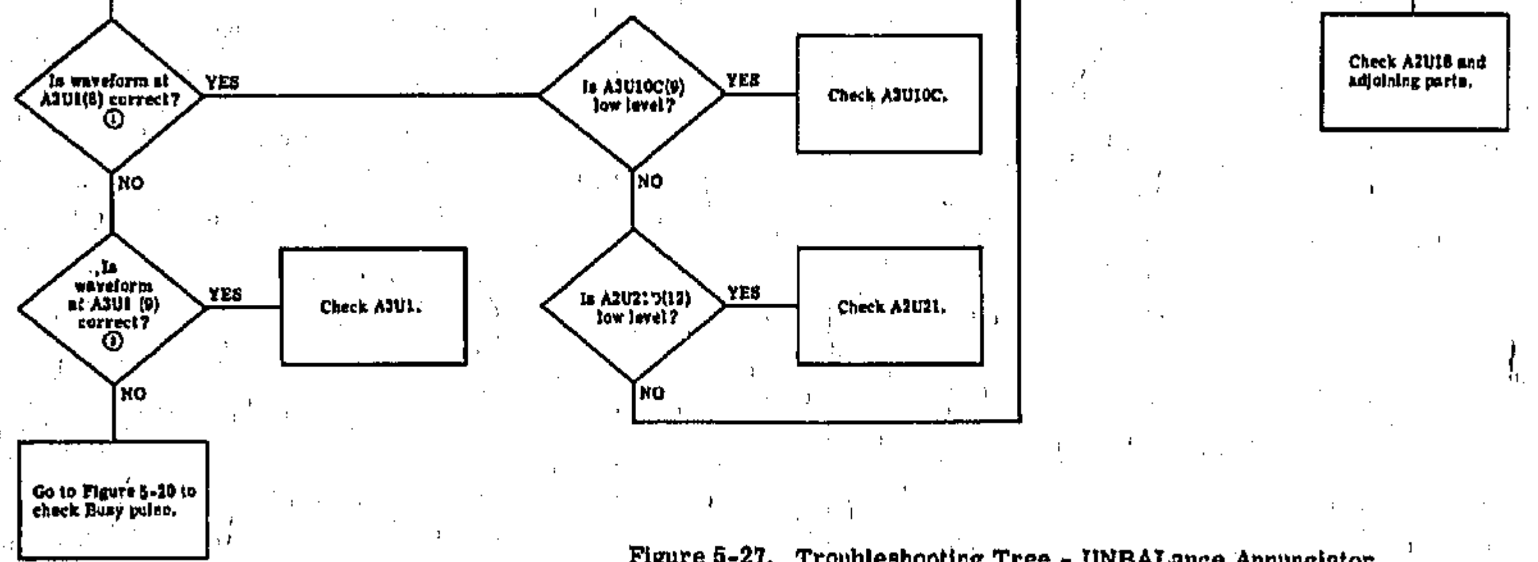
Capacitance .. .9900 to 1.0100µF
Dissipation factor ... .904 to .944
Ohm-farad ... 1.45 to 1.490mF
Rate annunciator .... flashing
Other annunciators .... off



① 5V/div. 20ms/div.

Figure 5-26. Troubleshooting Tree - Alternating Display (A3).





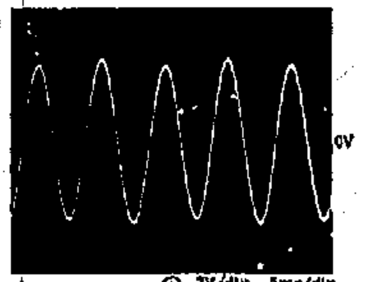
Reference Settings "C":

FUNCTION	C
C RANGE	1μF
MEAS FREQ	100Hz
DC BIAS RANGE	10V
DC BIAS ON OFF	OFF
DC BIAS control	0
UNKNOWN	1μF (SOSHIN TM-620-C) plus 1.47kΩ (-hp- P/N 0757-1078) in series. Use 16035A Test Lead.

- Normal Display -

Capacitance	.9900 to 1.0100μF
Dissipation factor	.904 to .944
Ohm-farad	1.45 to 1.49Ω mF
Rate annunciator	flashing
Other annunciators	off

Figure 5-27. Troubleshooting Tree - UNBALance Annunciator.



① 2V/div. 5ms/div.

②③ 2V/div. 50ms/div.

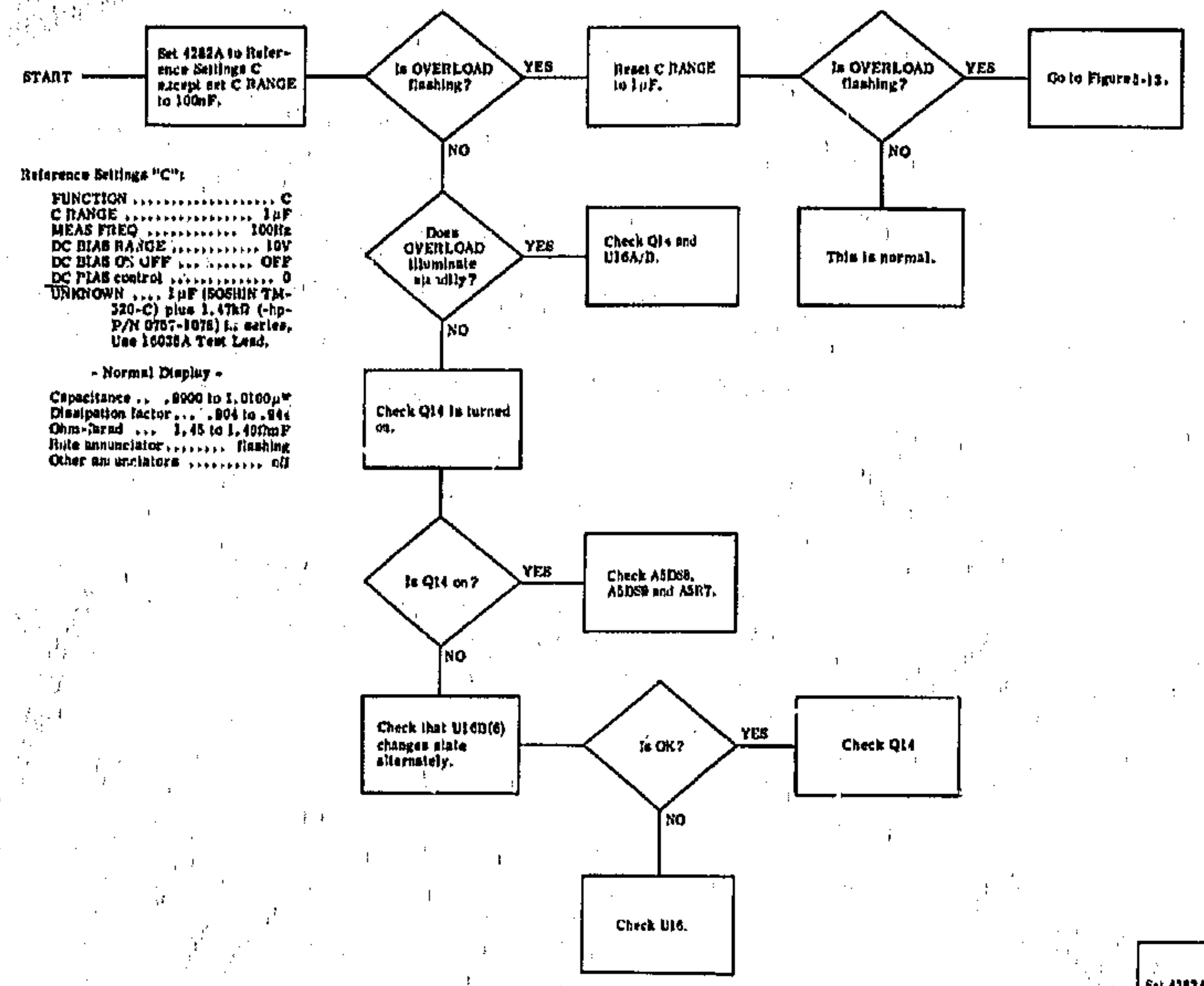


Figure 5-28. Troubleshooting Tree - OVERLOAD Annunciator(A4).

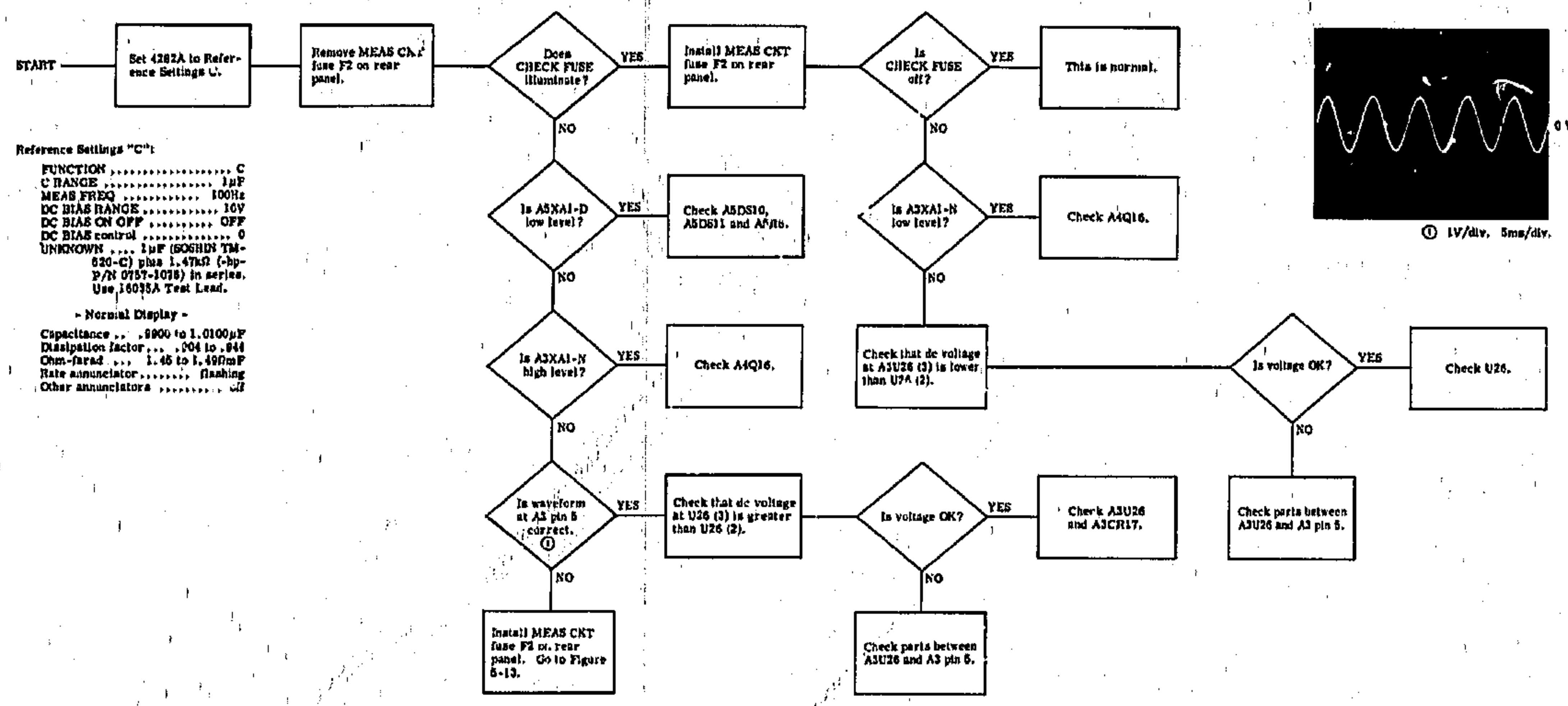


Figure 5-29. Troubleshooting Tree - CHECK FUSE Annunciator.

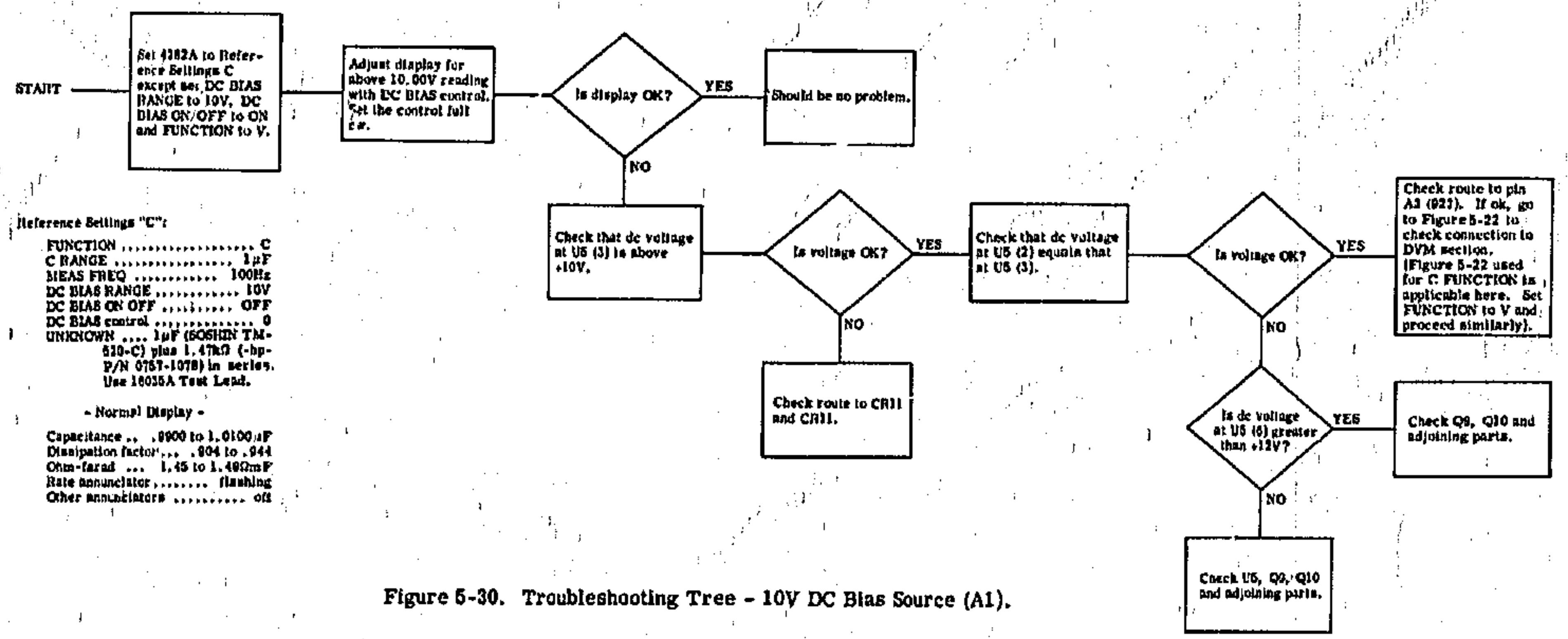


Figure 5-30. Troubleshooting Tree - 10V DC Bias Source (A1).

Figures 5-28 to 5-30

Troubleshooting Tree - OVERLOAD Annunciator (A4)
Troubleshooting Tree - CHECK FUSE Annunciator
Troubleshooting Tree - 10V DC Bias Source (A1)

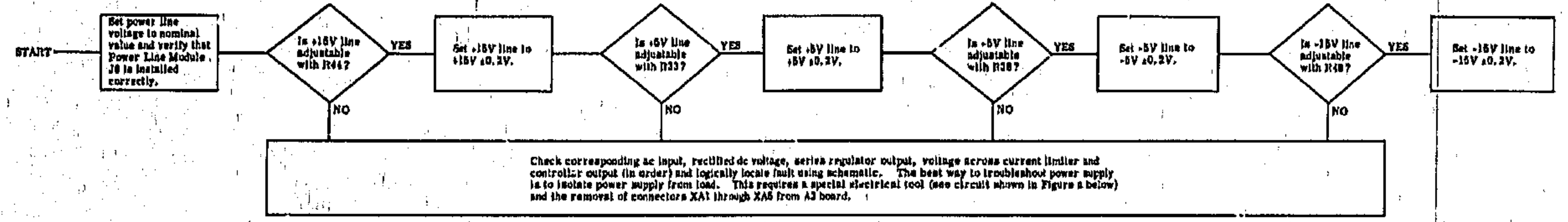
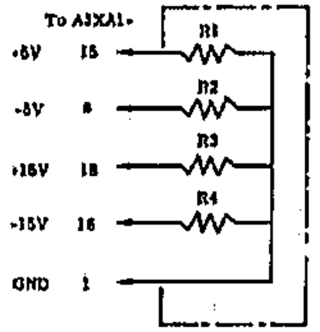
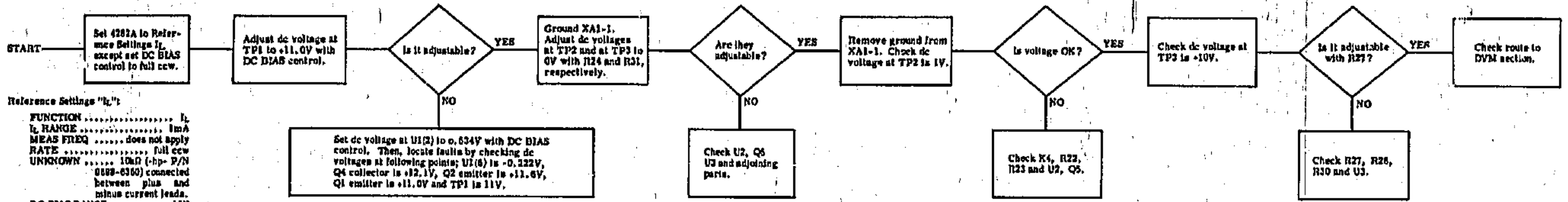


Figure a. Dummy Load.



Reference Designation	HP Part No.	Description
R1	0686-5105	R: FXD 50Ω 1W
R2	0698-4653	R: FXD 226Ω 1/2W
R3	0727-0090	R: FXD 750Ω 1W
R4	0727-0090	R: FXD 750Ω 1W

Figure 5-31. Troubleshooting Tree - Power Supply (A3).



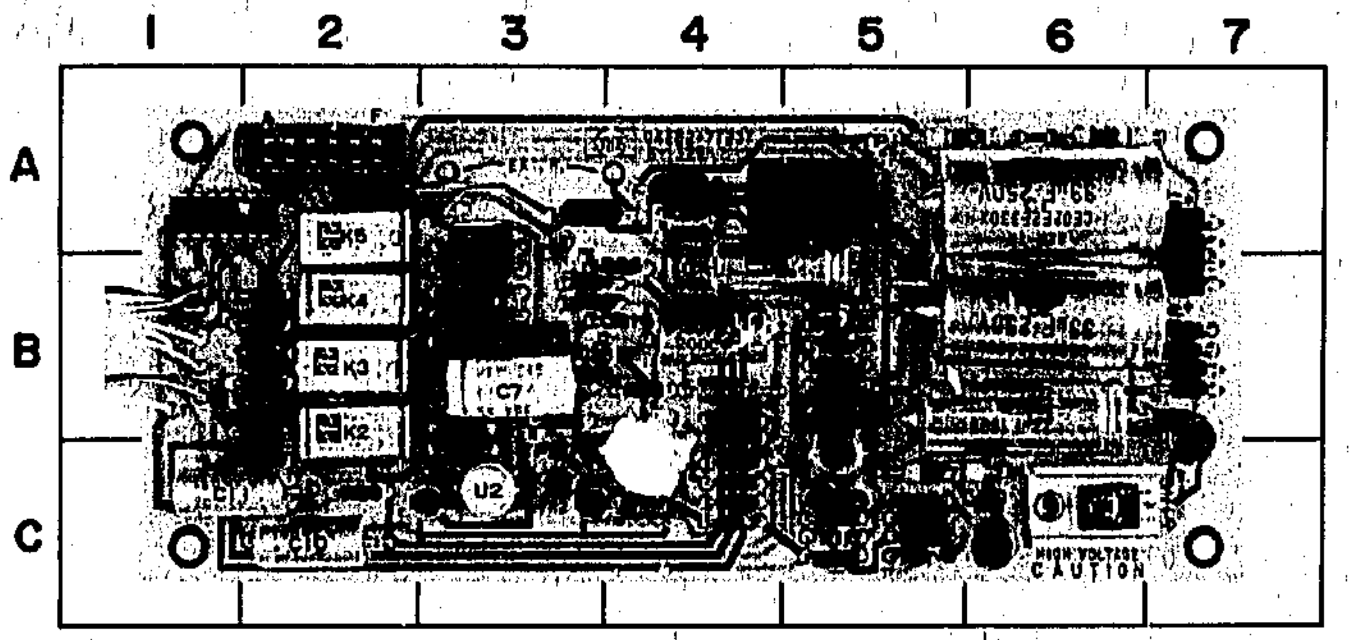
Reference Settings "I_L":

FUNCTION .... I_L
I_L RANGE 1mA
MEAS FREQ .... does not apply
RATE .... full ccw
UNKNOWN .... 10kΩ (-hp- P/N 0698-6360) connected between plus and minus current leads.
DC BIAS RANGE 10V
DC BIAS ON OFF .... ON
DC BIAS control .... set to 10V read from display when FUNCTION set to V.

- Normal Display -

Leakage Current .. 0.970 to 1.030 (in mA)
Rate annunciator .... flashing
Other annunciators .... off (except dc bias ON lamp).

Figure 5-32. Troubleshooting Tree - Leakage Current Measurement (A7).



A7 Test Point Locations

TEST POINTS LOCATOR

Test Point No.	Grid. Loc.	Test Point No.	Grid. Loc.	Test Point No.	Grid. Loc.
A7TP1	A-5	A7TP2	C-3	A7TP3	B-4

PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	A-6	K1	A-5	R17	B-5
C2	B-6	K2	B-2	R18	C-5
C3	B-6	K3	B-2	R19	B-3
C4	C-5	K4	B-2	R20	B-3
C5	B-5	K5	A-2	R21	B-3
C6	B-4			R22	B-3
C7	B-3	Q1	C-6	R23	A-3
C8	B-4	Q2	B-7	R24	C-3
C9	B-4	Q3	C-6	R25	C-4
C10	C-2	Q4	C-6	R26	B-3
C11	C-1	Q5	C-3	R27	C-3
		Q6	B-3	R28	C-4
		Q7	A-3	R29	C-4
CR1	A-7			R30	C-4
CR2	A-7			R31	C-3
CR3	B-7	R1	A-3	R32	C-4
CR4	B-7	R2	A-6	R33	B-4
CR5	B-7	R3	A-5	R34	B-2
CR6	B-7	R4	A-4	R35	B-2
CR7	C-5	R5	B-7	R36	B-4
CR8	C-5	R6	B-7	R37	B-3
CR9	A-4	R7	C-5	R38	B-3
CR10	C-3	R8	C-5	R39	C-2
CR11	B-3	R9	C-5	R40	C-2
CR12	B-4	R10	C-5		
CR13	B-4	R11	B-5	U1	C-5
CR14	B-4	R12	C-5	U2	C-3
CR15	B-2	R13	B-5	U3	C-4
CR16	B-2	R14	B-5	U4	A-1
CR17	B-2	R15	B-5		
CR18	B-2	R16	A-4	XA1	A-2

SEE INSIDE

PERFORMANCE CHECK TEST CARD

Hewlett-Packard Model 4282A

Serial No. ______________

Test Performed by ______________

Date ______________

Paragraph	Description	Check
5-10 Measuring Frequency Check	50 (60) Hz	49.3 (59.1) ______ 50.7 (60.9) Hz
	100Hz	98.5 ______ 101.5Hz
	120Hz	118.2 ______ 121.8Hz
5-12 Measuring Voltage Check	1μF range	______ 1V
	100mF range	______ 100mV
	1F range	______ 10mV
5-14 Capacitance Measurement Accuracy Check	10nF 120Hz 100nF range	9.880 ______ 10.120nF
	10nF 120Hz 100nF range	9.85 ______ 10.15nF
	100nF 120Hz 100nF range	99.40 ______ 100.60nF
	100nF 120Hz 1μF range	.0991 ______ .1009μF
	1μF 120Hz 1μF range	.9955 ______ 1.0045μF
	1μF 100Hz 1μF range	.9955 ______ 1.0045μF
	1μF 50 (60) Hz 1μF range	.9955 ______ 1.0045μF
	1μF 120Hz 10μF range	.991 ______ 1.009μF
	10μF 120Hz 10μF range	9.955 ______ 10.045μF
	10μF 120Hz 100μF range	9.91 ______ 10.09μF
	100μF 120Hz 100μF range	99.55 ______ 100.45μF
	100μF 120Hz 1mF range	.0991 ______ 1.009mF
	1mF 120Hz 1mF range	.9955 ______ 1.0045mF
	1mF 120Hz 10mF range	.985 ______ 1.015mF
	10mF 120Hz 10mF range	9.895 ______ 10.105mF
	10mF 120Hz 100mF range	9.80 ______ 10.20mF
	100mF 120Hz 100mF range	98.00 ______ 102.00mF
	100mF 120Hz 1F range	0.875 ______ .1125F
	1F 120Hz 1F range	.9650 ______ 1.0350F
5-16 Loss Measurement Accuracy Check (1) (refer to Table 5-4)	10nF - 1MΩ 120Hz 10nF range D	7.09 ______ 7.99
	10nF - 1MΩ 120Hz 100nF range D	7.08 ______ 8.00
	10nF - 100kΩ 120Hz 10nF range D	.735 ______ 7.73
	10nF - 100kΩ 120Hz 100nF range D	.719 ______ .789
	10nF - 10kΩ 120Hz 10nF range D	.069 ______ .081
	100nF - 100kΩ 120Hz 100nF range D	7.26 ______ 8.82
	100nF - 100kΩ 120Hz 100nF range ΩF	9.65 ______ 10.35ΩmF
	100nF - 100kΩ 100Hz 100nF range D	6.06 ______ 6.50
	100nF - 100kΩ 50 (60) Hz 100nF range D	3.02 (3.64) ______ 3.26 (3.90)
	100nF - 10kΩ 120Hz 100nF range D	.737 ______ .771
	100nF - 1kΩ 120Hz 100nF range D	.069 ______ .081

PERFORMANCE CHECK TEST CARD

Paragraph	Description			Check
5-16 Loss Measurement Accuracy Check (2) (refer to Table 5-5)	1μF - 10kΩ		1μF & 10μF ranges	________ ________
	1μF - 1kΩ		1μF & 10μF ranges	________ ________
	1μF - 100Ω		1μF & 10μF ranges	________ ________
	10μF - 1kΩ		10μF & 100μF ranges	________ ________
	10μF - 100Ω		10μF & 100μF ranges	________ ________
	10μF - 10Ω		10μF & 100μF ranges	________ ________
	100μF - 100Ω		100μF & 1mF ranges	________ ________
	100μF - 10Ω		100μF & 1mF ranges	________ ________
	100μF - 1Ω		100μF & 1mF ranges	________ ________
	1mF - 10Ω		1mF & 10mF ranges	________ ________
	1mF - 1Ω		1mF & 10mF ranges	________ ________
	1mF - .1Ω		1mF & 10mF ranges	________ ________
	10mF - 1Ω		10mF & 100mF ranges	________ ________
	10mF - .1Ω		10mF & 100mF ranges	________ ________
	100mF - .1Ω		100mF & 1F ranges	________ ________
	100mF - 0Ω		100mF & 1F ranges	________ ________
	1F - 0Ω		1F range	________
5-18 DC Voltage Measurement Accuracy Check	1V		10V range	0.99 + ________ − ________ 1.01V
	10V		10V range	9.99 + ________ − ________ 10.01V
	10V		100V range	9.9 + ________ − ________ 10.1V
	100V		100V range	99.7 + ________ − ________ 100.3V
	100V		EXT range	99 + ________ − ________ 101V
	600V		EXT range	598 + ________ − ________ 602V
5-20 Leakage Current Measurement Accuracy Check	1kΩ	10V	10mA range	9.77 ________ 10.23mA
	10kΩ	10V	1mA range	.977 ________ 1.023mA
	100kΩ	10V	100μA range	97.7 ________ 102.3μA
	1MΩ	10V	10μA range	9.77 ________ 10.23μA
	10MΩ	10V	1μA range	.960 ________ 1.040μA

SECTION VI
REPLACEABLE PARTS

6-1. INTRODUCTION.

6-2. This section contains information for ordering replacement parts. Table 6-1 provides an index of reference designations and abbreviations used in the replaceable parts list. Table 6-2 lists parts in alphanumerical order of their reference designators and indicates the description and HP stock number of each part, together with any applicable notes. Table 6-2 includes:

a. Description of the part (see list of abbreviations below).

b. Typical manufacturer of the part in a five-digit code; see list of manufacturers in Table 6-3.

c. Manufacturer's part number.

d. Total quantity used in the instrument (Q'ty column).

6-3. Miscellaneous parts 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 list at rear of this manual for addresses). Identify parts by their Hewlett-Packard stock numbers. Include instrument model and serial numbers.

6-6. NON-LISTED PARTS.

6-7. 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.

Table 6-1. List of Reference Designators and Abbreviations.

REFERENCE DESIGNATORS

A	= assembly
B	= motor
BT	= battery
C	= capacitor
CP	= coupler
CR	= diode
DL	= delay line
DS	= device signaling (lamp)
E	= misc electronic part
F	= fuse
FL	= filter
J	= jack
K	= relay
L	= inductor
M	= meter
MP	= mechanical part
P	= plug
Q	= transistor
R	= resistor
RT	= thermistor
S	= switch
T	= transformer
TB	= terminal board
TP	= test point
V	= vacuum, tube, neon bulb, photocell, etc.
VR	= voltage regulator
W	= cable
X	= socket
Y	= crystal

ABBREVIATIONS

A	= amperes
A.F.C.	= automatic frequency control
AMPL	= amplifier
B.F.O.	= beat frequency oscillator
BE CU	= beryllium copper
BH	= binder head
BP	= bandpass
BRS	= brass
BWO	= backward wave oscillator
CCW	= counter-clockwise
CER	= ceramic
CMO	= cabinet mount only
COEF	= coefficient
COM	= common
COMP	= composition
COMPL	= complete
CONN	= connector
CP	= cadmium plate
CRT	= cathode-ray tube
CW	= clockwise
DEPC	= deposited carbon
DR	= drive
ELECT	= electrolytic
ENCAP	= encapsulated
EXT	= external
F	= farads
FH	= flat head
FIL H	= fillister head
FXD	= fixed
GE	= germanium
GL	= glass
GRD	= ground(ed)
H	= henries
HEX	= hexagonal
HG	= mercury
HR	= hour(s)
IF	= intermediate freq
IMPG	= impregnated
INCD	= incandescent
INCL	= include(s)
INS	= insulation(ed)
INT	= internal
K	= kilo = 1000
LH	= left hand
LIN	= linear taper
LK WASH	= lock washer
LOG	= logarithmic taper
LPF	= low pass filter
M	= milli = 10^{-3}
MEG	= meg = 10^{6}
MET FLM	= metal film
MET OX	= metallic oxide
MFR	= manufacturer
MINAT	= miniature
MOM	= momentary
MTG	= mounting
MY	= "mylar"
N	= nano (10^{-9})
N/C	= normally closed
NE	= neon
NI PL	= nickel plate
N/O	= normally open
NPO	= negative positive zero (zero temperature coefficient)
NPN	= negative-positive-negative
NRFR	= not recommended for field replacement
NSR	= not separately replaceable
OBD	= order by description
OH	= oval head
OX	= oxide
P	= peak
PC	= printed circuit
PF	= picofarads = 10 farads
PH BRZ	= phosphor bronze
PHL	= Phillips
PIV	= peak inverse voltage
PNP	= positive-negative-positive
P/O	= part of
POLY	= polystyrene
PORC	= porcelain
POS	= position(s)
POT	= potentiometer
PP	= peak-to-peak
PT	= point
PWV	= peak working voltage
RECT	= rectifier
RF	= radio frequency
RH	= round head or right hand
RMO	= rack mount only
RMS	= root-mean square
RWV	= reverse working voltage
S-B	= slow-blow
SCR	= screw
SE	= selenium
SECT	= section(s)
SEMICON	= semiconductor
SI	= silicon
SIL	= silver
SL	= slide
SPG	= spring
SPL	= special
SST	= stainless steel
SR	= split ring
STL	= steel
TA	= tantalum
TD	= time delay
TGL	= toggle
THD	= thread
TI	= titanium
TOL	= tolerance
TRIM	= trimmer
TWT	= traveling wave tube
U	= micro = 10^{-6}
VAR	= variable
VDCW	= dc working volts
W/	= with
W	= watts
WIV	= working inverse voltage
WW	= wirewound
W/O	= without

Table 6-2. Replaceable Parts.

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1	04282-77211	1	BOARD ASSEMBLY, OSCILLATOR	28480	04282-77211
A1C1	0160-1639	1	CAPACITOR:FXD 0.05 UF 0.25% 25VDC POLY	28480	0160-1639
A1C2	0160-1637	1	CAPACITOR:FXD 5000 PF 0.25% 50VDC POLY	28480	0160-1637
A1C3	0180-0137	1	CAPACITOR-FXD; 100UF+-20% 10VDC TA	56289	150D107X0010R2
A1C4	0180-0374	8	CAPACITOR-FXD; 10UF+-10% 20VDC TA-SOLID	56289	150D106X9020B2
A1C5	0160-0128	5	CAPACITOR-FXD 2.2UF +-20% 25WVDC CER	28480	0160-0128
A1C6	0160-0128		CAPACITOR-FXD 2.2UF +-20% 25WVDC CER	28480	0160-0128
A1C7	0180-0374		CAPACITOR-FXD; 10UF+-10% 20VDC TA-SOLID	56289	150D106X9020B2
A1C8	0160-2211	4	CAPACITOR-FXD 910PF +-5% 300WVDC MICA	28480	0160-2211
A1C9	0160-0128		CAPACITOR-FXD 2.2UF +-20% 25WVDC CER	28480	0160-0128
A1C10	0180-1714	2	CAPACITOR-FXD; 330UF+-10% 6VDC TA-SOLID	56289	150D337X9006S2
A1C11	0180-1714		CAPACITOR-FXD; 330UF+-10% 6VDC TA-SOLID	56289	150D337X9006S2
A1C12	0180-0814	6	CAPACITOR:FXD 100UF +100-10% 16VDCW AL	28480	0180-0814
A1C13	0180-0814		CAPACITOR:FXD 100UF +100-10% 16VDCW AL	28480	0180-0814
A1C14	0180-0814		CAPACITOR:FXD 100UF +100-10% 16VDCW AL	28480	0180-0814
A1C15	0180-2338	3	CAPACITOR-FXD 650UF +-20% 13VDC TA-WET	56289	109D657X0020T2
A1C16	0180-0814		CAPACITOR:FXD 100UF +100-10% 16VDCW AL	28480	0180-0814
A1C17	0180-0814		CAPACITOR:FXD 100UF +100-10% 16VDCW AL	28480	0180-0814
A1C18	0180-0814		CAPACITOR:FXD 100UF +100-10% 16VDCW AL	28480	0180-0814
A1C19	0180-2338		CAPACITOR-FXD 650UF +-20% 13VDC TA-WET	56289	109D657X0020T2
A1C20	0160-1641	2	CAPACITOR:FXD 0.47 UF 20% 630VDC POLY	28480	0160-1641
A1C21	0160-1558	4	C:FXD MY 0.047 UF 5% 100VDCW	28480	0160-1558
A1C22	0160-1542	1	C:FXD MY 1500 PF 10% 50VDCW	28480	0160-1542
A1C23	0160-1641		CAPACITOR:FXD 0.47 UF 20% 630VDC POLY	28480	0160-1641
A1C24			NOT ASSIGNED		
A1C25			NOT ASSIGNED		
A1C26	0160-1643	2	CAPACITOR:FXD 150 PF 10% 600VDC	28480	0160-1643
A1C27	0160-1643		CAPACITOR:FXD 150 PF 10% 600VDC	28480	0160-1643
A1C28	0160-1544	1	C:FXD MY 4700 PF 5% 50VDCW	28480	0160-1544
A1C29	0180-2355	4	CAPACITOR-FXD; 7.5UF+-5% 20VDC TA-SOLID	56289	150D755X5020B2
A1C30	0180-2355		CAPACITOR-FXD; 7.5UF+-5% 20VDC TA-SOLID	56289	150D755X5020B2
A1C31	0180-2355		CAPACITOR-FXD; 7.5UF+-5% 20VDC TA-SOLID	56289	150D755X5020B2
A1C32	0180-2355		CAPACITOR-FXD; 7.5UF+-5% 20VDC TA-SOLID	56289	150D755X5020B2
A1C33	0160-0128		CAPACITOR-FXD 2.2UF +-20% 25WVDC CER	28480	0160-0128
A1CR1	1901-0040	47	DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR2	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR3	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR4	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR5	1902-3036	1	DIODE-ZNR 3.16V 5% DO-7 PD=.4W TC=-.064%	04713	SZ 10939-38
A1CR6	1902-3082	1	DIODE-ZNR 4.64V 5% DO-7 PD=.4W TC=-.021%	04713	SZ 10939-86
A1CR7	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR8	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR9	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR10	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR11	1902-3163	1	DIODE-ZNR 10.2V 2% DO-7 PD=.4W TC=+.061%	04713	SZ 10939-186
A1CR12	1902-0843	1	DIODE	28480	1902-0845
A1CR13	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR14	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR15	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR16	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR17	1901-0376	18	DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR18	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR19	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR20	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR21	1902-3193	12	DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A1CR22	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A1CR23	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR24	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR25	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR26	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR27	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A1CR28	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A1CR29			NOT ASSIGNED		
A1CR30			NOT ASSIGNED		
A1CR31			NOT ASSIGNED		
A1CR32			NOT ASSIGNED		
A1CR33	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A1CR34	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A1CR35	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR36	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR37	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR38	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A1CR39	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A1CR40	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1CR41	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A1CR42	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A1CR43	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR44	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR45	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR46	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR47	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR48	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR49	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A1CR50	1902-3059		DIODE-ZNR 3.83V 5% DO-7 PD=.4W TC=-.051%	04713	SZ 10939-62
A1CR51	1902-3059	8	DIODE-ZNR 3.83V 5% DO-7 PD=.4W TC=-.051%	04713	SZ 10939-62
A1K1	0490-0225	3	RELAY:REED DPST	28480	0490-0225
A1K2	0490-0225		RELAY:REED DPST	28480	0490-0225
A1K3	0490-0225		RELAY:REED DPST	28480	0490-0225
A1K4	0490-0875	9	RELAY; 12VDC; CONT 2A 30VDC FORM 2C	28480	0490-0875
A1K5	0490-0875		RELAY; 12VDC; CONT 2A 30VDC FORM 2C	28480	0490-0875
A1K6	0490-0875		RELAY; 12VDC; CONT 2A 30VDC FORM 2C	28480	0490-0875
A1K7	0490-0875		RELAY; 12VDC; CONT 2A 30VDC FORM 2C	28480	0490-0875
A1K8	0490-0226	15	RELAY:REED	28480	0490-0226
A1K9	0490-0226		RELAY:REED	28480	0490-0226
A1K10	0490-0226		RELAY:REED	28480	0490-0226
A1K11	0490-0226		RELAY:REED	28480	0490-0226
A1K12	0490-0226		RELAY:REED	28480	0490-0226
A1Q1	1855-0067	3	TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0067
A1Q2	1855-0091	2	TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A1Q3	1855-0091		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0091
A1Q4	1854-0090	1	TRANSISTOR NPN SI TO-39 PD=1W FT=100MHZ	28480	1854-0090
A1Q5	1853-0051	2	TRANSISTOR PNP 2N4037 SI TO-5 PD=1W	02735	2N4037
A1Q6	1854-0127	1	TRANSISTOR:NPN SI	02735	2SD 234
A1Q7	1853-0106	1	TRANSISTOR:PNP SI	02735	2SB 434
A1Q8	1853-0020	7	TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A1Q9	1854-0090		TRANSISTOR NPN SI	02735	2N4037
A1Q10	1853-0051	19	TRANSISTOR PNP 2N4037 SI TO -5 PD = 1W	28480	1854-0071
A1R1	0757-0401	7	RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-TO-101-F
A1R2	0698-2229	1	RESISTOR:FXD 453.9K OHM 5% 1/8W MF	28480	0698-2229
A1R3	0698-2230	2	RESISTOR:FXD 636.6K OHM 5% 1/4W MF	28480	0698-2230
A1R4	0698-2232	1	RESISTOR:FXD 3.183 MEGOHM 5% 1/2W MF	28480	0698-2232
A1R5	0698-2230		RESISTOR:FXD 636.6K OHM 5% 1/4W MF	28480	0698-2230
A1R6	0698-2221	1	RESISTOR:FXD 45.39K OHM 5% 1/8W MF	28480	0698-2221
A1R7	0698-2223	2	RESISTOR:FXD 63.65K OHM 5% 1/8W MF	28480	0698-2223
A1R8	0698-2228	1	RESISTOR:FXD 318.3K OHM 5% 1/8W MF	28480	0698-2228
A1R9	0698-2223		RESISTOR:FXD 63.65K OHM 5% 1/8W MF	28480	0698-2223
A1R10	0699-3457	2	RESISTOR 316K 1% .125W F TC=0+-100	03888	PME55
A1R11	0698-4479	4	RESISTOR 14K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1402-F
A1R12	0757-0280	10	RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1001-F
A1R13	2100-1986	3	RESISTOR-VAR TRMR 1KOHM 10% C TOP ADJ	84048	170-102
A1R14	0757-0279	2	RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-TO-3161-F
A1R15	0698-3457		RESISTOR 316K 1% .125W F TC=0+-100	03888	PME55
A1R16	0757-0454	4	RESISTOR 33.2K 1% .125W F TC=0+-100	24546	C4-1/8-TO-3322-F
A1R17	0698-4427	1	RESISTOR 1.4K 1% .125W F TC=0+-100	16299	C4-1/8-TO-1401-F
A1R18	2100-2497	3	RESISTOR-VAR TRMR 2KOHM 10% C TOP ADJ	19701	ET50W202
A1R19	0757-0279		RESISTOR 3.16K 1% .125W F TC=0+-100	24546	C4-1/8-TO-3161-F
A1R20	0757-0467	1	RESISTOR 121K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1213-F
A1R21	0698-0084	6	RESISTOR 2.15K 1% .125W F TC=0+-100	16299	C4-1/8-TO-2151-F
A1R22	0757-0442	33	RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1002-F
A1R23	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1002-F
A1R24	0757-0482	1	RESISTOR 511K 1% .125W F TC=0+-100	24546	NA4
A1R25	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1002-F
A1R26	0698-4444	2	RESISTOR 4.87K 1% .125W F TC=0+-100	16299	C4-1/8-TO-4871-F
A1R27	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1002-F
A1R28	0698-4444		RESISTOR 4.87K 1% .125W F TC=0+-100	16299	C4-1/8-TO-4871-F
A1R29	2100-1210	11	RESISTOR, VAR TRMR 10K OHM	28480	2100-1210
A1R30	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1002-F
A1R31	0698-4479		RESISTOR 14K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1402-F
A1R32	0698-4479		RESISTOR 14K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1402-F
A1R33	0812-0014	2	RESISTOR .5 3% 5W PW TC=0+-90	01686	T5
A1R34	0812-0014		RESISTOR .5 3% 5W PW TC=0+-90	01686	T5
A1R35	0757-0416	5	RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-TO-511R-F
A1R36	0683-5615	1	RESISTOR 560 5% .25W FC TC=-400/+600	01121	CB5615
A1R37	0811-0987	1	RESISTOR 68 3% 3W PW TC=0+-20	07088	KH-300
A1R38	0813-0009	1	RESISTOR 125 3% 4W PW TC=0+-20	07088	KH-350
A1R39	0686-7505	1	RESISTOR 75 5% .5W CC TC=0+412	01121	EB7505
A1R40	0811-1552	1	RESISTOR .56 5% 2W PW TC=0+-800	75042	BWH2-9/16-J
A1R41	0683-5605	4	RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R42	0698-4479		RESISTOR 14K 1% .125W F TC=0+-100	24546	C4-1/8-TO-1402-F
A1R43	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R44	0811-3079	2	RESISTOR .51 5% .5W PW TC=0+-300	75042	BW20-1/2-33/64-J

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1R45	0811-3079		RESISTOR .51 5% .5W PW TC=0+-300	75042	BW20-1/2-33/64-J
A1R46	0683-1005	6	RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A1R47	0683-1005		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A1R48	0683-1005		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A1R49	0698-3430	3	RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A1R50	0683-1005		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A1R51	0683-1005		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A1R52	0683-1005		RESISTOR 10 5% .25W FC TC=-400/+500	01121	CB1005
A1R53	0698-3430		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A1R54	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A1R55	0698-4420	12	RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A1R56	0683-1835	3	RESISTOR 18K 5% .25W FC TC=-400/+800	01121	CB1835
A1R57	0698-6286	6	RESISTOR 100M 10% .25W FC TC=-900/+1200	01121	CB1071
A1R58	0698-6286		RESISTOR 100M 10% .25W FC TC=-900/+1200	01121	CB1071
A1R59	0757-0438	25	RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A1R60	0698-2211	3	RESISTOR:FXD 5.00K OHM 0.05% 1/8W MF	28480	0698-2211
A1R61	0698-2211		RESISTOR:FXD 5.00K OHM 0.05% 1/8W MF	28480	0698-2211
A1R62	0698-2211		RESISTOR:FXD 5.00K OHM 0.05% 1/8W MF	28480	0698-2211
A1R63	2100-2061	1	RESISTOR-VAR TRMR 200 OHM 10% C TOP ADJ	84048	170-201
A1R64			NOT ASSIGNED		
A1R65			NOT ASSIGNED		
A1R66	0698-2219	1	RESISTOR:FXD 35.0K OHM 0.05% 1/8W MF	28480	0698-2219
A1R67	0698-3432	1	RESISTOR 26.1 1% .125W F TC=0+-100	03888	PME55-1/8-T0-26R1-F
A1R68	0698-3132	1	RESISTOR 261 1% .125W F TC=0+-100	16299	C4-1/8-T0-2610-F
A1R69	0683-1835		RESISTOR 18K 5% .25W FC TC=-400/+800	01121	CB1835
A1R70	0698-6286		RESISTOR 100M 10% .25W FC TC=-900/+1200	01121	CB1071
A1R71	0698-6286		RESISTOR 100M 10% .25W FC TC=-900/+1200	01121	CB1071
A1R72	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A1R73 - A1R82			NOT ASSIGNED		
A1R83	2100-2216	1	RESISTOR-VAR TRMR 5KOHM 10% C TOP ADJ	84048	170-502
A1R84	0757-0439	2	RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6811-F
A1R85	0757-0199	20	RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A1R86	0698-6286		RESISTOR 100M 10% .25W FC TC=-900/+1200	01121	CB1071
A1R87	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A1R88	2100-1985	1	RESISTOR-VAR TRMR 20 OHM 20% C TOP ADJ	32997	3329H-1-200
A1R89	0811-0755	1		28480	0811-0755
A1R90	0811-0751	1	RESISTOR:FXD 0.90 OHM 0.05% 1/2W WW	28480	0811-0751
A1R91	0811-0752	1	RESISTOR:FXD 9.00 OHM 0.05% 1/2W WW	28480	0811-0752
A1R92	0698-2205	1	RESISTOR:FXD 90.0 OHM .05% 1/8W MF	28480	0698-2205
A1R93	0698-2207	2	RESISTOR:FXD 900 OHM 0.05% 1/8W MF	28480	0698-2207
A1R94	0698-2213	3	RESISTOR:FXD 9.00K OHM 0.05% 1/8W MF	28480	0698-2213
A1R95	0698-2225	5	RESISTOR:FXD 90.0K OHM 0.05% 1/8W MF	28480	0698-2225
A1R96	0683-1835		RESISTOR 18K 5% .25W FC TC=-400/+800	01121	CB1835
A1R97	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A1R98	0698-3491	2	RESISTOR 1K .1% .125W F TC=0+-50	24546	NC55
A1R99	0698-5437	2	RESISTOR 12K .1% .125W F TC=0+-50	24546	NC55
A1R100	0698-3491		RESISTOR 1K .1% .125W F TC=0+-50	24546	NC55
A1R101	0698-5437		RESISTOR 12K .1% .125W F TC=0+-50	24546	NC55
A1R102			NOT ASSIGNED		
A1R103	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A1R104	2100-1210		RESISTOR, VAR TRMR 10K OHM	28480	2100-1210
A1R105*	0698-3259	1	RESISTOR 7.87K 1% .125W F TC=0+-100	16299	C4-1/8-T0-7871-F
A1R106	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A1R107	0698-6286		RESISTOR 100M 10% .25W FC TC=-900/+1200	01121	CB1071
A1R108*	0757-0346	17	RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A1R109	0698-8212	1	RESISTOR 6K .25% .125W F TC=0+-25	19701	MF4C1/8-T9-6001-C
A1R110	0698-4511	2	RESISTOR 86.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8662-F
A1R111	0811-1185	2	RESISTOR 10K .01% .0125W PWW TC=0+-10	20940	140-1/20-1002-T
A1R112	0811-1185		RESISTOR 10K .01% .0125W PWW TC=0+-10	20940	140-1/20-1002-T
A1R113	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A1R114	0698-2225		RESISTOR:FXD 90.0K OHM 0.05% 1/8W MF	28480	0698-2225
A1R115	0698-4442	3	RESISTOR 4.42K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4421-F
A1R116	0698-2225		RESISTOR:FXD 90.0K OHM 0.05% 1/8W MF	28480	0698-2225
A1R117	0698-3162	1	RESISTOR 46.4K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4642-F
A1R118	2100-1210		RESISTOR, VAR TRMR 10K OHM	28480	2100-1210
A1R119*	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A1R120	2100-1986		RESISTOR-VAR TRMR 1KOHM 10% C TOP ADJ	84048	170-102
A1U1	1820-0216	29	IC AMPLIFIER	28480	1820-0216
A1U2	1820-0216		IC AMPLIFIER	28480	1820-0216
A1U3	1820-0216		IC AMPLIFIER	28480	1820-0216
A1U4	1820-0216		IC AMPLIFIER	28480	1820-0216
A1U5	1820-0216		IC AMPLIFIER	28480	1820-0216
A1U6	1826-0121	2	IC AMPLIFIER	32293	8007C
A1U7	1826-0009	1	IC AMPLIFIER	07263	725HC
A1U8	1826-0121		IC AMPLIFIER	32293	8007C
A1U9	1820-0216		IC AMPLIFIER	28480	1820-0216
A1U10			NOT ASSIGNED		

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A1U11	1826-0136	3	IC:LIN OP. AMPL. FET-INPT	28480	1826-0136
A1U12	1820-0216		IC AMPLIFIER	28480	1820-0216
A1U13	1820-0216		IC AMPLIFIER	28480	1820-0216
A1U14	1820-0216		IC AMPLIFIER	28480	1820-0216
A1U15	1820-0216		IC AMPLIFIER	28480	1820-0216
A1XA1	1251-2034	3	CONNECTOR; PC EDGE; 10-CONT; DIP SOLDER	71785	252-10-30-300
A1XA2	1251-0472	3	CONNECTOR; PC EDGE; 6-CONT; DIP SOLDER	71785	252-06-30-300
			A1 MISCELLANEOUS		
	0340-0469	1	INSULATOR, XSTR, TO- 66, .003 THK	86684	DF1038
	04282-10029	1	PLATE ANGLE, HEAT SINK	28480	04282-10029
A2	04282-77212	1	BOARD ASSEMBLY, MULTIPLIER	28480	04282-77212
A2C1	0160-1557	2	CAPACITOR, FXD 1000PF 10% 100WVDC	28480	0160-1557
A2C2	0160-1557		CAPACITOR, FXD 1000PF 10% 100WVDC	28480	0160-1557
A2C3	0160-2216	4	CAPACITOR-FXD 820PF +-5% 300WVDC MICA	28480	0160-2216
A2C4	0140-0196	6	CAPACITOR-FXD 150PF +-5% 300WVDC MICA	72136	DM15F151J0300WV1CR
A2C5	0160-2210	2	CAPACITOR-FXD 470PF +-5% 300WVDC MICA	28480	0160-2210
A2C6	0160-2209	1	CAPACITOR-FXD 360PF +-5% 300WVDC MICA	28480	0160-2209
A2C7	0180-0197	25	CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C8	0140-0196		CAPACITOR-FXD 150PF +-5% 300WVDC MICA	72136	DM15F151J0300WV1CR
A2C9	0140-0196		CAPACITOR-FXD 150PF +-5% 300WVDC MICA	72136	DM15F151J0300WV1CR
A2C10	0160-2216		CAPACITOR-FXD 820PF +-5% 300WVDC MICA	28480	0160-2216
A2C11	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C12	0160-2257	2	CAPACITOR-FXD 10PF +-5% 500WVDC CER	28480	0160-2257
A2C13	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C14	0160-2208	3	CAPACITOR-FXD 330PF +-5% 300WVDC MICA	28480	0160-2208
A2C15	0160-1271	2	C:FXD MY 0.01 UF 5% 50VDCW	28480	0160-1271
A2C16	0180-0374		CAPACITOR-FXD; 10UF+-10% 20VDC TA-SOLID	56289	150D106X9020B2
A2C17	0180-0374		CAPACITOR-FXD; 10UF+-10% 20VDC TA-SOLID	56289	150D106X9020B2
A2C18	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C19	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C20	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C21	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C22	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C23	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C24	0160-0128		CAPACITOR-FXD 2.2UF +-20% 25WVDC CER	28480	0160-0128
A2C25	0180-0228	7	CAPACITOR-FXD; 22UF+-10% 15VDC TA-SOLID	56289	150D226X9015B2
A2C26	0180-0228		CAPACITOR-FXD; 22UF+-10% 15VDC TA-SOLID	56289	150D226X9015B2
A2C27	0180-0228		CAPACITOR-FXD; 22UF+-10% 15VDC TA-SOLID	56289	150D226X9015B2
A2C28	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C29	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C30	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C31	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C32	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C33	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C34	0140-0196		CAPACITOR-FXD 150PF +-5% 300WVDC MICA	72136	DM15F151J0300WV1CR
A2C35	0160-2216		CAPACITOR-FXD 820PF +-5% 300WVDC MICA	28480	0160-2216
A2C36	0160-2210		CAPACITOR-FXD 470PF +-5% 300WVDC MICA	28480	0160-2210
A2C37	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C38	0140-0196		CAPACITOR-FXD 150PF +-5% 300WVDC MICA	72136	DM15F151J0300WV1CR
A2C39	0160-2208		CAPACITOR-FXD 330PF +-5% 300WVDC MICA	28480	0160-2208
A2C40	0140-0196		CAPACITOR-FXD 150PF +-5% 300WVDC MICA	72136	DM15F151J0300WV1CR
A2C41	0160-2216		CAPACITOR-FXD 820PF +-5% 300WVDC MICA	28480	0160-2216
A2C42	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C43	0160-2257		CAPACITOR-FXD 10PF +-5% 500WVDC CER	28480	0160-2257
A2C44	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C45	0160-2208		CAPACITOR-FXD 330PF +-5% 300WVDC MICA	28480	0160-2208
A2C46	0160-1271		C:FXD MY 0.01 UF 5% 50VDCW	28480	0160-1271
A2C47	0180-0374		CAPACITOR-FXD; 10UF+-10% 20VDC TA-SOLID	56289	150D106X9020B2
A2C48	0180-0374		CAPACITOR-FXD; 10UF+-10% 20VDC TA-SOLID	56289	150D106X9020B2
A2C49	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C50	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C51	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C52	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C53	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C54	0160-3459	6	CAPACITOR-FXD .02UF +-20% 100WVDC CER	28480	0160-3459
A2C55	0160-1640	1	CAPACITOR:FXD 0.01 UF 1% 300VAC MICA	28480	0160-1640
A2C56			NOT ASSIGNED		
A2C57	0160-1638	1	CAPACITOR:FXD 0.02 UF 1% 100VDC MICA	28480	0160-1638
A2C58	0160-1558		C:FXD MY 0.047 UF 5% 100VDCW	28480	0160-1558
A2C59	0180-0106	6	CAPACITOR-FXD; 60UF+-20% 6VDC TA-SOLID	56289	150D606X0006B2
A2C60	0160-1558		C:FXD MY 0.047 UF 5% 100VDCW	28480	0160-1558

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2C61	0160-1558		C:FXD MY 0.047 UF 5% 100VDCW	28480	0160-1558
A2C62	0160-1554	2	C:FXD MY 0.33 UF 5% 200VDCW	28480	0160-1554
A2C63	0160-1554		C:FXD MY 0.33 UF 5% 200VDCW	28480	0160-1554
A2C64	0180-0106		CAPACITOR-FXD; 60UF+-20% 6VDC TA-SOLID	56289	150D606X0006B2
A2C65	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C66	0180-0197		CAPACITOR-FXD; 2.2UF+-10% 20VDC TA	56289	150D225X9020A2
A2C67	0180-0374		CAPACITOR-FXD; 10UF+-10% 20VDC TA-SOLID	56289	150D106X9020B2
A2C68	0180-0106		CAPACITOR-FXD; 60UF+-20% 6VDC TA-SOLID	56289	150D606X0006B2
A2C69	0180-0106		CAPACITOR-FXD; 60UF+-20% 6VDC TA-SOLID	56289	150D606X0006B2
A2C70	0160-1546	1	C:FXD MY 0.15 UF 10% 200VDCW	28480	0160-1546
A2C71	0180-0106		CAPACITOR-FXD; 60UF+-20% 6VDC TA-SOLID	56289	150D606X0006B2
A2C72	0180-0106		CAPACITOR-FXD; 60UF+-20% 6VDC TA-SOLID	56289	150D606X0006B2
A2CR1	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR2	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR3	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR4	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR5	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR6	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR7	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR8	1902-0071	2	DIODE-ZNR 9V 5% DO-14 PD=.5W TC=+.001%	28480	1902-0071
A2CR9	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR10	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR11	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR12	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR13	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR14	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR15	1902-3234	1	DIODE-ZNR 19.6V 5% DO-7 PD=.4W TC=+.071%	04713	SZ 10939-266
A2CR16	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR17	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR18	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR19	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR20	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR21	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR22	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR23	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR24	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR25	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR26	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR27	1902-0071		DIODE-ZNR 9V 5% DO-14 PD=.5W TC=+.001%	28480	1902-0071
A2CR28	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR29	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR30	1902-3059		DIODE-ZNR 3.83V 5% DO-7 PD=.4W TC=-.051%	04713	SZ 10939-62
A2CR31	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR32	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR33	1902-3059		DIODE-ZNR 3.83V 5% DO-7 PD=.4W TC=-.051%	04713	SZ 10939-62
A2CR34	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR35	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR36	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR37	1902-3059		DIODE-ZNR 3.83V 5% DO-7 PD=.4W TC=-.051%	04713	SZ 10939-62
A2CR38	1902-3059		DIODE-ZNR 3.83V 5% DO-7 PD=.4W TC=-.051%	04713	SZ 10939-62
A2CR39	1910-0016	3	DIODE-SWITCHING 1US 60V 60MA	28480	1910-0016
A2CR40	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR41	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR42	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR43	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR44	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR45	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A2CR46	1902-3059		DIODE-ZNR 3.83V 5% DO-7 PD=.4W TC=-.051%	04713	SZ 10939-62
A2K1	0490-0226		RELAY;REED	28480	0490-0226
A2K2	0490-0226		RELAY;REED	28480	0490-0226
A2K3	0490-0226		RELAY;REED	28480	0490-0226
A2K4	0490-0226		RELAY;REED	28480	0490-0226
A2K5	0490-0226		RELAY;REED	28480	0490-0226
A2K6	0490-0226		RELAY;REED	28480	0490-0226
A2K7	0490-0226		RELAY;REED	28480	0490-0226
A2L1	9140-0114	5	COIL-FXD MOLDED RF CHOKE 10UH 10%	24226	15/102
A2L2	9140-0114		COIL-FXD MOLDED RF CHOKE 10UH 10%	24226	15/102
A2L3	9140-0114		COIL-FXD MOLDED RF CHOKE 10UH 10%	24226	15/102
A2L4	9140-0114		COIL-FXD MOLDED RF CHOKE 10UH 10%	24226	15/102
A2L5	9140-0114		COIL-FXD MOLDED RF CHOKE 10UH 10%	24226	15/102
A2Q1	1855-0112	22	TSTR;FET (2SK23A)	28480	1855-0112
A2Q2	1855-0112		TSTR;FET (2SK23A)	28480	1855-0112
A2Q3	1855-0112		TSTR;FET (2SK23A)	28480	1855-0112
A2Q4	1855-0112		TSTR;FET (2SK23A)	28480	1855-0112
A2Q5	1855-0112		TSTR;FET (2SK23A)	28480	1855-0112

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2Q6	1854-0039	3	TRANSISTOR NPN 2N3053 SI TO-5 PD=1W	04713	2N3053
A2Q7	1855-0067		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0067
A2Q8	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q9	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q10	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A2Q11	1854-0009	2	TRANSISTOR NPN 2N709 SI TO-18 PD=300MW	28480	1854-0009
A2Q12	1855-0081	2	TRANSISTOR J-FET 2N5245 N-CHAN D-MODE SI	01295	2N5245
A2Q13	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A2Q14	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A2Q15	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A2Q16	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A2Q17	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A2Q18	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A2Q19	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q20	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q21	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q22	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q23	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q24	1854-0039		TRANSISTOR NPN 2N3053 SI TO-5 PD=1W	04713	2N3053
A2Q25	1855-0067		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0067
A2Q26	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q27	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q28	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A2Q29	1854-0009		TRANSISTOR NPN 2N709 SI TO-18 PD=300MW	28480	1854-0009
A2Q30	1855-0081		TRANSISTOR J-FET 2N5245 N-CHAN D-MODE SI	01295	2N5245
A2Q31	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A2Q32	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A2Q33	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q34	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q35	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q36	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q37	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q38	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q39	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q40	1855-0112		TSTR:FET (2SK23A)	28480	1855-0112
A2Q41	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A2Q42	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A2Q43	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A2R1	0698-4420		RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A2R2	0698-4420		RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A2R3	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R4	0698-2208	12	RESISTOR:FXD 1K OHM 0.05% 1/8W MF	28480	0698-2208
A2R5	0698-2213		RESISTOR:FXD 9.00K OHM 0.05% 1/8W MF	28480	0698-2213
A2R6	2100-1210		RESISTOR, VAR TRMR 10K OHM	28480	2100-1210
A2R7	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R8	0698-2208		RESISTOR:FXD 1K OHM 0.05% 1/8W MF	28480	0698-2208
A2R9	0698-7314	1	RESISTOR 8.5K .1% .25W F TC=0+-25	19701	MF52C1/4-T9-852-B
A2R10	2100-1986		RESISTOR-VAR TRMR 1KOHM 10% C TOP ADJ	84048	170-102
A2R11	2100-2031	3	RESISTOR-VAR TRMR 50KOHM 10% C TOP ADJ	84048	170-503
A2R12	0683-4755	2	RESISTOR 4.7M 5% .25W FC TC=-900/+1100	01121	CB4755
A2R13	0698-2214	17	RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R14	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R15	0757-0433	6	RESISTOR 3.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3321-F
A2R16	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R17	0698-2216	4	RESISTOR:FXD 20.0K OHM 0.05% 1/8W MF	28480	0698-2216
A2R18	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R19	0698-4483	12	RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R20	0698-2220	4	RESISTOR:FXD 40K OHM 0.5% 1/8W MF	28480	0698-2220
A2R21	0757-0077	2	RESISTOR 1.2K 2% .25W F TC=0+-100	24546	C5-1/4-T0-1201-G
A2R22	0757-0433		RESISTOR 3.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3321-F
A2R23	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R24	0757-0433		RESISTOR 3.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3321-F
A2R25	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R26	0698-4483		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R27	0698-3156	8	RESISTOR 14.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1472-F
A2R28	2100-2497		RESISTOR-VAR TRMR 2KOHM 10% C TOP ADJ	19701	ET50W202
A2R29	0757-0273	5	RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011-F
A2R30	2100-1210		RESISTOR, VAR TRMR 10K OHM	28480	2100-1210
A2R31	2100-1788	2	RESISTOR-VAR TRMR 500 OHM 10% C TOP ADJ	84048	170-501
A2R32	0698-2114	1	R:FXD MET FLM 44.42K OHM 0.1% 1/8W	28480	0698-2114
A2R33	0757-0421		RESISTOR 825 1% .125W F TC=0+-100	24546	C4-1/8-T0-825R-F
A2R34	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R35	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A2R36	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R37	0698-2216		RESISTOR:FXD 20.0K OHM 0.05% 1/8W MF	28480	0698-2216
A2R38	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R39	0698-4020	6	RESISTOR 9.53K 1% .125W F TC=0+-100	16299	C4-1/8-T0-9531-F
A2R40	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F

See introduction to this section for ordering information

Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2R41	0698-3155	10	RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A2R42	0757-1094	1	RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A2R43	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R44	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A2R45	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R46	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R47	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R48	2100-2030	2	RESISTOR-VAR TRMR 20KOHM 10% C TOP ADJ	84048	170-203
A2R49	0757-0453	7	RESISTOR 30.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3012-F
A2R50	0698-4483		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R51	0698-4463		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R52	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A2R53	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A2R54	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R55	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R56	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R57	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R58	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R59	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R60	0757-0441	2	RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A2R61	0757-0441		RESISTOR 8.25K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8251-F
A2R62	0698-3154	1	RESISTOR 4.22K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4221-F
A2R63	0698-3558	1	RESISTOR 4.02K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4021-F
A2R64	0757-0288	1	RESISTOR 9.09K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-9091-F
A2R65	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R66	0757-0443	1	RESISTOR 11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1102-F
A2R67	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R68	0698-4420		RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A2R69	0698-4420		RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A2R70	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R71	0757-0453		RESISTOR 30.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3012-F
A2R72	2100-2031		RESISTOR-VAR TRMR 50KOHM 10% C TOP ADJ	84048	170-503
A2R73	0698-3162		RESISTOR 46.4K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4642-F
A2R74	0698-3454	3	RESISTOR 215K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2153-F
A2R75	0698-3459	2	RESISTOR 383K 1% .125W F TC=0+-100	03888	PME55
A2R76	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A2R77	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R78	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R79	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R80	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R81	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R82	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R83	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R84	2100-2031		RESISTOR-VAR TRMR 50KOHM 10% C TOP ADJ	84048	170-503
A2R85	0757-0433		RESISTOR 3.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3321-F
A2R86	0683-4755		RESISTOR 4.7M 5% .25W FC TC=-900/+1100	01121	CB4755
A2R87	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R88	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R89	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R90	0698-2214		RESISTOR:FXD 20.0K OHM 0.05% 1/8W MF	28480	0698-22[illegible]
A2R91	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R92	0698-4483		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R93	0698-2220		RESISTOR:FXD 40K OHM 0.5% 1/8W MF	28480	0698-2220
A2R94	0757-0077		RESISTOR 1.2K 2% .25W F TC=0+-100	24546	C5-1/4-T0-1201-G
A2R95	0757-0433		RESISTOR 3.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3321-F
A2R96	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R97	0757-0433		RESISTOR 3.32K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3321-F
A2R98	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R99	0698-4483		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R100	0698-3156		RESISTOR 14.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1472-F
A2R101	2100-2497		RESISTOR-VAR TRMR 2KOHM 10% C TOP ADJ	19701	ET50W202
A2R102	0757-0273		RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011-F
A2R103	0698-4420		RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A2R104	0698-4420		RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A2R105	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R106	0698-2210	1	RESISTOR:FXD 3.8463K OHM 0.05% 1/8W MF	28480	0698-2210
A2R107	0698-2212	1	RESISTOR:FXD 8.1134K OHM 0.05% 1/8W MF	28480	0698-2212
A2R108	0698-2224	1	RESISTOR:FXD 67.569K OHM 0.05% 1/8W MF	28480	0698-2224
A2R109	0698-2217	1	RESISTOR:FXD 21.831K OHM 0.05% 1/8W MF	28480	0698-2217
A2R110	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R111	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R112	0757-0421		RESISTOR 825 1% .125W F TC=0+-100	24546	C4-1/8-T0-825R-F
A2R113	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R114	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A2R115	2100-1210		RESISTOR, VAR TRMR 10K OHM	28480	2100-1210

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2R116	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R117	2100-1788		RESISTOR-VAR TRMR 500 OHM 10% C TOP ADJ	84048	170-501
A2R118	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A2R119	0698-4020		RESISTOR 9.53K 1% .125W F TC=0+-100	16299	C4-1/8-T0-9531-F
A2R120	0698-2220		RESISTOR:FXD 40K OHM 0.5% 1/8W MF	28480	0698-2220
A2R121	0698-2216		RESISTOR:FXD 20.0K OHM 0.05% 1/8W MF	28480	0698-2216
A2R122	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A2R123	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A2R124	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R125	0757-1094		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A2R126	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A2R127	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R128	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R129	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A2R130	2100-2030		RESISTOR-VAR TRMR 20KOHM 10% C TOP ADJ	84048	170-203
A2R131	0757-0453		RESISTOR 30.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3012-F
A2R132	0698-4483		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R133	0698-4483		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R134	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A2R135	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A2R136	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R137	0757-0465	9	RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A2R138	0698-3161	3	RESISTOR 38.3K 1% .125W F TC=0+-100	16299	C4-1/8-T0-3832-F
A2R139	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A2R140	0698-4483		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R141	0698-4483		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R142	0698-4483		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A2R143	0698-3459		RESISTOR 383K 1% .125W F TC=0+-100	03888	PME55
A2R144	2100-1210		RESISTOR, VAR TRMR 10K OHM	28480	2100-1210
A2R145	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R146	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R147	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R148	0698-3260	1	RESISTOR 464K 1% .125W F TC=0+-100	03888	PME55
A2R149	0757-0453		RESISTOR 30.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3012-F
A2R150	0698-0060	1	RESISTOR 3.6M 5% .25W FC TC=-900/+1100	01121	CB3655
A2R151	0698-2226	1	RESISTOR:FXD 100K OHM 0.05% 1/8W MF	28480	0698-2226
A2R152	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A2R153	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R154	0698-3156		RESISTOR 14.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1472-F
A2R155	0698-3156		RESISTOR 14.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1472-F
A2R156	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R157	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R158	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R159	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A2R160	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R161	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R162	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A2R163	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A2R164	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A2R165	0698-3161		RESISTOR 38.3K 1% .125W F TC=0+-100	16299	C4-1/8-T0-3832-F
A2R166	0698-3161		RESISTOR 38.3K 1% .125W F TC=0+-100	16299	C4-1/8-T0-3832-F
A2R167	2100-1210		RESISTOR, VAR TRMR 10K OHM	28480	2100-1210
A2R168	2100-1210		RESISTOR, VAR TRMR 10K OHM	28480	2100-1210
A2R169	0698-3151	1	RESISTOR 2.87K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2871-F
A2R170	0698-4477	1	RESISTOR 10.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1052-F
A2R171	0698-4125	2	RESISTOR 953 1% .125W F TC=0+-100	16299	C4-1/8-T0-953R-F
A2R172	0698-4420		RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A2R173	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R174	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R175	0757-0346		RESISTOR 10 1% .125W F TC=0+-100	24546	C4-1/8-T0-10R0-F
A2R176	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A2R177	0757-0453		RESISTOR 30.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3012-F
A2R178	0683-6245	1	RESISTOR 620K 5% .25W FC TC=-800/+900	01121	CB6245
A2R179	0698-4020		RESISTOR 9.53K 1% .125W F TC=0+-100	16299	C4-1/8-T0-9531-F
A2R180	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R181	0698-3156		RESISTOR 14.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1472-F
A2R182	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A2R183	0698-4020		RESISTOR 9.53K 1% .125W F TC=0+-100	16299	C4-1/8-T0-9531-F
A2R184	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R185	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R186	0698-4020		RESISTOR 9.53K 1% .125W F TC=0+-100	16299	C4-1/8-T0-9531-F
A2R187	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A2R188	0698-3156		RESISTOR 14.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1472-F
A2R189	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A2R190	0698-4020		RESISTOR 9.53K 1% .125W F TC=0+-100	16299	C4-1/8-T0-9531-F

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A2R191	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R192	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A2R193	0698-3268	3	RESISTOR 11.5K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1152-F
A2R194	0698-3268		RESISTOR 11.5K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1152-F
A2R195	0757-0461	1	RESISTOR 68.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6812-F
A2R196	0757-0462	1	RESISTOR 75K 1% .125W F TC=0+-100	24546	C4-1/8-T0-7502-F
A2T1	9100-0828	2	TRANSFORMER:PULSE 4:1:4	28480	9100-0828
A2T2	9100-0828		TRANSFORMER:PULSE 4:1:4	28480	9100-0828
A2U1	1826-0007		IC AMPLIFIER	28480	1826-0007
A2U2	1826-0007		IC AMPLIFIER	28480	1826-0007
A2U3	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U4	1820-0223	9	IC LM301AH	27014	LM301AH
A2U5	1820-0054	15	IC SN74 00 N	01295	SN7400N
A2U6	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U7	1820-0223		IC LM301AH	27014	LM301AH
A2U8	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U9			NOT ASSIGNED		
A2U10	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U11	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U12	1820-0223		IC LM301AH	27014	LM301AH
A2U13	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U14	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U15	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U16	1820-0223		IC LM301AH	27014	LM301AH
A2U17	1820-0054		IC SN74 00 N	01295	SN7400N
A2U18	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U19	1820-0223		IC LM301AH	27014	LM301AH
A2U20	1820-0223		IC LM301AH	27014	LM301AH
A2U21	1820-0583	1	IC DM74L 00N	27014	DM74L00N
A2U22	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U23	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U24	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U25	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U26	5080-3821	3	IC, LIN OP. AMP, FET-INPUT	28480	5080-3821
A2U27	5080-3821		IC, LIN OP. AMP, FET-INPUT	28480	5080-3821
A2U28	1820-0223		IC LM301AH	27014	LM301AH
A2U29	1820-0223		IC LM301AH	27014	LM301AH
A2U30	1820-0054		IC SN74 00 N	01295	SN7400N
A2U31	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U32	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U33	1820-0054		IC SN74 00 N	01295	SN7400N
A2U34	1820-0216		IC AMPLIFIER	28480	1820-0216
A2U35	1820-0223		IC LM301AH	27014	LM301AH
A2XA1	1251-2034		CONNECTOR; PC EDGE; 10-CONT; DIP SOLDER	71785	252-10-30-300
A3	04282-77213	1	BOARD ASSEMBLY, CONTROL	28480	04282-77213
A3C1	0150-0024	2	CAPACITOR-FXD .02UF +80-20% 600WVDC CER	71590	DD203-Z5U-+80-20
A3C2	0150-0024		CAPACITOR-FXD .02UF +80-20% 600WVDC CER	71590	DD203-Z5U-+80-20
A3C3	0160-0170	1	CAPACITOR-FXD .22UF +80-20% 25WVDC CER	28480	0160-0170
A3C4	0180-1057	4	CAPACITOR:FXD 2200 UF 16VDCW AL ELECT	28480	0180-1057
A3C5	0180-1057		CAPACITOR:FXD 2200 UF 16VDCW AL ELECT	28480	0180-1057
A3C6	0160-1568	1	C:FXD MY 0.0068 UF 5% 100VDCW	28480	0160-1568
A3C7	0180-0229	4	CAPACITOR-FXD; 33UF+-10% 10VDC TA-SOLID	56289	150D336X9010B2
A3C8	0180-1057		CAPACITOR:FXD 2200 UF 16VDCW AL ELECT	28480	0180-1057
A3C9	0180-1057		CAPACITOR:FXD 2200 UF 16VDCW AL ELECT	28480	0180-1057
A3C10	0160-1550	1	CAPACITOR:FXD 0.015 UF 5% 100VDC MY	28480	0160-1550
A3C11	0180-0229		CAPACITOR-FXD; 33UF+-10% 10VDC TA-SOLID	56289	150D336X9010B2
A3C12	0180-1056	2	CAPACITOR:FXD 1000 UF 25VDC AL ELECT	28480	0180-1056
A3C13	0160-2211		CAPACITOR-FXD 510PF +-5% 300WVDC MICA	28480	0160-2211
A3C14	0180-1746	2	CAPACITOR-FXD; 15UF+-10% 20VDC TA-SOLID	56289	150D156X9020B2
A3C15	0180-1056		CAPACITOR:FXD 1000 UF 25VDC AL ELECT	28480	0180-1056
A3C16	0160-2211		CAPACITOR-FXD 510PF +-5% 300WVDC MICA	28480	0160-2211
A3C17	0180-1746		CAPACITOR-FXD; 15UF+-10% 20VDC TA-SOLID	56289	150D156X9020B2
A3C18	0160-3451	2	CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-3451
A3C19	0160-3451		CAPACITOR-FXD .01UF +80-20% 100WVDC CER	28480	0160-3451
A3CR1	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A3CR2	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A3CR3	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A3CR4	1902-3182	2	DIODE-ZNR 12.1V 5% DO-7 PD=.4W TC=+.064%	04713	SZ 10939-206
A3CR5	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A3CR6	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A3CR7	1902-3182		DIODE-ZNR 12.1V 5% DO-7 PD=.4W TC=+.064%	04713	SZ 10939-206
A3CR8	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A3CR9	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A3CR10	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376

Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A3CR11	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A3CR12	1902-0837	2	DIODE BREAKDOWN:7.7-8.7V 1W	28480	1902-0837
A3CR13	1902-0837		DIODE BREAKDOWN:7.7-8.7V 1W	28480	1902-0837
A3CR14	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A3CR15	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A3CR16	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A3CR17	1902-0041	1	DIODE-ZNR 5.11V 5% DO-7 PD=.4W TC=-.009%	04713	SZ 10939-98
A3CR18	1901-0415	4	DIODE-PWR RECT 50V 1.5A	04713	SR1846-8
A3CR19	1901-0415		DIODE-PWR RECT 50V 1.5A	04713	SR1846-8
A3CR20	1901-0415		DIODE-PWR RECT 50V 1.5A	04713	SR1846-8
A3CR21	1901-0415		DIODE-PWR RECT 50V 1.5A	04713	SR1846-8
A3CR22	1901-0237	3	DIODE:SI, RECTIFIER BRIDGE, 200V	28480	1901-0237
A3CR23	1901-0237		DIODE:SI, RECTIFIER BRIDGE, 200V	28480	1901-0237
A3CR24	1901-0237		DIODE:SI, RECTIFIER BRIDGE, 200V	28480	1901-0237
A3CR25	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A3K1	0490-0226		RELAY:REED	28480	0490-0226
A3K2	0490-0226		RELAY:REED	28480	0490-0226
A3K3	0490-0227	1	RELAY:REED SPST 12VDC 400 OHM	28480	0490-0227
A3K4	0490-0226		RELAY:REED	28480	0490-0226
A3Q1	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3Q2	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A3Q3	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A3Q4	1855-0062	2	TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0062
A3Q5	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A3Q6	1855-0062		TRANSISTOR J-FET N-CHAN D-MODE SI	28480	1855-0062
A3Q7	1854-0039		TRANSISTOR NPN 2N3053 SI TO-5 PD=1W	04713	2N3053
A3Q8	1854-0072	3	TRANSISTOR NPN 2N3054 SI TO-66 PD=25W	02735	2N3054
A3Q9	1854-0072		TRANSISTOR NPN 2N3054 SI TO-66 PD=25W	02735	2N3054
A3Q10	1854-0072		TRANSISTOR NPN 2N3054 SI TO-66 PD=25W	02735	2N3054
A3R1	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A3R2	0698-4420		RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A3R3	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A3R4	0698-4420		RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A3R5	0698-2231	2	RESISTOR:FXD 900K OHM 0.1% 1/8W MF	28480	0698-2231
A3R6	0698-2225		RESISTOR:FXD 90.0K OHM 0.05% 1/8W MF	28480	0698-2225
A3R7	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A3R8	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A3R9	0757-0453		RESISTOR 30.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3012-F
A3R10	0698-0085	3	RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A3R11	0757-0454		RESISTOR 33.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3322-F
A3R12	0698-3454		RESISTOR 215K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2153-F
A3R13	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A3R14	0757-0453		RESISTOR 30.1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3012-F
A3R15	0698-0085		RESISTOR 2.61K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2611-F
A3R16	0757-0454		RESISTOR 33.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3322-F
A3R17	0698-3454		RESISTOR 215K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2155-F
A3R18	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A3R19	1810-0055	6	NETWORK-RES 9-PIN SIP .15-PIN-SPCG	28480	1810-0055
A3R20	1810-0055		NETWORK-RES 9-PIN SIP .15-PIN-SPCG	28480	1810-0055
A3R21	1810-0055		NETWORK-RES 9-PIN SIP .15-PIN-SPCG	28480	1810-0055
A3R22	1810-0055		NETWORK-RES 9-PIN SIP .15-PIN-SPCG	28480	1810-0055
A3R23	1810-0055		NETWORK-RES 9-PIN SIP .15-PIN-SPCG	28480	1810-0055
A3R24	1810-0055		NETWORK-RES 9-PIN SIP .15-PIN-SPCG	28480	1810-0055
A3R25	0757-0367	1	RESISTOR 100K 1% .5W F TC=0+-100	19701	MF7C1/2-T0-1003-F
A3R26	0683-1515	2	RESISTOR 150 5% .25W FC TC=-400/+600	01121	CB1515
A3R27	0683-1515		RESISTOR 150 5% .25W FC TC=-400/+600	01121	CB1515
A3R28	0683-1065	3	RESISTOR 10M 5% .25W FC TC=-900/+1100	01121	CB1065
A3R29	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A3R30	0683-1065		RESISTOR 10M 5% .25W FC TC=-900/+1100	01121	CB1065
A3R31	0698-3243	1	RESISTOR 178K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1783-F
A3R32	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A3R33	2100-1220	2	RESISTOR:VAR 500 OHM 20% LIN 1/2W C	28480	2100-1220
A3R34	0698-0084		RESISTOR 2.15K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2151-F
A3R35	0757-0420	3	RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
A3R36	0811-1746	2	RESISTOR .36 5% 2W PW TC=0+-800	75042	BWH2-36/100-J
A3R37	0811-1746		RESISTOR .36 5% 2W PW TC=0+-800	75042	BWH2-36/100-J
A3R38	2100-1220		RESISTOR:VAR 500 OHM 20% LIN 1/2W C	28480	2100-1220
A3R39	0698-0084		RESISTOR 2.15K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2151-F
A3R40	0757-0420		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
A3R41	0812-0021	1	RESISTOR .47 5% 3W PW TC=0+-90	91637	CW2B1-3-T2-47/100-J
A3R42	0813-0029	2	RESISTOR 1 3% 3W PW TC=0+-50	07088	KH-300
A3R43	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A3R44	2100-1221	2	RESISTOR:VAR 1K OHM 20% LIN 1/2W C	28480	2100-1221

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A3R45	0698-4442		RESISTOR 4.42K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4421-F
A3R46	0813-0029		RESISTOR 1 3% 3W PW TC=0+-50	07088	KM-100
A3R47	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A3R48	2100-1221		RESISTOR:VAR 1K OHM 20% LIN 1/2W C	28480	2100-1221
A3R49	0698-4442		RESISTOR 4.42K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4421-F
A3R50	0683-1865	1	RESISTOR 18M 5% .25W FC TC=-900/+1200	01121	CB1865
A3R51	0698-4420		RESISTOR 226 1% .125W F TC=0+-100	16299	C4-1/8-T0-226R-F
A3R52	0813-0032	1	RESISTOR 50K 5% 5W PW TC=0+-20	07088	KM-800
A3U1	1820-0537	1	IC SN74 13 N	01295	SN7413N
A3U2	1820-0077	1	IC SN74 74 N	01295	SN7474N
A3U3	1820-0661	10	IC SN74 32 N	01295	SN7432N
A3U4	1820-0661		IC SN74 32 N	01295	SN7432N
A3U5	1820-0054		IC SN74 00 N	01295	SN7400N
A3U6	1820-0054		IC SN74 00 N	01295	SN7400N
A3U7	1820-0054		IC SN74 00 N	01295	SN7400N
A3U8	1820-0328	2	IC SN74 02 N	01295	SN7402N
A3U9	1820-0782	1	IC SN74 27 N	01295	SN7427N
A3U10	1820-0328		IC SN74 02 N	01295	SN7402N
A3U11	1820-0661		IC SN74 32 N	01295	SN7432N
A3U12	1820-0661		IC SN74 32 N	01295	SN7432N
A3U13	1820-0661		IC SN74 32 N	01295	SN7432N
A3U14	1820-0661		IC SN74 32 N	01295	SN7432N
A3U15	1820-0661		IC SN74 32 N	01295	SN7432N
A3U16	1820-0511	6	IC SN74 08 N	01295	SN7408N
A3U17	1820-0511		IC SN74 08 N	01295	SN7408N
A3U18	1820-0661		IC SN74 32 N	01295	SN7432N
A3U19	1820-0068	4	IC SN74 10 N	01295	SN7410N
A3U20	1820-0668	3	IC SN74 07 N	01295	SN7407N
A3U21	1820-0668		IC SN74 07 N	01295	SN7407N
A3U22	1820-0661		IC SN74 32 N	01295	SN7432N
A3U23	1820-0511		IC SN74 08 N	01295	SN7408N
A3U24	1820-0511		IC SN74 08 N	01295	SN7408N
A3U25	1820-0661		IC SN74 32 N	01295	SN7432N
A3U26	1826-0136		IC:LIN OP. AMPL. FET-INPT	28480	1826-0136
A3U27	1820-0196	4	IC REGULATOR	07263	723HC
A3U28	1820-0196		IC REGULATOR	07263	723HC
A3U29	1820-0196		IC REGULATOR	07263	723HC
A3U30	1820-0196		IC REGULATOR	07263	723HC
A3XA1	1251-2026	4	CONNECTOR; PC EDGE; 18-CONT; DIP SOLDER	71785	252-18-30-300
A3XA2	1251-2026		CONNECTOR; PC EDGE; 18-CONT; DIP SOLDER	71785	252-18-30-300
A3XA3	1251-0472		CONNECTOR; PC EDGE; 6-CONT; DIP SOLDER	71785	252-06-30-300
A3XA4	1251-2026		CONNECTOR; PC EDGE; 18-CONT; DIP SOLDER	71785	252-18-30-300
A3XA5	1251-3076	2	CONNECTOR; PC EDGE; 18-CONT; EXTENDER	71785	251-18-30-340
	04282-10130	1	HEAT SINK, POWER	28480	04282-10130
A4	04282-77214	1	BOARD ASSEMBLY, D.V.M.	28480	04282-77214
A4C1	0160-1588	1	CAPACITOR:FXD 0.68 UF 200VDC MET	28480	0160-1588
A4C2	0160-0134	2	CAPACITOR-FXD 220PF +-5% 300WVDC MICA	28480	0160-0134
A4C3	0160-2150	2	CAPACITOR-FXD 33PF +-5% 300WVDC MICA	28480	0160-2150
A4C4	0160-2150		CAPACITOR-FXD 33PF +-5% 300WVDC MICA	28480	0160-2150
A4C5	0140-0197	1	CAPACITOR-FXD 180PF +-5% 300WVDC MICA	72136	DM15F181J0300WV1CR
A4C6	0160-3459		CAPACITOR-FXD .02UF +-20% 100WVDC CER	28480	0160-3459
A4C7	0160-2204	3	CAPACITOR-FXD 100PF +-5% 300WVDC MICA	28480	0160-2204
A4C8	0180-0228		CAPACITOR-FXD; 22UF+-10% 15VDC TA-SOLID	56289	150D226X9015B2
A4C9	0180-0228		CAPACITOR-FXD; 22UF+-10% 15VDC TA-SOLID	56289	150D226X9015B2
A4C10	0160-0127	2	CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
A4C11	0160-0127		CAPACITOR-FXD 1UF +-20% 25WVDC CER	28480	0160-0127
A4C12	0180-1745	1	CAPACITOR-FXD; 1.5UF+-10% 20VDC TA	56289	150D155X9020A2
A4C13	0180-0374		CAPACITOR-FXD; 10UF+-10% 20VDC TA-SOLID	56289	150D106X9020B2
A4C14	0180-0228		CAPACITOR-FXD; 22UF+-10% 15VDC TA-SOLID	56289	150D226X9015B2
A4C15	0180-0229		CAPACITOR-FXD; 33UF+-10% 10VDC TA-SOLID	56289	150D336X9010B2
A4C16	0180-0229		CAPACITOR-FXD; 33UF+-10% 10VDC TA-SOLID	56289	150D336X9010B2
A4C17	0180-1743	1	CAPACITOR-FXD; .1UF+-10% 35VDC TA-SOLID	56289	150D104X9035A2
A4C18	0160-2204		CAPACITOR-FXD 100PF +-5% 300WVDC MICA	28480	0160-2204
A4C19	0160-0134		CAPACITOR-FXD 220PF +-5% 300WVDC MICA	28480	0160-0134
A4C20	0140-0145	1	CAPACITOR-FXD 22PF +-5% 500WVDC MICA	72136	DM15C220J0500WV1CR
A4C21	0160-3459		CAPACITOR-FXD .02UF +-20% 100WVDC CER	28480	0160-3459
A4C22	0160-3459		CAPACITOR-FXD .02UF +-20% 100WVDC CER	28480	0160-3459
A4C23	0160-3459		CAPACITOR-FXD .02UF +-20% 100WVDC CER	28480	0160-3459
A4C24	0160-3459		CAPACITOR-FXD .02UF +-20% 100WVDC CER	28480	0160-3459
A4CR1	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A4CR2	1901-0376		DIODE-GEN PRP 35V 50MA	28480	1901-0376
A4CR3	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A4CR4	1902-3193		DIODE-ZNR 13.3V 5% DO-7 PD=.4W TC=+.059%	04713	SZ 10939-218
A4CR5	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A4CR6	1902-3190	3	DIODE-ZNR 9.09V 2% DO-7 PD=.4W TC=+.057%	04713	SZ 10939-171
A4CR7	1902-3150		DIODE-ZNR 9.09V 2% DO-7 PD=.4W TC=+.057%	04713	SZ 10939-171
A4CR8	1901-0040		DIODE-SWITCHING 2NS 30V 50MA	28480	1901-0040
A4CR9	1902-0071		DIODE-ZNR 9V 5% DO-14 PD=.5W TC=+.001%	28480	1902-0071
A4CR10	1902-3070	1	DIODE-ZNR 4.22V 5% DO-7 PD=.4W TC=-.038%	04713	SZ 10939-74
A4CR11	1910-0016		DIODE-SWITCHING 1US 60V 60MA	28480	1910-0016
A4Q1	1858-0033	3	TRANSISTOR	28480	1858-0033
A4Q2	1858-0033		TRANSISTOR	28480	1858-0033
A4Q3	1853-0036	5	TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
A4Q4	1854-0215	3	TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A4Q5	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A4Q6	1853-0020		TRANSISTOR PNP SI PD=300MW FT=150MHZ	28480	1853-0020
A4Q7	1854-0215		TRANSISTOR NPN SI PD=310MW FT=300MHZ	04713	SPS 3611
A4Q8	1853-0036		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
A4Q9	1853-0036		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
A4Q10			NOT ASSIGNED		
A4Q11			NOT ASSIGNED		
A4Q12	1858-0033		TRANSISTOR	28480	1858-0033
A4Q13	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A4Q14	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A4Q15	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A4Q16	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A4Q17	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A4R1	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R2	0698-4036	1	RESISTOR 9.09K .25% .125W F TC=0+-100	03888	PME55-1/8-T0-9091-C
A4R3	0698-5322	1	RESISTOR 1.01K .5% .125W F TC=0+-50	24546	NC4-1/8-T2-1011-D
A4R4	2100-1226	1	RESISTOR:VAR 2K OHM 20% LIN 1/2W C	28480	2100-1226
A4R5	0698-2222	1	RESISTOR:FXD 60K OHM 0.05% 1/8W MF	28480	0698-2222
A4R6	0698-4486	1	RESISTOR 24.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2492-F
A4R7	0683-1065		RESISTOR 10M 5% .25W FC TC=-900/+1100	01121	CB1065
A4R8	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A4R9	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A4R10	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A4R11	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A4R12	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R13	0757-0439		RESISTOR 6.81K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6811-F
A4R14	0757-0454		RESISTOR 33.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3322-F
A4R15	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R16	0757-0419	1	RESISTOR 681 1% .125W F TC=0+-100	24546	C4-1/8-T0-681R-F
A4R17	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R18	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R19	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R20	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R21	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R22	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A4R23	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A4R24	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R25	0757-0447	1	RESISTOR 16.2K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1622-F
A4R26	0757-0290	3	RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A4R27	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A4R28	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A4R29	0698-3156		RESISTOR 14.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1472-F
A4R30			NOT ASSIGNED		
A4R31	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R32	0757-0273		RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011-F
A4R33	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R34	0757-0417	1	RESISTOR 562 1% .125W F TC=0+-100	24546	C4-1/8-T0-562R-F
A4R35	0757-0278	2	RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
A4R36	0698-3441	4	RESISTOR 215 1% .125W F TC=0+-100	16299	C4-1/8-T0-215R-F
A4R37	0698-3441		RESISTOR 215 1% .125W F TC=0+-100	16299	C4-1/8-T0-215R-F
A4R38	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R39	0698-1055	1	RESISTOR,FXD 1M 1% .125W F TUBULAR	28480	0698-1055
A4R40	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A4R41	2100-1224	1	RESISTOR:VAR 20K OHM 20% LIN 1/2W C	28480	2100-1224
A4R42	0698-2220		RESISTOR:FXD 40K OHM 0.5% 1/8W MF	28480	0698-2220
A4R43	0757-0290		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A4R44	0757-0418	1	RESISTOR 619 1% .125W F TC=0+-100	24546	C4-1/8-T0-619R-F
A4R45	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A4R46	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R47	0698-2214		RESISTOR:FXD 10.0K OHM 0.05% 1/8W MF	28480	0698-2214
A4R48	0757-0290		RESISTOR 6.19K 1% .125W F TC=0+-100	19701	MF4C1/8-T0-6191-F
A4R49	0757-0421		RESISTOR 825 1% .125W F TC=0+-100	24546	C4-1/8-T0-825R-F
A4R50	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A4R51	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R52	0698-0084		RESISTOR 2.15K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2151-F
A4R53	0698-3155		RESISTOR 4.64K 1% .125W F TC=0+-100	16299	C4-1/8-T0-4641-F
A4R54	0757-0401		RESISTOR 100 1% .125W F TC=0+-100	24546	C4-1/8-T0-101-F
A4R55	0698-3260		RESISTOR 11.5K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1152-F
A4R56	0757-0273		RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011-F
A4R57	0698-4483		RESISTOR 18.7K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1872-F
A4R58	0698-4421	36	RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R59	0757-0273		RESISTOR 3.01K 1% .125W F TC=0+-100	24546	C4-1/8-T0-3011-F
A4R60	0698-0084		RESISTOR 2.15K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2151-F
A4R61	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A4R62	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R63	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R64	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R65	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R66	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A4R67	0698-0084		RESISTOR 2.15K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2151-F
A4R68	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R69	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R70	0698-3156		RESISTOR 14.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1472-F
A4R71	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A4R72	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R73	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R74	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R75	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4R76	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R77	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R78	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R79	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R80	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R81	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R82	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R83	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R84	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R85	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R86	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R87	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R88	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R89	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R90	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R91	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R92	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R93	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R94	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R95	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R96	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R97	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R98	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R99	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R100	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R101	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R102	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R103	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A4R104	0757-0278		RESISTOR 1.78K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1781-F
A4R105	0757-0438		RESISTOR 5.11K 1% .125W F TC=0+-100	24546	C4-1/8-T0-5111-F
A4U1	5080-1821		IC, LIN OP. AMP. FET-INPUT	28480	5080-3821
A4U2	1820-0493	2	IC LM307N	27014	LM307N
A4U3	1820-0493		IC LM307N	27014	LM307N
A4U4	1820-1104	1	IC:DGTL TD 2005P 15V M-S JK F-F	28480	1820-1104
A4U5	1820-0056	3	IC SN74 92 N	01295	SN7492N
A4U6	1820-0600	3	IC DM85L 90N	27014	DM74L90N
A4U7	1820-0600		IC DM85L 90N	27014	DM74L90N
A4U8	1820-0600		IC DM85L 90N	27014	DM74L90N
A4U9	1820-0056		IC SN74 92 N	01295	SN7492N
A4U10	1820-0054		IC SN74 00 N	01295	SN7400N
A4U11	1820-0068		IC SN74 10 N	01295	SN7410N
A4U12	1820-0054		IC SN74 00 N	01295	SN7400N
A4U13	1820-0261	1	IC SN74 121 N	01295	SN74121N
A4U14	1820-0054		IC SN74 00 N	01295	SN7400N
A4U15	1820-0075	4	IC SN74 73 N	01295	SN7473N
A4U16	1820-0054		IC SN74 00 N	01295	SN7400N
A4U17	1820-0075		IC SN74 73 N	01295	SN7473N
A4U18	1820-0056		IC SN74 92 N	01295	SN7492N
A4U19	1820-0511		IC SN74 08 N	01295	SN7408N
A4U20	1820-0054		IC SN74 00 N	01295	SN7400N

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A4U21	1820-0054		IC SN74 00 N	01295	SN7400N
A4U22	1820-0372	1	IC SN74H 11 N	01295	SN74H11N
A4U23	1820-0511		IC SN74 08 N	01295	SN7408N
A4U24	1820-0054		IC SN74 00 N	01295	SN7400N
A4U25	1820-0068		IC SN74 10 N	01295	SN7410N
A4U26	1820-0068		IC SN74 10 N	01295	SN7410N
A4U27	1820-0055	3	IC SN74 90 N	01295	SN7490N
A4U28	1820-0055		IC SN74 90 N	01295	SN7490N
A4U29	1820-0055		IC SN74 90 N	01295	SN7490N
A4U30	1820-0075		IC SN74 73 N	01295	SN7473N
A4U31	1820-0075		IC SN74 73 N	01295	SN7473N
A4U32	1820-0301	4	IC SN74 75 N	01295	SN7475N
A4U33	1820-0301		IC SN74 75 N	01295	SN7475N
A4U34	1820-0301		IC SN74 75 N	01295	SN7475N
A4U35	1820-0301		IC SN74 75 N	01295	SN7475N
A4U36	1820-0054		IC SN74 00 N	01295	SN7400N
A4U37	1820-0995	4	IC SN74 47AN	01295	SN7447AN
A4U38	1820-0995		IC SN74 47AN	01295	SN7447AN
A4U39	1820-0995		IC SN74 47AN	01295	SN7447AN
A4U40	1820-0995		IC SN74 47AN	01295	SN7447AN
A4XA1	1251-2034		CONNECTOR; PC EDGE; 15-CONT; DIP SOLDER	71785	252-10-30-300
A4XA2	1251-2035	1	CONNECTOR; PC EDGE; 15-CONT; DIP SOLDER	71785	252-15-30-300
A4XA3	1251-2026		CONNECTOR; PC EDGE; 18-CONT; DIP SOLDER	71785	252-18-30-300
A4XA4	1251-3076		CONNECTOR; PC EDGE; 18-CONT; EXTENDER	71785	251-18-30-300
A4Y1	0410-0207	1	CRYSTAL;2.88 MHZ	28480	0410-0207
A5	04282-77205	1	BOARD ASSEMBLY, DISPLAY	28480	04282-77205
A5DS1	1990-0102	4	NUMERICAL DISPLAY;SOLID STATE	28480	1990-0102
A5DS2	1990-0102		NUMERICAL DISPLAY;SOLID STATE	28480	1990-0102
A5DS3	1990-0102		NUMERICAL DISPLAY;SOLID STATE	28480	1990-0102
A5DS4	1990-0102		NUMERICAL DISPLAY;SOLID STATE	28480	1990-0102
A5DS5	1990-0101	1	DISPLAY MINUS OVER RANGE, SOLID STATE	28480	1990-0101
A5DS6	2140-0129	13	LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS7	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS8	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS9	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS10	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS11	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS12	5082-5462	1	LED LAMP	28480	5082-5462
A5DS13	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS14	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS15			NOT ASSIGNED		
A5DS16			NOT ASSIGNED		
A5DS17	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS18	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS19	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS20	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5DS21	2140-0129		LAMP;INCD T-1 BULB 5V 20MA	28480	2140-0129
A5R1	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A5R2	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A5R3	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A5R4	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A5R5	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A5R6	0698-3427	3	RESISTOR 13.3 1% .125W F TC=0+-100	03888	PME55-1/8-T0-13R3-F
A5R7	0698-3427		RESISTOR 13.3 1% .125W F TC=0+-100	03888	PME55-1/8-T0-13R3-F
A5R8	0698-3427		RESISTOR 13.3 1% .125W F TC=0+-100	03888	PME55-1/8-T0-13R3-F
A5R9	0698-4421		RESISTOR 249 1% .125W F TC=0+-100	16299	C4-1/8-T0-249R-F
A5R10	0698-3430		RESISTOR 21.5 1% .125W F TC=0+-100	03888	PME55-1/8-T0-21R5-F
A5U1	1820-0577	2	IC SN74 16 N	01295	SN7416N
A5U2	1820-0577		IC SN74 16 N	01295	SN7416N
			A5 MISCELLANEOUS		
	04271-50042	1	LAMP HOUSE, 9-ROOM	28480	04271-50042
	04282-80021	1	FILM, DISPLAY UNIT	28480	04282-80021
	04282-80022	1	FILM, DISPLAY ANNUNCIATOR	28480	04282-80022
A6	04282-77206	1	BOARD ASSEMBLY, SWITCH	28480	04282-77206
			A6 MISCELLANEOUS		
	5020-3440	4	SPRING, DETENT	28480	5020-3440
	5040-0292	2	GUIDE, SLIDE SWITCH	28480	5040-0292
	5060-4802	2	SWITCH, SLIDE ASSEMBLY	28480	5060-4802
	5060-4803	2	SLIDE SWITCH ASSEMBLY (4-ROW)	28480	5060-4803
	04282-50021	1	GUIDE, SLIDE SWITCH	28480	04282-50021

See introduction to this section for ordering information

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A7	04282-77237	1	BOARD ASSEMBLY, LEAKAGE (OPTION 001)	28480	04282-77207
A7C1	0180-0990	2	CAPACITOR;FXD 33 UF 250VDC AL ELECT	28480	0180-0990
A7C2	0180-0990		CAPACITOR;FXD 33 UF 250VDC AL ELECT	28480	0180-0990
A7C3	0180-0981	1	CAPACITOR;FXD 22 UF 160VDC AL ELECT	28480	0180-0981
A7C4	0160-2204		CAPACITOR-FXD 100PF +-5% 300WVDC MICA	28480	0160-2204
A7C5	0160-2218	1	CAPACITOR-FXD 1000PF +-5% 300WVDC MICA	28480	0160-2218
A7C6	0160-0963	1	CAPACITOR-FXD 2.2UF +100-0% 3WVDC CER	28480	0160-0963
A7C7	0160-3501	1	CAPACITOR-FXD 4UF +-10% 50WVDC MET POLYC	28480	0160-3501
A7C8	0180-2318		CAPACITOR-FXD 650UF +-20% 13VDC TA-WET	56289	109D657X0020T2
A7C9	0180-0228		CAPACITOR-FXD, 22UF+-10% 15VDC TA-SOLID	56289	150D226X9015B2
A7C10	0180-0098	2	CAPACITOR-FXD; 100UF+-20% 20VDC TA	56289	150D107X0020S2
A7C11	0180-0098		CAPACITOR-FXD; 100UF+-20% 20VDC TA	56289	150D107X0020S2
A7CR1	1901-0230	6	DIODE;SI	28480	1901-0230
A7CR2	1901-0230		DIODE;SI	28480	1901-0230
A7CR3	1901-0230		DIODE;SI	28480	1901-0230
A7CR4	1901-0230		DIODE;SI	28480	1901-0230
A7CR5	1902-0574	2	DIODE-ZNR 64.9V 5% DO-15 PD=1W TC=+.083%	04713	SZ 11213-374
A7CR6	1902-0574		DIODE-ZNR 64.9V 5% DO-15 PD=1W TC=+.083%	04713	SZ 11213-374
A7CR7	1902-3059		DIODE-ZNR 3.83V 5% DO-7 PD=.4W TC=-.051%	04713	SZ 30939-62
A7CR8	1902-3097	1	DIODE-ZNR 5.23V 2% DO-7 PD=.4W TC=-.005%	12954	DZ7307I2C
A7CR9	1901-0025	6	DIODE-GEN PRP 100V 200MA	28480	1901-0025
A7CR10	1901-0230		DIODE;SI	28480	1901-0230
A7CR11	1901-0230		DIODE;SI	28480	1901-0230
A7CR12	1901-0053	2	DIODE-GEN PRP 30V 150MA	28480	1901-0053
A7CR13	1901-0053		DIODE-GEN PRP 30V 150MA	28480	1901-0053
A7CR14	1901-0025		DIODE-GEN PRP 100V 200MA	28480	1901-0025
A7CR15	1901-0025		DIODE-GEN PRP 100V 200MA	28480	1901-0025
A7CR16	1901-0025		DIODE-GEN PRP 100V 200MA	28480	1901-0025
A7CR17	1901-0025		DIODE-GEN PRP 100V 200MA	28480	1901-0025
A7CR18	1901-0025		DIODE-GEN PRP 100V 200MA	28480	1901-0025
A7K1	0490-0875		RELAY; 12VDC; CONT 2A 30VDC FORM 2C	28480	0490-0875
A7K2	0490-0226		RELAY; REED	28480	0490-0226
A7K3	0490-0226		RELAY; REED	28480	0490-0226
A7K4	0490-0226		RELAY; REED	28480	0490-0226
A7K5	0490-0226		RELAY; REED	28480	0490-0226
A7Q1	1854-0330	1	TRANSISTOR NPN SI PD=21W FT=10MHZ	28480	1854-0330
A7Q2	1854-0232	2	TRANSISTOR NPN SI TO-39 PD=1W FT=15MHZ	28480	1854-0232
A7Q3	1854-0071		TRANSISTOR NPN SI PD=300MW FT=200MHZ	28480	1854-0071
A7Q4	1854-0232		TRANSISTOR NPN SI TO-39 PD=1W FT=15MHZ	28480	1854-0232
A7Q5	1853-0036		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
A7Q6	1855-0020	1	TRANSISTOR J-FET N-CHAN D-MODE TO-18 SI	28480	1855-0020
A7Q7	1853-0036		TRANSISTOR PNP SI PD=310MW FT=250MHZ	28480	1853-0036
A7R1	0812-0071	1	RESISTOR 1K 5% 2W PW TC=0+-20	01686	T2B
A7R2	0698-3400	1	RESISTOR 147 1% .5W F TC=0+-100	24546	NA6
A7R3	0757-0198	1	RESISTOR 100 1% .5W F TC=0+-100	19701	MF7C1/2-T0-101-F
A7R4	0811-1203	1	RESISTOR 68 5% 2W PW TC=0+-20	56289	240E68R5
A7R5	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R6	0757-0460	1	RESISTOR 61.9K 1% .125W F TC=0+-100	24546	C4-1/8-T0-6192-F
A7R7	0757-0984	1	RESISTOR 10 1% .5W F TC=0+-100	19701	MF7C1/2-T0-10R0-F
A7R8	0698-4431	1	RESISTOR 2.05K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2051-F
A7R9	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R10	0698-3158	1	RESISTOR 23.7K 1% .125W F TC=0+-100	16299	C4-1/8-T0-2372-F
A7R11	0757-1094		RESISTOR 1.47K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1471-F
A7R12	0683-1055	1	RESISTOR 1M 5% .25W FC TC=-800/+900	01121	CB1055
A7R13	0698-3157	1	RESISTOR 19.6K 1% .125W F TC=0+-100	16299	C4-1/8-T0-1962-F
A7R14	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R15	0698-3152	1	RESISTOR 3.48K 1% .125W F TC=0+-100	16299	C4-1/8-T0-3481-F
A7R16	0683-5605		RESISTOR 56 5% .25W FC TC=-400/+500	01121	CB5605
A7R17	0757-0416		RESISTOR 511 1% .125W F TC=0+-100	24546	C4-1/8-T0-511R-F
A7R18	0757-0280		RESISTOR 1K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1001-F
A7R19	0698-2231		RESISTOR;FXD 900K OHM 0.1% 1/8W MF	28480	0698-2231
A7R20	0698-2225		RESISTOR;FXD 90.0K OHM 0.05% 1/8W MF	28480	0698-2225
A7R21	0698-2213		RESISTOR;FXD 9.00K OHM 0.05% 1/8W MF	28480	0698-2213
A7R22	0698-2207		RESISTOR;FXD 900 OHM 0.05% 1/8W MF	28480	0698-2207
A7R23	0698-2206	1	RESISTOR;FXD 100 OHM 0.05% 1/8W MF	28480	0698-2206
A7R24	2100-1210		RESISTOR, VAR TRMR 10K OHM	28480	2100-1210
A7R25	0757-0420		RESISTOR 750 1% .125W F TC=0+-100	24546	C4-1/8-T0-751-F
A7R26	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R27	2100-1984	1	RESISTOR-VAR TRMR 100 OHM 10% C TOP ADJ	84048	170-101
A7R28	0698-4125		RESISTOR 953 1% .125W F TC=0+-100	16299	C4-1/8-T0-953R-F
A7R29	0757-0422	1	RESISTOR 909 1% .125W F TC=0+-100	24546	C4-1/8-T0-909R-F
A7R30	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
A7R31	2100-1210		RESISTOR, VAR TRMR 10K OHM	28480	2100-1210
A7R32	0698-4002	1	RESISTOR 5K 1% .125W F TC=0+-100	16299	C4-1/8-T0-5001-F
A7R33	0757-0465		RESISTOR 100K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1003-F
A7R34	0698-3441		RESISTOR 215 1% .125W F TC=0+-100	16299	C4-1/8-T0-215R-F
A7R35	0698-3441		RESISTOR 215 1% .125W F TC=0+-100	16299	C4-1/8-T0-215R-F
A7R36	0757-0199		RESISTOR 21.5K 1% .125W F TC=0+-100	24546	C4-1/8-T0-2152-F
A7R37	0698-4511		RESISTOR 86.6K 1% .125W F TC=0+-100	24546	C4-1/8-T0-8662-F
A7R38	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
A7R39	0698-3429	2	RESISTOR 19.6 1% .125W F TC=0+-100	03888	PME55-1/8-T0-19R6-F
A7R40	0698-3429		RESISTOR 19.6 1% .125W F TC=0+-100	03888	PME55-1/8-T0-19R6-F
A7U1	1820-0058	1	IC AMPLIFIER	07263	709HC
A7U2	1826-0136		IC:LIN OP. AMPL. FET-INPT	28480	1826-0136
A7U3	1820-0216		IC AMPLIFIER	28480	1820-0216
A7U4	1820-0668		.C SN74 07 N	01295	SN7407N
A7XA1	1251-0472		CONNECTOR; PC EDGE; 6-CONT; DIP SOLDER	71785	252-06-30-300
			A7 MISCELLANEOUS		
	5040-3304	2	HOLDER	28480	5040-3304
	04350-1032	1	HEAT SINK	28480	04350-1032
			CHASSIS PARTS		
C1	0180-2352	1	CAPACITOR-FXD 6000UF +75-10% 15VDC AL	28480	0180-2352
DS1	1450-0132	1	LIGHT; IND; INCANDESCENT; RED TP LENS	72765	699-172 (RED)
F1	2110-0007	1	FUSE 1A 250V SLO-BLO 1.25X.25 (FOR 100-120VOLT LINE)	71400	MDL-1
F1	2110-0202	1	FUSE .5A 250V SLO-BLO 1.25X.25 IEC (FOR 220-240VOLT LINE)	75915	313.500S
F2	2110-0001	1	FUSE 1A 250V NORM-BLO 1.25X.25 IEC	71400	AGC-1
J1	1250-0315	2	CONNECTOR	28480	1250-0315
J2	1251-0917	1	JACK:EAR-PHONE	28480	1251-0917
J3	1250-0315		CONNECTOR	28480	1250-0315
J4	04282-77254	4	PART OF W4	28480	04282-77254
J5	04282-77254		PART OF W7	28480	04282-77254
J6	1510-0084	2	BINDING POST-SGL 6-32 JGK/RED THD STUD	28480	1510-0084
J7	1510-0084		BINDING POST-SGL 6-32 JGK/RED THD STUD	28480	1510-0084
J7	1510-0087	1	BINDING POST-SGL 6-32 JGK/BLK THD STUD	28480	1510-0087
J8	1510-0076	1	BINDING-POST; SINGLE;6-32;JGK;SGL TU	28480	1510-0076
J8	1510-0087	1	BINDING POST-SGL 6-32 JGK/BLK THD STUD	28480	1510-0087
J9	5060-9409	1	LINE MODULE WITH FILTER, JADE GRAY	28480	5060-9409
J10	1250-0083	1	CONNECTOR-RF BNC FEM SGL HOLE FR	24931	28JR-130-1
Q1	1854-0063	1	TRANSISTOR NPN 2N3055 SI TO-3 PD=115W	28480	1854-0063
R1	2100-3040	1	RESISTOR-VAR W/SW 100K 10% SPST-SW	28480	2100-3040
R2	2100-1223	1	RESISTOR,VAR 2 X 10K 20% LIN CC	28480	2100-1223
R3	0757-0442		RESISTOR 10K 1% .125W F TC=0+-100	24546	C4-1/8-T0-1002-F
R4	0811-1657	1	RESISTOR 400 5% 5W PW TC=0+-20	07088	KM-500
R5	0698-3404	1	RESISTOR 383 1% .5W F TC=0+-100	24546	NA6
S1	3101-1258	1	SWITCH-TGL SUBMIN SPDT NS 2A 250VAC	09353	7101-I
S2			PART OF R1		
S3	3101-0112	1	SWITCH; PB 1-STA CYL SPDT	82389	933
S4	3101-0956	1	SWITCH-TGL SUBMIN 3PDT NS 3A 115VAC SLDR	28480	3101-0956
S5	3101-0255	1	SWITCH	28480	3101-0255
T1	9100-0830	1	TRANSFORMER:POWER	28480	9100-0830
T2	9100-0829	1	TRANSFORMER:OUTPUT	28480	9100-0829
W1	04282-72001	1	CABLE ASSY, MAIN	28480	04282-72001
W2	04282-77251	1	CABLE ASSY, FLEXIBLE PC	28480	04282-77251
W3	04282-77252	1	CABLE ASSY, FLEXIBLE PC	28480	04282-77252
W4	04282-77254		CABLE ASSY, FLEXIBLE PC (INCLUDES J4)	28480	04282-77254
W5	04282-77253	1	CABLE ASSY, FLEXIBLE PC	28480	04282-77253
W6	04282-72031	1	CABLE ASSY, LEAKAGE (INCLUDES J5)	28480	04282-72031
W7	04282-77254		CABLE ASSY, FLEXIBLE PC	28480	04282-77254
W8	04282-72006	1	CABLE ASSY, MEASURING SIGNAL	28480	04282-72006
W9	04282-.2005	1	CABLE ASSY, LINE	28480	04282-72005
W10	8120-1378	1	CABLE CA ASSY 3-COND 18AWG	28480	8120-1378
XF1	1400-0084	1	FUSEHOLDER-EXTR POST 15A 250V UL	28480	1400-0084
			MISCELLANEOUS PARTS		
	0340-0732	12	INSULATOR, BDG POST, SINGLE .14 ID.	28480	0340-0732
	0370-1097	2	KNOB; BASE; PTR; .5 IN; JGK; SGI DECAL	28480	0370-1097
	0380-0200	8	STANDOFF-HNGD .875-LG 6-32-THD .25-OD	30897	SERIES HS-200-Z
	1200-0077	1	INSULATOR:TRANSISTOR, MICA	18037	#112
	1490-0033	1	PULLEY:DRIVE 3/4" OD X 5/32" DIA SHAFT	28480	1490-0033

See introduction to this section for ordering information

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Table 6-2. Replaceable Parts (Cont'd).

Reference Designation	HP Part Number	Qty	Description	Mfr Code	Mfr Part Number
	5000-0050	2	TRIM:SIDES	28480	5000-0050
	5060-0730	2	FRAME ASSY:3 X 16	28480	5060-0730
	[illegible]0-0767	5	FOOT ASSY:FM	28480	5060-0767
	[illegible]-8739	1	KIT:RACK MOUNT 3H	28480	5060-8739
	[illegible]-0307	1	LAVEL;POWER MODULE	28480	7120-0307
	7120-0461	1	PLATE:SERIAL	28480	7120-0461
	03480-04107	2	COVER, SIDE B	28480	03480-04107
	04282-10032	1	COVER, TOP	28480	04282-10032
	04271-10028	1	COVER, BOTTOM	28480	04271-10028
	04282-10021	1	PANEL, FRONT (YHP)	28480	04282-10021
	04282-10022	1	PANEL, FRONT (HP)	28480	04282-10022
	04282-10023	1	PANEL, SUB, FRONT	28480	04282-10023
	04282-10024	1	PANEL, REAR	28480	04282-10024
	04282-10026	1	PLATE, WINDOW GUIDE	28480	04282-10026
	04282-50022	1	WINDOW, DISPLAY	28480	04282-50022
	04282-50024	4	PROTECTOR, MOLD	28480	04282-50024
	04282-80023	1	FILM "NO" DISPLAY	28480	04282-80023
			(DELETE WHEN OPTION 001 IS FURNISHED)		

See introduction to this section for ordering information

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Table 6-3. Manufacturers Code List.

Mfr. No.	Manufacturer Name	Adress	Zip Code
01121	ALLEN BRADLEY CO	MILWAUKEE WI	53212
01295	TEXAS INSTR INC SEMICOND CMPNT DIV	DALLAS TX	75231
01686	RCL ELECTRONICS INC	MANC[illegible]ESTER NH	03102
02735	RCA CORP SOLID STATE DIV	SOM[illegible]VILLE NJ	08876
03888	PYROFILM CORP	WH[illegible]NY NJ	07981
04713	MOTOROLA SEMICONDUCTOR PRODUCTS	PHO[illegible]IX AZ	85008
07088	KELVIN ELECTRIC CO	VAN NUYS CA	91401
07263	FAIRCHILD SEMICONDUCTOR DIV	MOUNTAIN VIEW CA	94040
09353	C AND K COMPONENTS INC	WATERTOWN MA	02172
12954	DICKSON ELECTRONICS CORP	SCOTTSDALE AZ	85252
16037	SPRUCE PINE MICA CO	SPRUCE PINE NC	28777
16299	CORNING GL WK ELEC CMPNT DIV	RALEIGH NC	27604
19701	MEPCO/ELECTRA CORP	MINERAL WELLS TX	76067
20940	MICRO-OHM CORP	EL MONTE CA	91731
24226	GOWANDA ELECTRONICS CORP	GOWANDA NY	14070
24546	CORNING GLASS WORKS (BRADFORD)	BRADFORD PA	16701
24931	SPECIALTY CONNECTOR CO INC	INDIANAPOLIS IN	46227
27014	NATIONAL SEMICONDUCTOR CORP	SANTA CLARA CA	95051
28480	HEWLETT-PACKARD CO CORPORATE HQ	PALO ALTO CA	94304
30897	DORANN CO THE	SYLMAR CA	91342
32293	INTERSIL INC	CUPERTINO CA	95014
32997	BOURNS INC TRIMPOT PROD DIV	RIVERSIDE CA	92507
56289	SPRAGUE ELECTRIC CO	NORTH ADAMS MA	01247
71400	BUSSMAN MFG DIV OF MCGRAM-EDISON CO	ST LOUIS MO	63017
71590	CENTRALAB ELEK DIV GLOBE-UNION INC	MILWAUKEE WI	53201
71785	TRW ELEC COMPONENTS CINCH DIV	ELK GROVE VILLAGE IL	60007
72136	ELECTRO MOTIVE MFG CO INC	WILLIMANTIC CT	06226
72765	DRAKE MFG CO	HARWOOD HEIGHTS IL	60656
75042	TRW INC PHILADELPHIA DIV	PHILADELPHIA PA	19108
75915	LITTLEFUSE INC	DES PLAINES IL	60016
82389	SWITCHCRAFT INC	CHICAGO IL	60630
84048	TRW INC ST PETERSBURG DIV	ST PETERSBURG FL	33702
86684	RCA CORP ELECTRONIC COMPONENTS	HARRISON NJ	07029
91637	DALE ELECTRONICS INC	COLUMNBUS NE	68601

SECTION VII
MANUAL CHANGES AND OPTIONS

7-1. OPTIONS.

7-2. Options are standard modifications performed on -hp- instruments at the factory. Option 001 for Leakage Current Measurements is a currently available option. Operating instructions and other option 001 information are covered in manual corresponding to that for standard instrument.

7-3. SPECIAL INSTRUMENTS.

7-4. "Specials" are standard -hp- instruments that are modified according to customer specifications. A separate insert sheet is included with the manual for special instruments having electrical changes. Make the changes specified in addition to any other changes that are necessary.

7-5. MANUAL CHANGES.

7-6. This manual applies direcly to the Model 4282A with serials prefixed 1515. The following paragraphs explain how to adapt this manual to apply to later instruments with higher serial prefix, or earlier instruments with 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.

7-7. LATER INSTRUMENT: If the serial prefix of your Model 4282A is above 1515, refer to a separate "Manual Changes" sheet supplied with this manual. Locate the serial prefix of your instrument and make the indicated changes.

7-8. EARLIER INSTRUMENTS.
(Backdating Changes):
If the serial prefix of your Model 4282A is below 1515, refer to Table 7-1 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 7-1. Manual Backdating Changes.

Serial Prefix or Number	Make Changes
1319J00170 and below	1

CHANGE 1

Page 6-2, Table 6-2,
A1: Change to HP Part No. 04262-77201; BOARD ASSY:OSCILLATOR.

Pages 6-2 thru 6-4, Table 6-2,
Delete following parts,

A1C29 thru C33, R109 thru R120 and U13 thru U15.

Add following parts,

A1C24: HP Part No. 0180-01C6; CAPACITOR:FXD 60µF ±20% 6VDC TA-SOLID.
A1C25: HP Part No. 0180-0374; CAPACITOR:FXD 10µF ±10% 20VDC TA SOLID.
A1CR29 thru C32: HP Part No. 1901-0040; DIODE SWITCHING SI 30V MAX VRM 50MA.
A1K13 and K14: HP Part No. 0490-0226; RELAY REED.
A1Q11: HP Part No. 1853-0051; TRANSISTOR:PNP SI.
A1Q12 and Q13: HP Part No. 1854-0071; TRANSISTOR:NPN SI.
A1R64: HP Part No. 2100-2655; RESISTOR:VAR TRMR 100kΩ 10% C.
A1R73 and R74: HP Part No. 0686-2045; RESISTOR:FXD 200kΩ5% .5W CC TUBULAR.
A1R75: HP Part No. 0698-4406; RESISTOR:FXD 115Ω 1% .125W F.
A1R76: HP Part No. 0698-3454; RESISTOR:FXD 215kΩ 1% .125W F TUBULAR.
A1R77: HP Part No. 0698-3460; RESISTOR:FXD 422kΩ 1% .125W F TUBULAR.
A1R78 and R81: HP Part No. 0757-0453; RESISTOR:FXD 30.1kΩ 1% .125W F TUBULAR.
A1R79 and R82: HP Part No. 0757-0467; RESISTOR:FXD 121kΩ 1% .125W F TUBULAR.
A1R80: HP Part No. 0757-0444; RESISTOR:FXD 12.1kΩ 1% .125W F TUBULAR.
A1U10: HP Part No. 1826-0092; IC:LIN OP. AMPL DUAL.

Page 6-3, Table 6-2 and page 8-11, Figure 8-6,
Delete A1CR50 and CR51.

Page 6-3, Table 6-2,
A1K7: Change to HP Part No. 0490-0226; RELAY REED.

Page 6-4, Table 6-2,
A1R62: Change to HP Part No. 0698-2218; RESISTOR:FXD 33.5kΩ 1% .125W MET FLM.
A1R63: Change to HP Part No. 2100-2216; RESISTOR:VAR 5kΩ ±10% .5W CER.
A1R88: Change to HP Part No. 2100-2060; RESISTOR:VAR 50Ω 20% CER.

Page 8-13, Figure 8-7,
Change Figure 8-7 partially as shown in Figure 7-1.

Page 8-11, Figure 8-6 (in Table of Active Components),
Delete CR50 and 51; 1902-3059.
Change Q10 to 1854-0071

Page 8-13, Figure 8-7 (in Table of Active Components),
Add Q11; 1853-0051, Q12 and Q13; 1854-0071, U10; 1826-0092, CR29 thru 32; 1901-0040.

Page 6-5, Table 6-2,
A2: Change to HP Part No. 04262-77202; BOARD ASSY:MULTIPLIER.

Page 6-6, Table 6-2,
A2CR15: Change to HP Part No. 1902-0184; DIODE:VREG 16.2V VZ .4W MAX.

Page 6-8, Table 6-2,
A2R74: Change to HP Part No. 0757-0199; RESISTOR:FXD 21.5kΩ 1% .125W F TUBULAR.
A2R75: Change to HP Part No. 0698-3454; RESISTOR:FXD 215kΩ 1% .125W F TUBULAR.

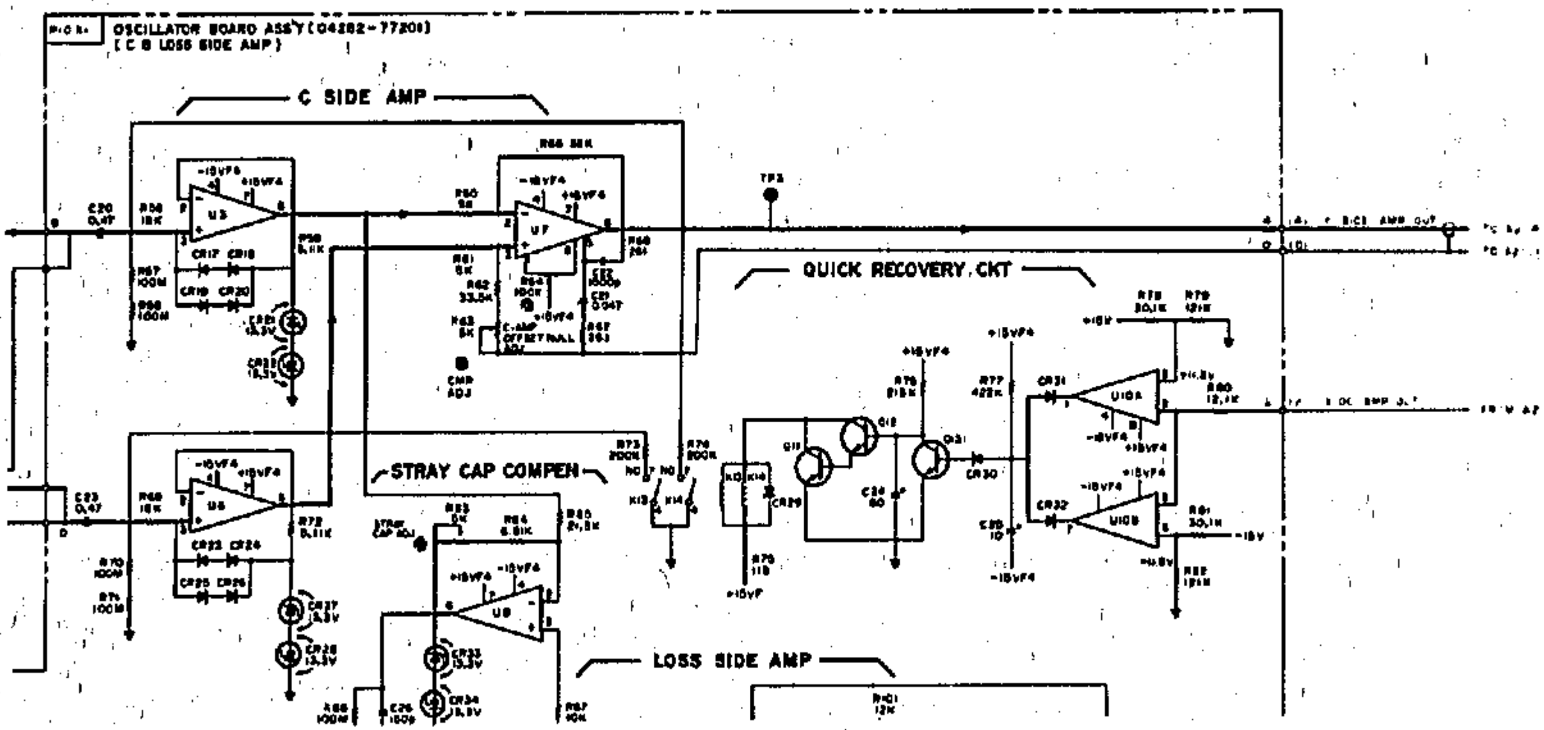
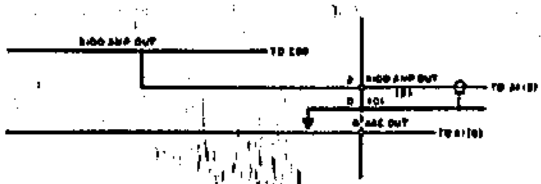

OSCILLATOR BOARD ASS'Y (04282-77201)
(C & LOSS SIDE AMP)
C SIDE AMP
QUICK RECOVERY CKT
STRAY CAP COMPEN
LOSS SIDE AMP
TP3

Figure 7-1.

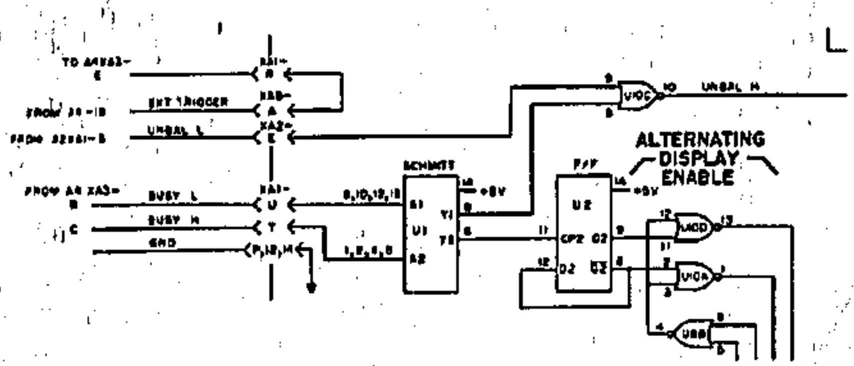
Page 8-15, Figure 8-8,
Change Figure 8-8 partially as follows:



Page 8-15, Figure 8-8 (in Table of Active Components),
CR15: Change to 1902-0184.

Page 6-10, Table 6-2,
A3: Change to HP Part No. 04282-77203; BOARD ASSY:CONTROL.

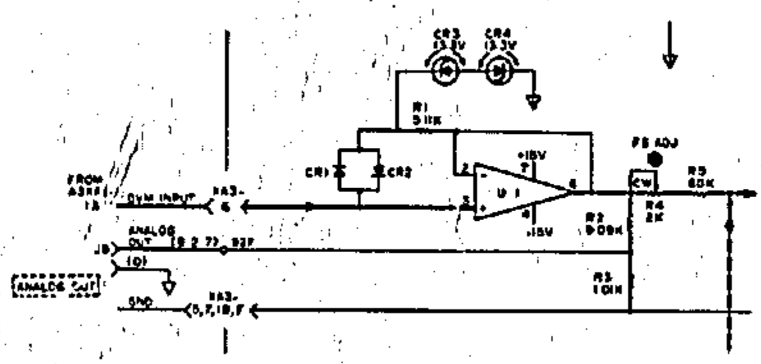
Page 8-21, Figure 8-11,
Change Figure 8-11 partially as follows:



Page 8-21, Figure 8-11 (in Table of Active Components),
Delete CR26.

Pages 6-12 through 6-14, Table 6-2,
A4: Change to HP Part No. 04282-77204; BOARD ASSY:DVM.
A4R58: Change to HP Part No. 0698-4431; RESISTOR:FXD 2.05kΩ 1% .125W F TUBULAR.
Delete following parts,
A4CR11, Q17, R104 and R105.

Page 8-29, Figure 8-15,
Change Figure 8-15 partially as follows:



Page 5-13, paragraph 5-54,
Replace with following paragraphs.

5-54. High Capacitance Ranges Adjustment (A1, A2).

5-55. This adjustment uses a standard capacitor (SOSHIN TM 520-C). Proceed as follows:

a. Set 4282A to same as paragraph 5-31 step a except set C RANGE to 10mF.

b. Set SOSHIN TM 520-C to 10mF.

c. Connect 16035A Test Leads to UNKNOWN connector.

d. Twist two current leads with each other (at lead five times) and also twist the two voltage lead together (see paragraph 3-34) and connect to SOSHIN TM-520-C.

e. Adjust 4282A display for certified 10mF capacitance value with A1R88 (10mF Range Adj.).

f. Set C RANGE and SOSHIN TM 520-C to 1F.

g. Adjust 4282A display for certified 1F capacitance value with A2R10 (1F Full-Scale Adj.).

Page 8-31, Figure 8-16,
Change Figure 8-16 partially as shown in Figure 7-2.

Page 8-31, Figure 8-16 (in Table of Active Components),
Delete CR11 and Q17.

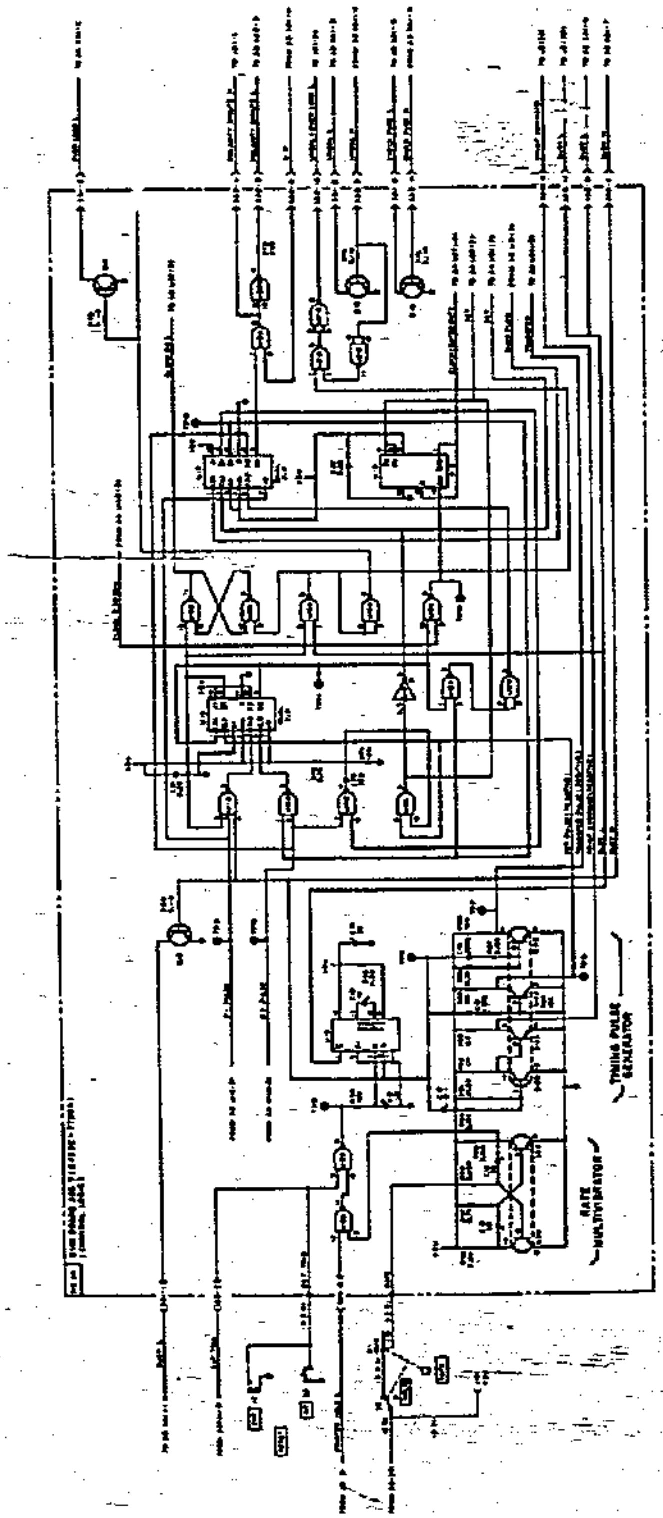


Figure 7-2.

SECTION VIII
CIRCUIT DIAGRAMS

8-1. INTRODUCTION.

8-2. This section includes the following:

a. General Notes for Schematic Diagrams.

b. Block Diagram.

c. Schematic Diagrams and part location illustrations.

d. Circuit Operations.

8-3. The Block Diagram or schematic diagrams can be unfolded and used with any other portion of the manual.

Resistance is in ohms, capacitance is in microfarads and inductance is in microhenries unless otherwise noted.

P/O = part of.

* Asterisk denotes a factory-selected value. Value shown is typical. Capacitors may be omitted or resistors jumpered.

L or H after signal name means the line goes to low or high level, respectively, when the signal is enabled.

R G (RELAY GROUND) or OPEN after signal name means the line is grounded or open, respectively, when the signal is enabled.

	Screwdriver adjustment.		Panel control.
	Encloses front panel designations.		Encloses rear panel designation.
	AND gate.		NAND gate.
	OR gate.		NOR gate.
	Exclusive OR gate.		Operational amplifier.
	Non-inverting.		Inverting.
	Assembly circuit common.		Floating circuit common.
	Chassis ground.		Protective ground.

Figure 8-1. Schematic Diagram Notes (sheet 1 of 2).

Circuit assembly borderline.

Other assembly borderline.

Heavy line with arrows indicates path and direction of main signal.

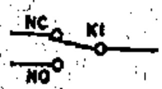
Heavy dashed line with arrows indicates path and direction of main feedback.

Wiper moves toward CW with clockwise rotation of control as viewed from shaft or knob.

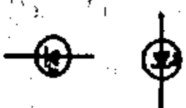
Shows location and number of test point.

(9-4-7) Encloses wire color code. Code used (MIL-STD-681) is the same as resistor color code. First number identifies the base color, second number the wider stripe, and third number identifies narrower stripe (e.g., 947 denotes white base, yellow wide stripe and violet narrow stripe).

A1 (5) Shows square pin number used in circuit assembly [e.g., A1(5) denotes pin 5 in A1 assembly].



Indicates NC are normally closed contacts and NO are narmally open contacts when relay K1 is not energized.



Voltage regulator (breakdown diode).

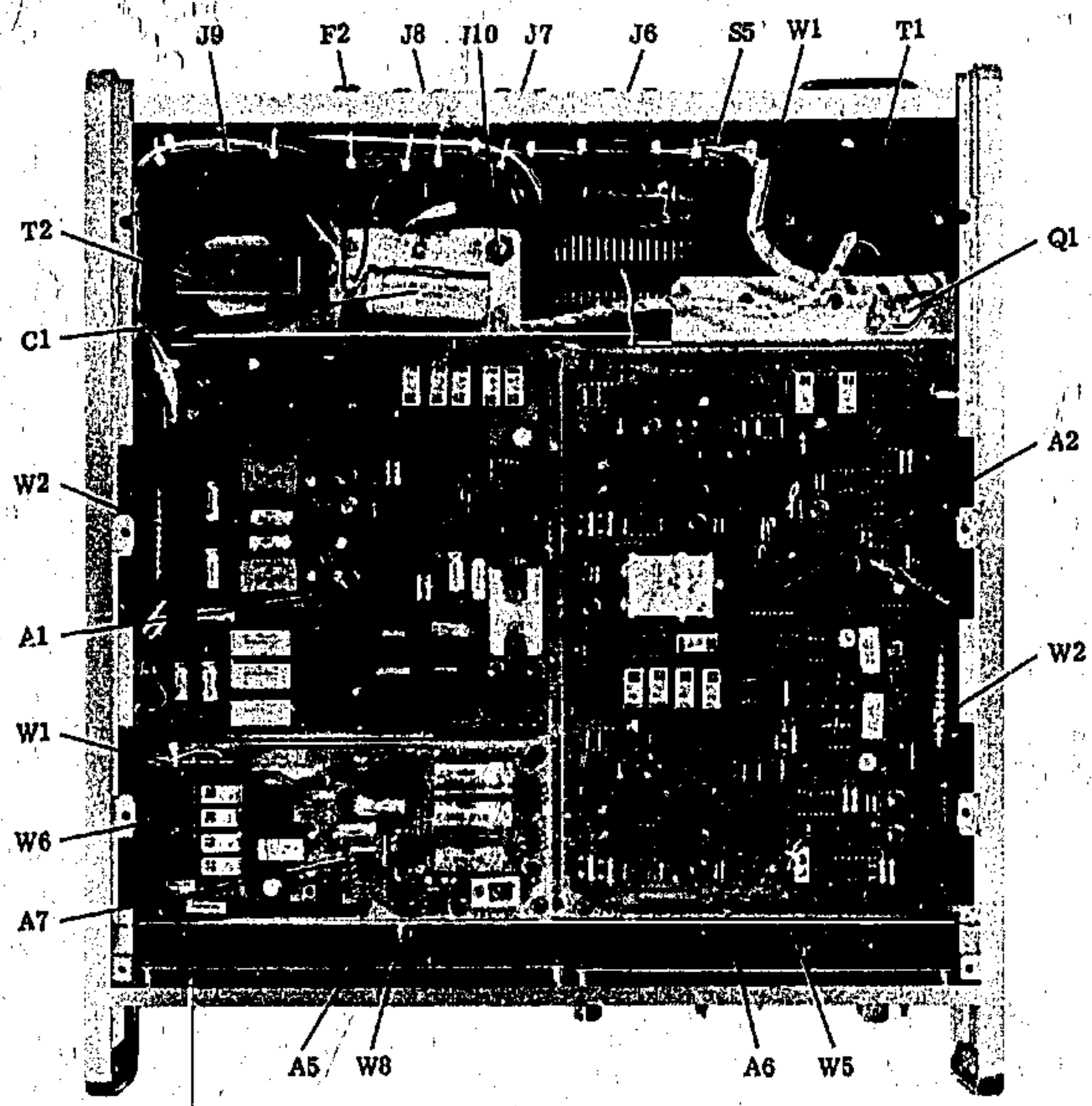
Field Effect transistor (FET) with N-type base.

FET with P-type base.

Tunnel diode.

Light emitting diode (LED).

Figure 8-1. Schematic Diagram Notes (sheet 2 of 2).



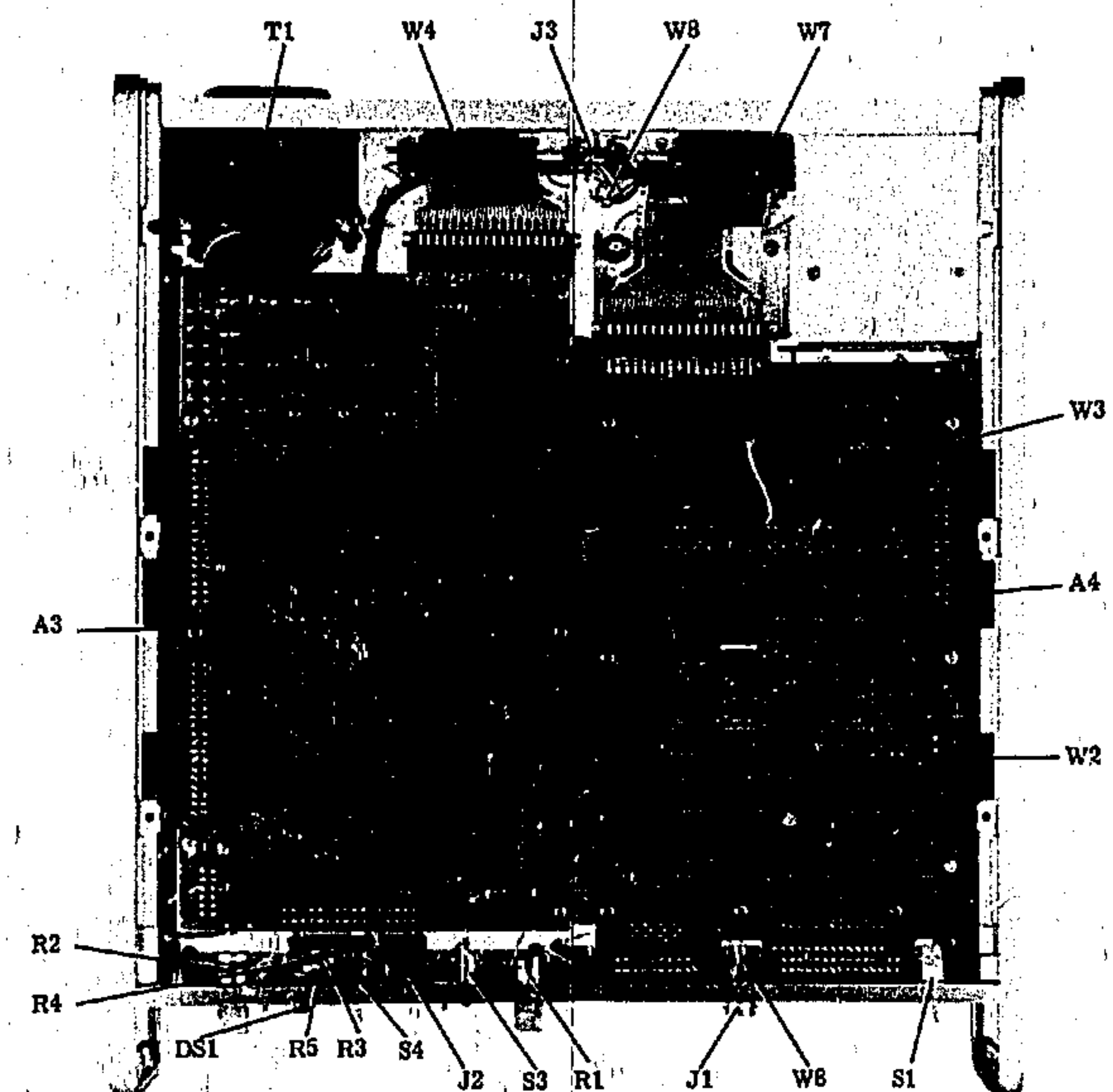


Figure 8-2. Assembly Location.

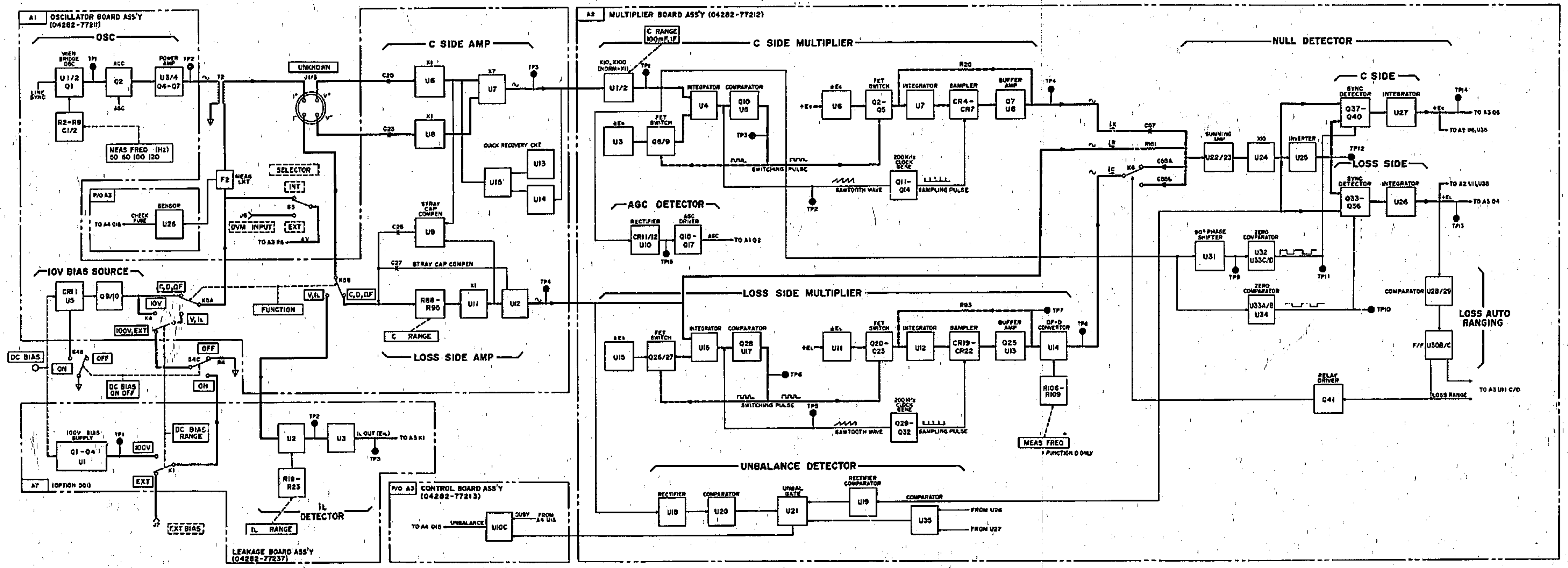


Figure 8-3. Block Diagram - Bridge Section.

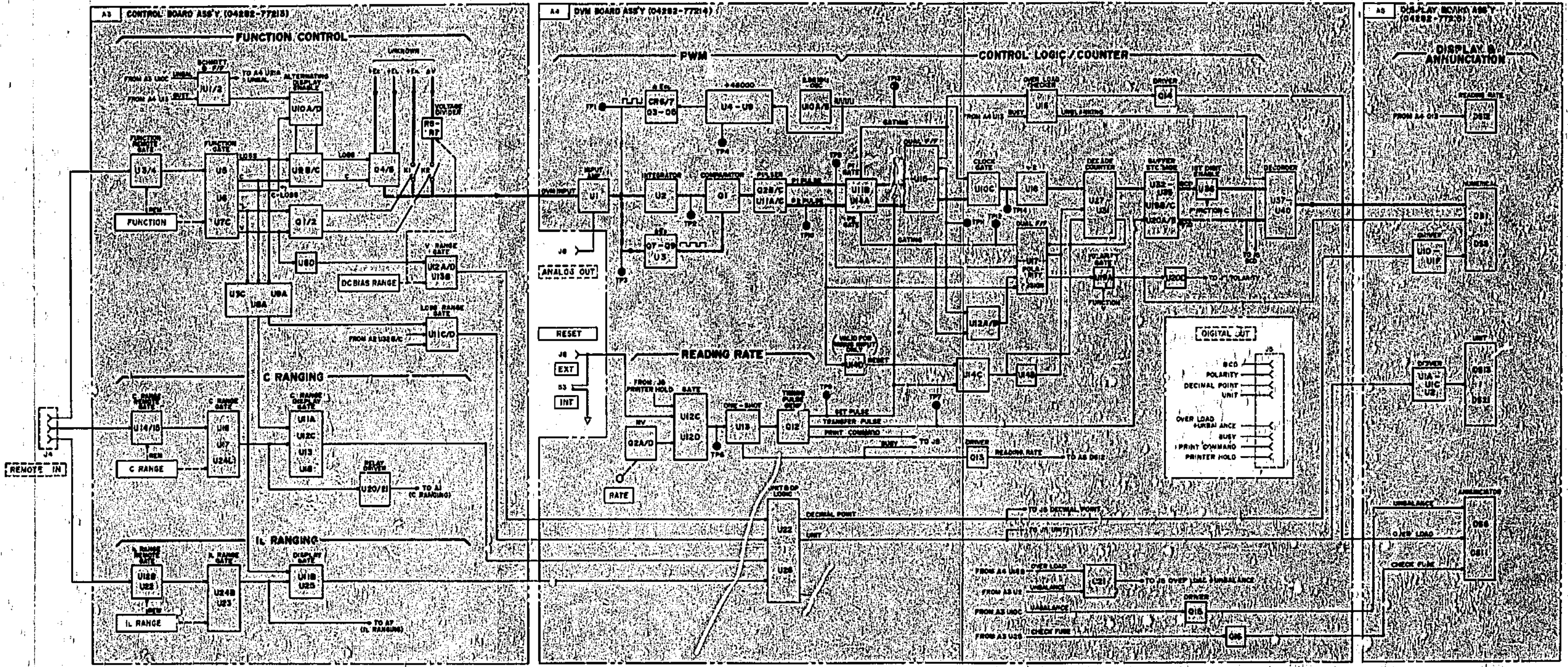


Figure 8-4. Block Diagram - Logic Section.

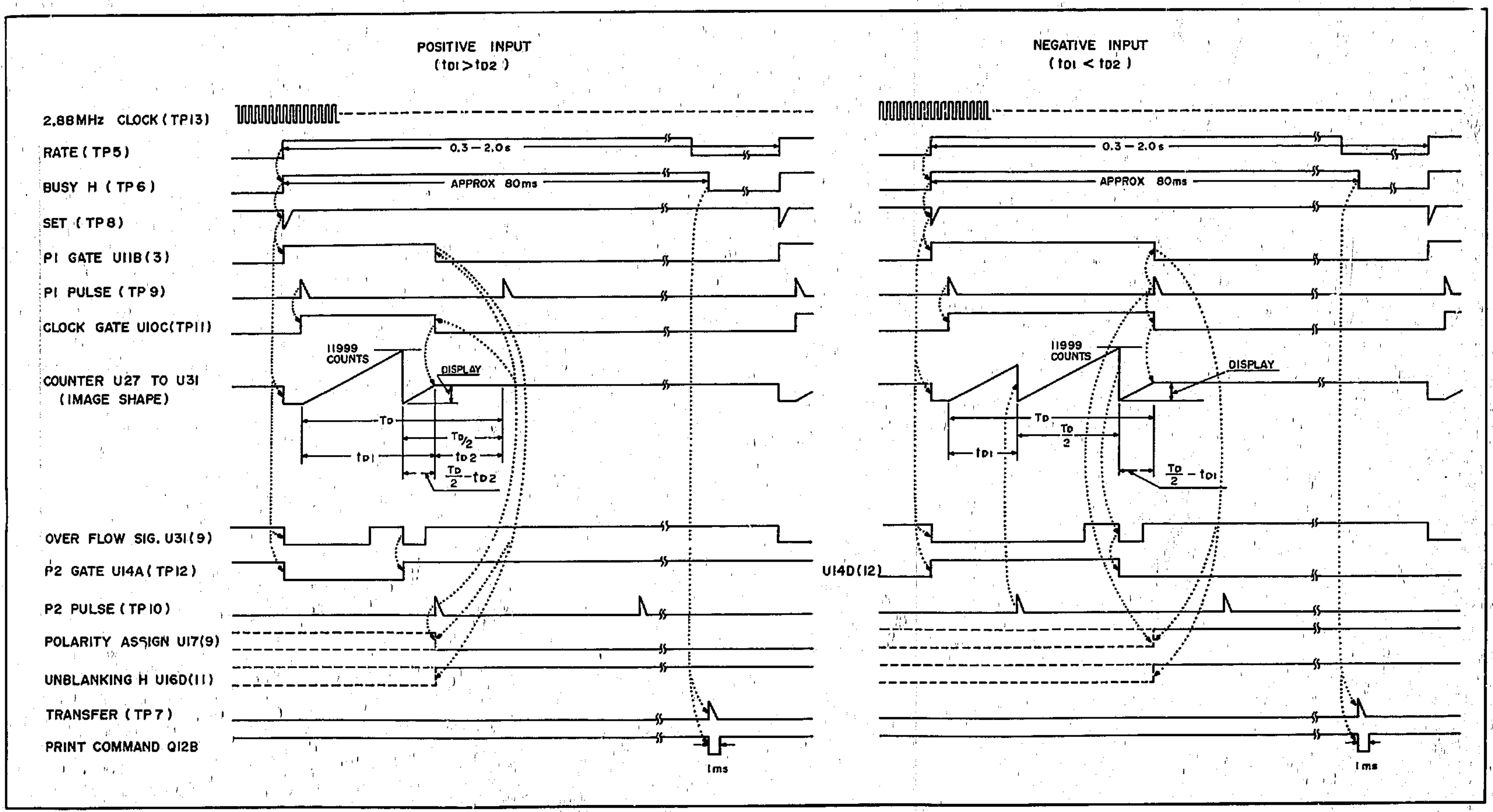
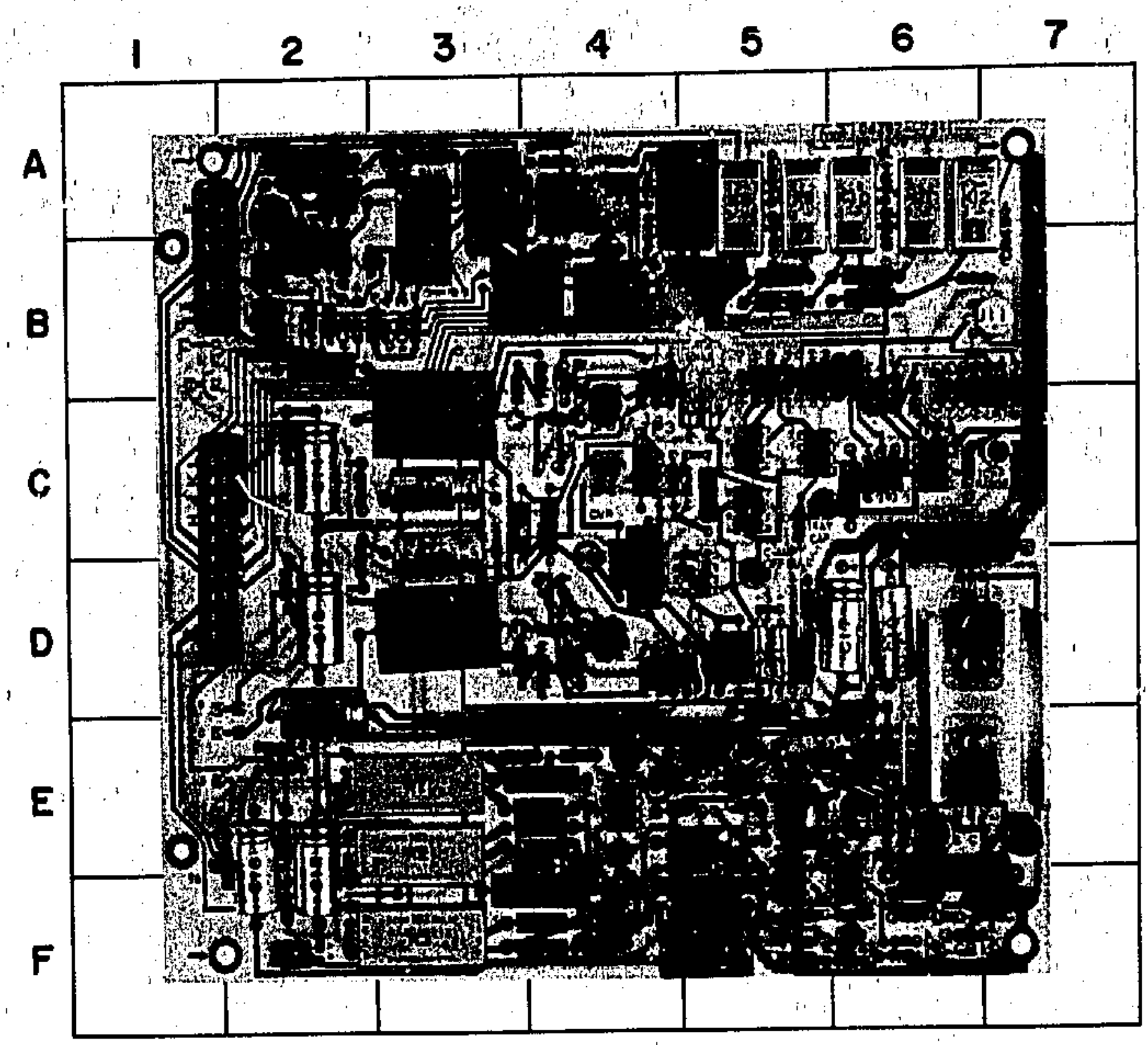


Figure 8-5. DVM Timing Diagram.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.
C1	F-5
C2	F-5
C3	E-5
C4	E-5
C5	F-5
C6	E-5
C7	E-5
C8	F-7
C9	B-2
C10	D-6
C11	E-5
C12	E-2
C13	E-2

Ref. Desig.	Grid. Loc.
C14	C-2
C15	C-3
C16	E-2
C17	D-6
C18	D-2
C19	C-3
CR1	E-2
CR2	E-2
CR3	F-3
CR4	E-5
CR5	E-3
CR6	E-5
CR7	F-6

Ref. Desig.	Grid. Loc.
CR8	F-6
CR9	F-6
CR10	F-6
CR11	B-2
CR12	A-2
CR13	B-3
CR14	B-3
CR15	B-2
CR16	B-2
CR50	F-2
CR51	F-2
K1	E-3
K2	E-3

Ref. Desig.	Grid. Loc.
K3	F-3
K4	A-3
K5	A-3
Q1	E-4
Q2	E-5
Q3	F-6
Q4	E-6
Q5	E-7
Q6	E-6
Q7	D-6
Q8	B-2
Q9	B-2

Ref. Desig.	Grid. Loc.
Q10	A-2
R1	F-2
R2	E-4
R3	E-4
R4	F-4
R5	F-5
R6	E-4
R7	E-4
R8	F-4
R9	F-4
R10	E-4
R11	E-4

Ref. Desig.	Grid. Loc.
R12	E-5
R13	F-4
R14	E-4
R15	E-4
R16	E-4
R17	E-5
R18	E-4
R19	E-4
R20	F-6
R21	F-6
R22	F-5
R23	F-5
R24	F-6

Ref. Desig.	Grid. Loc.
R25	E-6
R26	E-5
R27	E-6
R28	F-6
R29	E-6
R30	E-6
R31	F-6
R32	F-6
R33	F-6
R34	D-6
R35	B-2
R36	B-2
R37	A-2

Ref. Desig.	Grid. Loc.
R38	A-2
R39	B-2
R40	B-2
R41	B-3
R42	B-2
R43	B-3
R44	E-5
R45	E-6
R46	E-2
R47	E-2
R48	C-2
R49	C-2
R50	E-1

Ref. Desig.	Grid. Loc.
R51	E-2
R52	D-2
R53	D-2
U1	F-4
U2	E-4
U3	F-5
U4	F-6
U5	B-2
XA1	B-1
XA2	C-1

SEE INSIDE

Figure 8-5
DVM Timing Diagram

A1 OSCILLATOR BOARD OPERATION

Measuring Signal Generator.

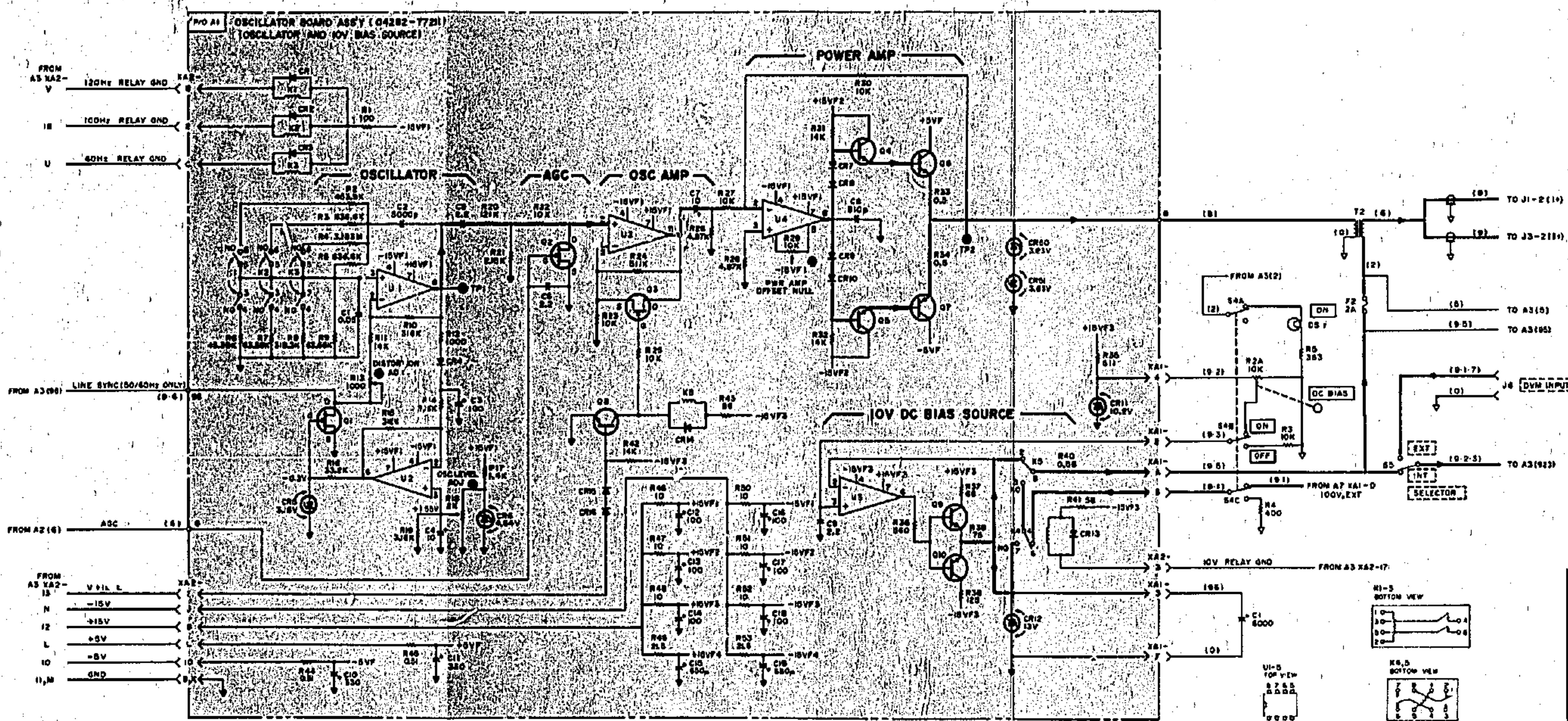
This section is the signal source of Bridge and consists of an oscillator, amplifier and power amplifier. The oscillator employs the Wien Bridge technique and provides four measuring frequencies of 50, 60, 100 and 120Hz. Selection and determination of frequency are done by relays K1, K2 and K3 which select R2 through R9 in combination with C1 and C2. FET Q1 is driven by U2 whose input is difference between Peak Detector CR4 output and reference voltage established by CR6. Q1 operates to maintain voltage ratio at U1(2) at one twenty first of voltage at U1(6) (because, for example, C1 is ten times of C2, R9 is one tenth of R5 at 50Hz setting, and so on). Output at U1(6) can be changed or maintained by potentiometer R18. When MEAS FREQ switch is set to 50 or 60Hz, line synchronous signal is applied to Q1 drain to synchronize frequency to line frequency.

AGC(Q2) only operates when C range is set to 100mF or 1F. On these two ranges, range is determined not by changing range resistances but by increasing amplifier A2U1, U2 gain from 1 to 10 or to 100. Amplifiers could be saturated depending upon unknown values. To prevent this, appropriate AGC signals reduce measuring signal level. Amplifier U3 amplifies oscillator signal to furnish sufficient drive to Power Amplifier. Both Q2 and Q3 turn on when function is set to V or I_L (option 001) which operate to extinguish oscillator signal. The Power Amplifier, which is comprised of U4 and Q4 through Q7, has unity gain and the capability to feed maximum signal current of about 660mA (equivalent to 1A) through transformer T2 which has a turns ratio of three to two. Q4, Q6 and Q5, A7 form a complementary push-pull circuit.

10V DC Bias Source.

A 10 volts DC Bias Source is provided by reference diode CR11, differential amplifier U5 and power amplifier Q9 and Q10. Bias voltage is controlled by DC BIAS control R2A. Maximum current is about 100mA.

A1 Parts Locations under Fold



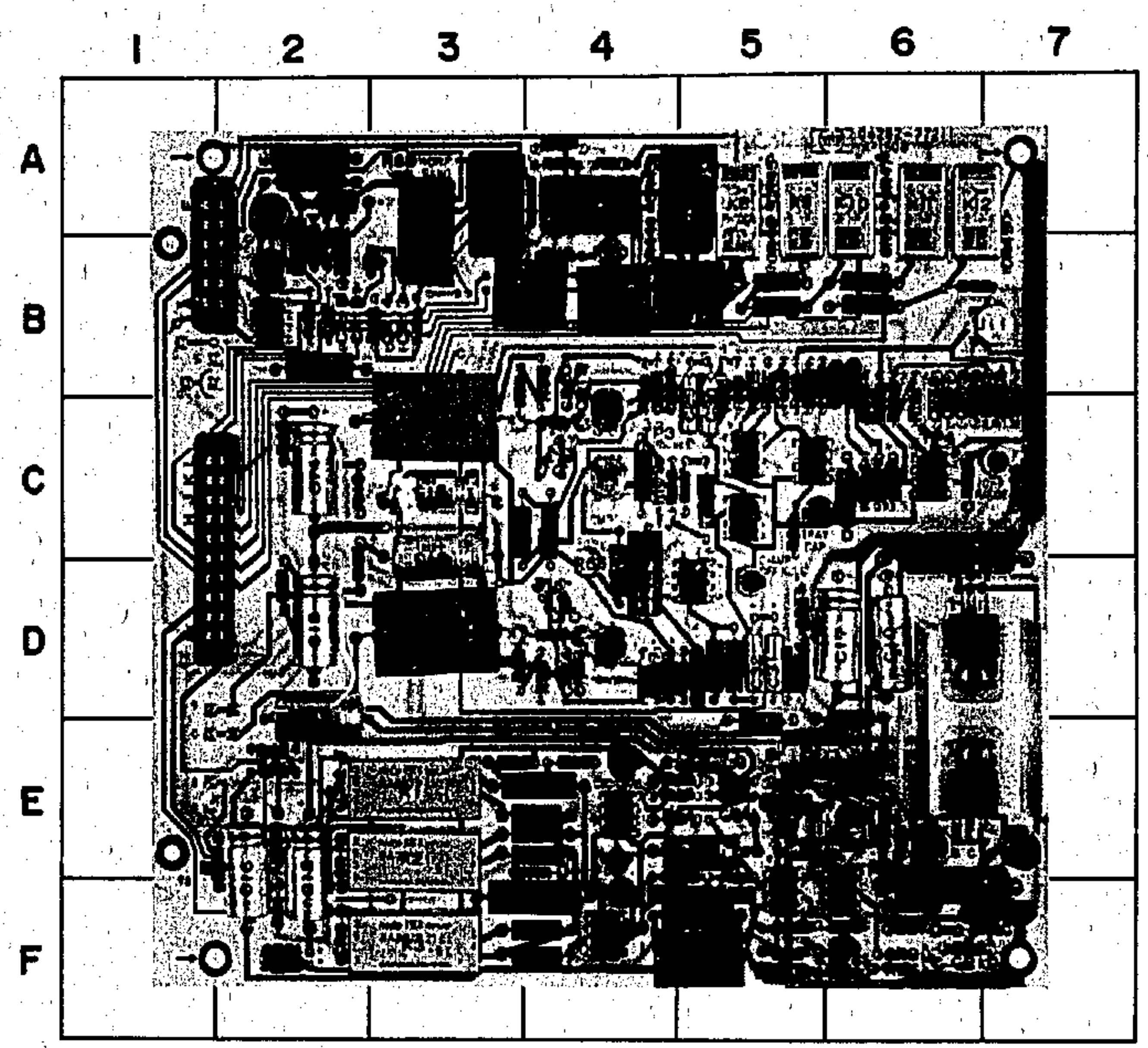
Reference Designations

NO PREFIX	A1
C1 DS1 F2 J6 R2 - 5 S4, 5 T2	C1 - 19 CR1 - 16, 60, 61 K1 - 5 Q1 - 10 R1 - 53 U1 - 5 XA1, 2

Table of Active Components.

Reference Designations	HP Part Number
A1	
CR1 - 4, 7 - 10	1901-0040
CR13 - 16	1901-0040
CR5	1902-3036
CR60, 61	1902-3059
CR6	1902-3082
CR11	1902-3183
CR12	1902-0643
Q1	1855-0087
Q2, 3	1855-0081
Q4, 9	1854-0090
Q5	1853-0051
Q6	1854-0127
Q7	1853-0106
Q8	1853-0020
Q10	1853-0051
U1 - 5	1820-0216

Figure 8-6. A1 Oscillator Board Ass'y (Oscillator and 10V Bias Source)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C20	C-3	CR20	B-4	CR34	D-5	CR48	A-6	Q11	D-5	R63	D-5	R78	B-5	R92	B-5	R107	B-5
C21	D-5	CR21	C-4	CR35	B-6	CR49	B-7	Q12	D-5	R64	B-4	R79	B-5	R93	B-5	R108	A-3
C22	C-5	CR22	C-4	CR36	B-7			Q13	D-5	R66	C-4	R80	B-5	R94	B-6		
C23	D-3	CR23	D-4	CR37	B-6	K5	A-3			R67	D-5	R81	B-5	R95	B-6	U6	C-4
C24	D-5	CR24	D-4	CR38	B-6	K6	A-4	R43	B-3	R68	C-5	R82	B-5	R96	B-7	U7	C-5
C25	D-5	CR25	D-4	CR39	B-7	K7	A-5	R54	A-4	R69	D-4	R83	C-5	R97	B-7	U8	D-4
C26	B-6	CR26	D-4	CR40	B-7	K8	A-5	R55	A-4	R70	D-3	R84	C-5	R98	B-6	U9	C-5
C27	B-6	CR27	D-4	CR41	C-6	K9	A-5	R56	C-4	R71	D-4	R85	B-5	R99	B-6	U10	C-5
C28	C-6	CR28	D-4	CR42	C-6	K10	A-6	R57	C-3	R72	D-4	R86	B-5	R100	B-6	U11	B-7
		CR29	D-4	CR43	A-4	K11	A-6	R58	B-4	R73	D-3	R87	B-5	R101	B-6	U12	C-6
CR14	B-3	CR30	D-5	CR44	B-4	K12	A-7	R59	B-4	R74	C-3	R88	A-3	R103	C-6		
CR17	C-4	CR31	C-5	CR45	A-5	K13	C-4	R60	C-5	R75	D-4	R89	B-4	R104	C-7	XA1	B-1
CR18	C-4	CR32	C-5	CR46	A-5	K14	C-4	R61	D-5	R76	C-5	R90	B-4	R105	C-7		
CR19	B-4	CR33	D-5	CR47	A-6			R62	D-5	R77	C-5	R91	B-5	R106	C-6		

MEASURING CIRCUIT OPERATION

C, D, and ΩF Measurements.

Both UNKNOWN connectors J1 (front) and J3 (rear) each have the two current terminals and the two voltage terminals required for Four-Terminal operation. Measuring current from T2 appears at current terminal I^+ and flows through unknown to current terminal I^- into the range resistors in A1. Voltage terminals detect voltage across unknown and send it to C Side Amplifier in A1. When dc bias is superimposed, dc bias is fed from A1XA1-A and applied to unknown through T2. Quick action fuse F2 (2A) works to protect measuring circuit from excessive current. If fuse blows, measuring signal becomes input of Check Fuse Sensor in A3.

V (Voltage) Measurement.

When FUNCTION is set to V, voltage across unknown is connected to DVM Board (A4) through Control Board (A3). Both external input voltage and biasing voltages up to 600V are measureable. Selection is made with DVM INPUT SELECTOR switch S5.

I_L Measurement (Option 001).

When FUNCTION is set to I_L or V and DC BIAS ON-OFF switch S4 to ON, dc bias is fed from A1XA1-A and applied to unknown through current lead I^+. Leakage current through unknown is connected to A1XA1-6 and fed to Leakage Current Board (A7) through current lead I^-. A7 assembly converts this current to voltage. When S4 is set to OFF, discharge resistor R4 is connected to unknown.

SEE INSIDE

Figure 8-6
A1 Oscillator Board Ass'y
(Oscillator and 10V Bias Source)

A1 OSCILLATOR BOARD OPERATION
(C and Loss Side Amplifier Section).

C Side Amplifier.

The C side Amplifier contains two Impedance Converters U6 and U8 plus Amplifier U7. The impedance converters, whose inputs are connected to voltage terminals V^+ or V^-, provide high input impedance so as not to affect unknown. Amplifier U7 amplifies voltage across unknown seven times and sends an output opposite in phase to Multiplier Board A2. CR17 to CR22 and CR23 to CR28 form a protective circuit for large changes of dc bias. U13 to U15 provides negative feed back loop for stable dc offset nulling.

Loss Side Amplifier.

The Loss Side Amplifier includes C Range resistors R88 to R95, Impedance Converter U11 and Amplifier U12. Measuring signal goes to ground through current lead I^- and selected C Range Resistor. Impedance Converter U11 sends voltage across C Range resistor to Amplifier U12. U12 amplifies U11 output and provides an output in phase with measuring current which is sent to Multiplier Board A2.

Stray Capacitance Compensation Circuit.

Differential amplifier U9 and C26 compensate for stray capacitance between measuring leads and C27 compensates for stray capacitance of C Range Resistors.

A1 Part Locations under Fold

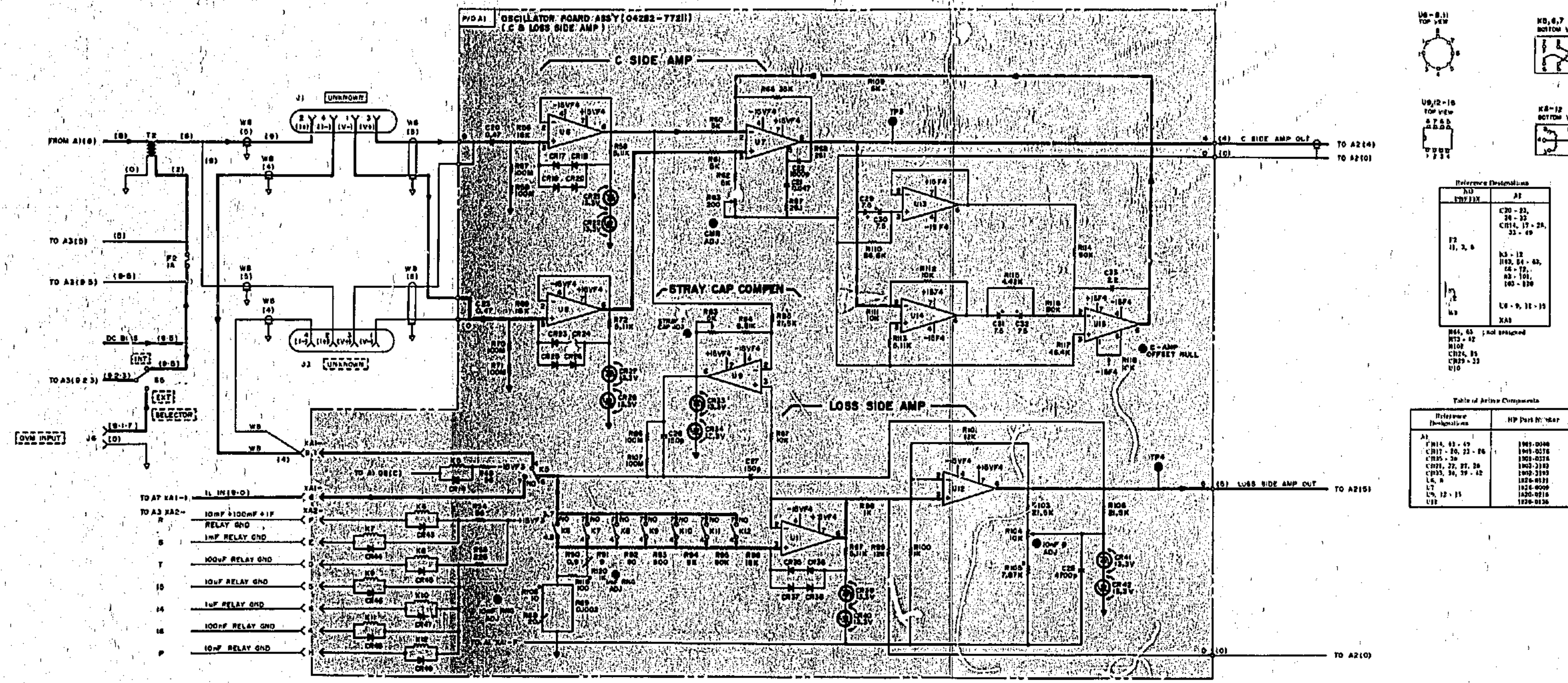
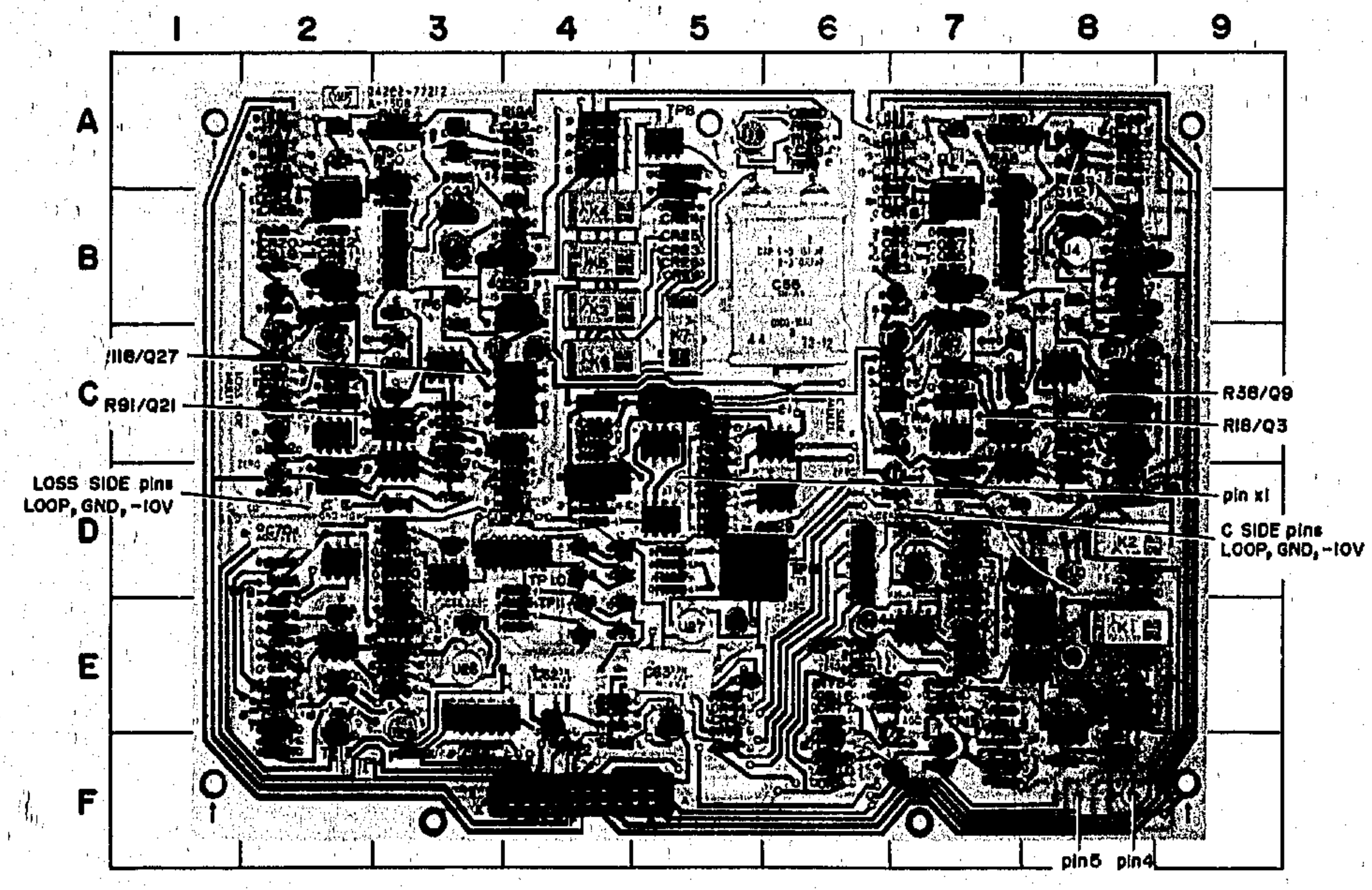


Figure 8-7. A1 Oscillator Board Ass'y.
(C & Loss Side Amp)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	E-8	Q4	C-7	R39	C-8
C2	D-7	Q5	C-7	R40	B-8
C3	B-7	Q6	C-6	R41	B-8
C4	C-7	Q7	B-6	R42	B-8
C5	B-7	Q8	B-8	R43	A-8
C6	D-8	Q9	B-8	R44	B-8
C7	D-8	Q10	B-8	R45	B-8
C8	C-2	Q11	A-7	R46	B-7
C9	B-8	Q12	A-7	R47	B-6
C10	B-8	Q13	A-8	R48	A-7
C11	A-8	Q14	A-8	R49	B-7
C12	B-8	Q15	E-7	R50	A-7
C13	B-6	Q16	F-6	R51	A-8
C14	B-7	Q17	F-7	R52	A-8
C15	A-7			R53	A-8
C16	A-6	R1	E-8	R54	C-8
C17	A-6	R2	D-8	R55	C-6
C18	C-8	R3	E-8	R56	B-8
C19	C-8	R4	E-8	R57	C-8
C20	C-6	R5	E-8	R58	C-6
C21	C-6	R6	E-8	R59	B-8
C22	B-8	R7	D-8	R60	F-8
C23	B-8	R8	E-8	R61	E-8
C24	D-8	R9	D-7	R62	F-8
C25	E-7	R10	D-8	R63	F-8
C26	F-7	R11	D-6	R64	E-7
C27	E-6	R12	D-6	R65	E-7
		R13	D-7	R66	F-7
CR1	E-8	R14	D-7	R67	E-7
CR2	E-8	R15	D-8	R68	F-7
CR3	D-8	R16	D-8	R69	E-7
CR4	B-6	R17	C-7	R70	E-6
CR5	B-7	R18	C-7	R71	E-6
CR6	B-6	R19	C-7	R72	E-6
CR7	B-7	R20	C-7	R73	E-6
CR8	C-8	R21	B-7	R74	E-6
CR9	F-6	R22	B-6	R75	E-6
CR10	F-6	R23	B-6	R76	F-6
CR11	E-8	R24	B-6		
CR12	E-8	R25	B-7	T1	B-7
CR13	E-7	R26	B-6		
CR14	E-7	R27	C-6	U1	E-7
CR15	E-6	R28	C-6	U2	D-7
CR16	E-6	R29	C-6	U3	C-8
CR17	E-6	R30	C-8	U4	B-8
CR13	B-6	R31	C-8	U5	B-7
		R32	C-8	U6	C-7
K1	E-8	R33	D-8	U7	C-7
K2	D-8	R34	C-8	U8	C-7
		R35	D-8	U10	E-8
Q1	D-7	R36	C-8		
Q2	B-7	R37	C-8	XA1	F-4
Q3	C-7	R38	C-8		

SEE INSIDE

Figure 8-7
A1 Oscillator Board Ass'y
(C & Loss Side Amp)

A2 MULTIPLIER BOARD OPERATION
(C Side Multiplier and AGC Detector Section).

C Side Multiplier.

The C Side Multiplier, shown in top section of schematic Figure 8-8, produces the product of C Side Amplifier output in A1 and C Side Integrator output (E_C) in A2. Amplifiers U1 and U2 (x10 and x100) have a gains of 1 below a C Range 10mF and increase their gains to 10 on 100mF range and to 100 on 1F range. U2 output is applied to integrator U4. The $\pm E_S$ Generator CR8 and U3 provide plus and minus references through R38 and R37, respectively. The $+E_S$ is switched by FET Switch Q8 and Q9 as U4 input goes to zero during one period of 200kHz clock. U4 output produces both positive and negative going ramps during one clock period. Changing of ramp polarity occurs at the same level of U4 output and sawtooth waveform of Q14 in 200kHz Clock Generator. This is sensed by Comparator Q10, which changes state of U5C and U5B whose output is connected to FET Switch Q8 and Q9 (to complete negative feedback loop) and also to FET switch Q2 to Q5. U5 is driven in negative domain to match action of FET Switches and provides a waveform modulated to pulse width by U2 output.

The $\pm E_C$ Generator U6 accepts C Side Integrator output ($+E_C$) and develops $-E_C$. Q1 is temperature compensator for U6. The $+E_C$ is connected to Integrator U7 through R17 and the $-E_C$ is connected to U7 through R18 and FET Switch Q2 to Q5 which is switched by timing from U5. U7 integrates the sum of these two inputs. U7 output through Q6 is sampled by applying sampling pulse issued at each end of sawtooth from T1 in 200kHz Clock Generator to Sampler (CR4 to CR7) and is stored in C5. Charge stored in C5 maintains input to Buffer Amplifier Q7 and U8. Therefore, U8 output forms staircase which is similar to and in phase with C Side Amp output in A1. Negative feedback loop through R20 operates to cancel result of previous integration. The heart of 200kHz Clock Generator is the Blocking Oscillator (Q11, T1 and CR18). This provides two outputs, one is sampling pulse of 10V peak at T1 (1-2) and the other is sawtooth at Q14 emitter.

AGC Detector.

AGC Detector, shown on bottom section of schematic Figure 8-8, provides a valid signal only when C Range is 100mF or 1F to reduce Oscillator signal level in A1 according to conditions of U1 and U2. On the other ranges, U2 output never exceeds about 7Vrms but on two ranges the 7Vrms may be exceeded which saturates U1 and U2 due to increased gain. Rectifier CR11 and CR12 and U10 rectifies U2 output and sends it to Smoothing Circuit and again to AGC Driver Q16. Q16 emitter level is normally negative and goes towards positive when U2 output increases. Q17 is on when Function is V or I_L to break out Oscillator signal in A1.

A2 Parts Locations under Fold

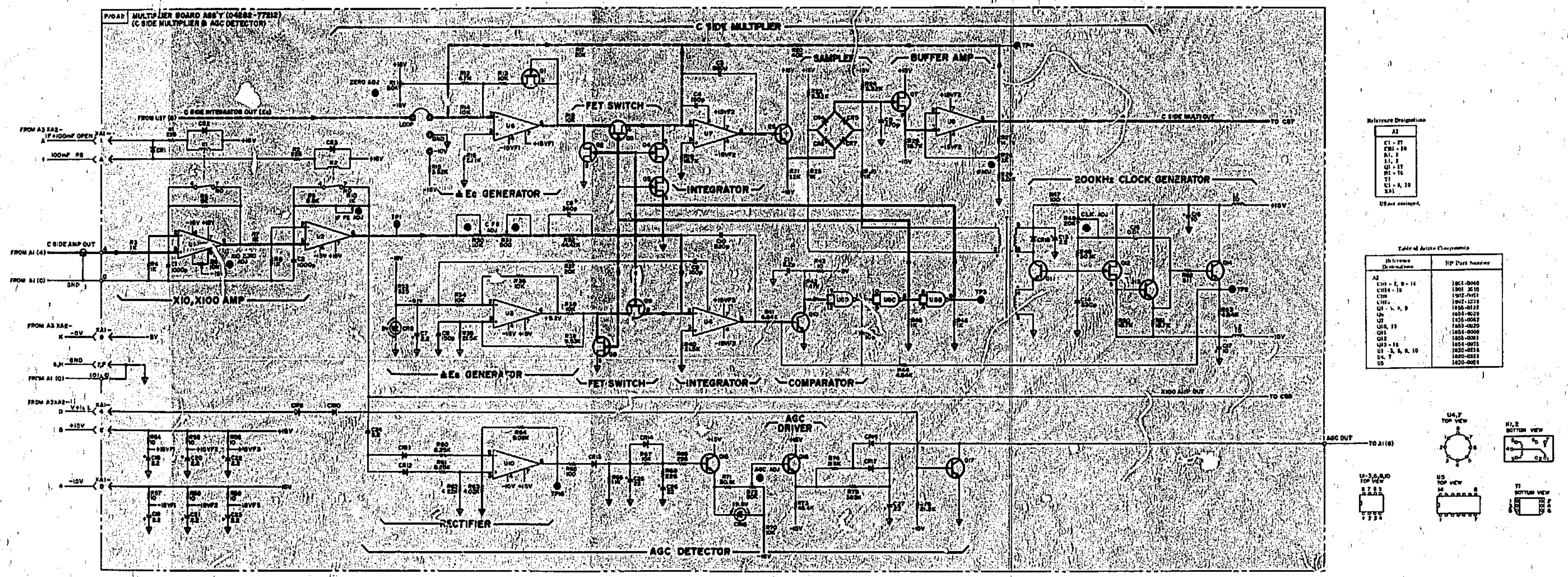
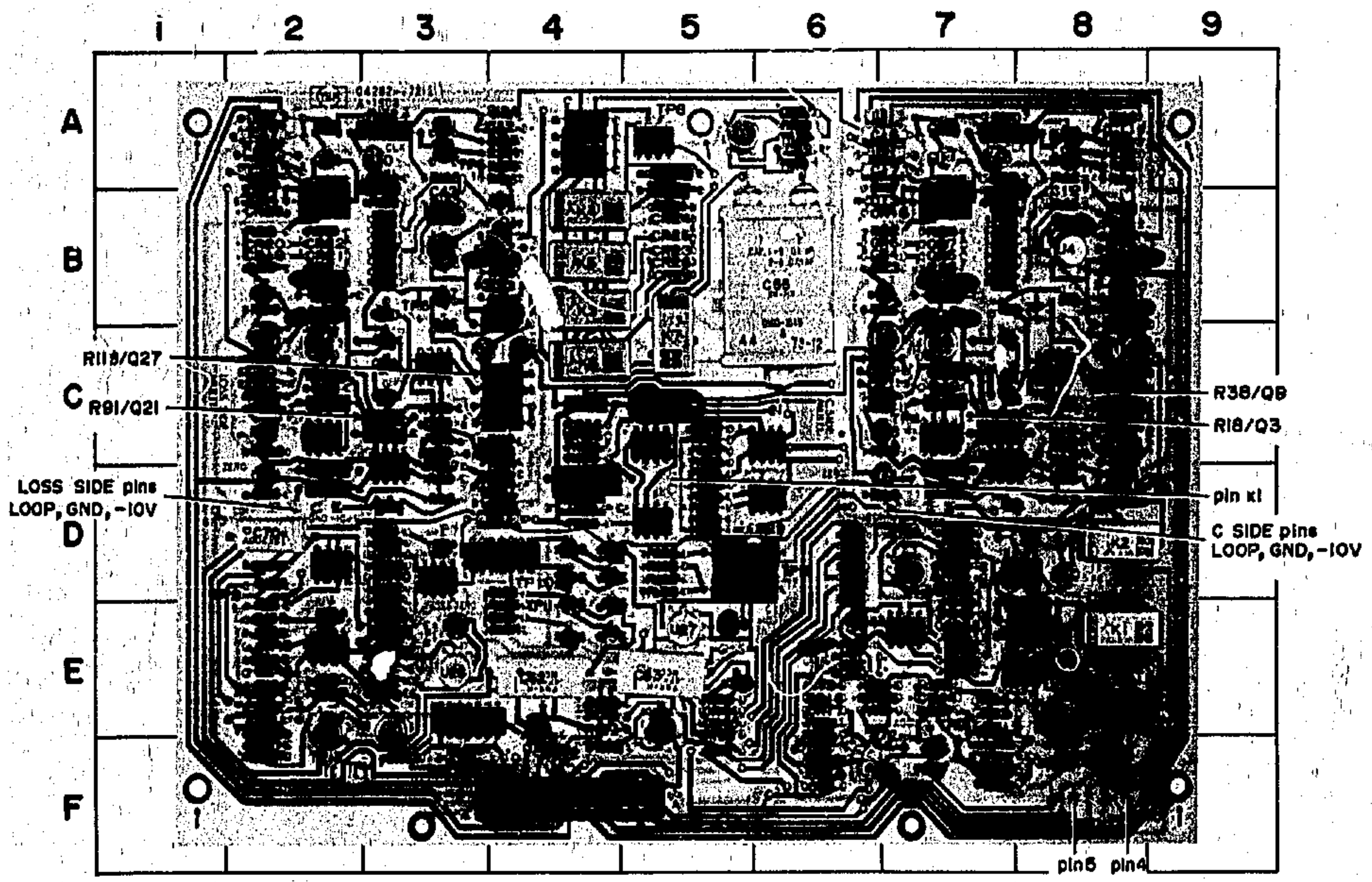


Figure 8-8. A2 Multiplier Board Ass'y.
(C Side Multiplier & AGC Detector)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C28	C-3	Q19	D-3	R115	C-4
C29	C-3	Q20	B-3	R116	C-4
C30	C-2	Q21	C-3	R117	C-3
C31	C-2	Q22	C-3	R118	C-4
C32	B-4	Q23	C-3	R119	C-4
C33	B-4	Q24	C-2	R120	B-4
C34	C-2	Q25	B-2	R121	C-4
C35	B-2	Q26	B-3	R122	B-4
C36	B-2	Q27	B-3	R123	D-4
C37	D-4	Q28	B-4	R124	A-4
C38	C-4	Q29	A-2	R125	A-3
C39	B-4	Q30	A-2	R126	A-4
C40	B-3	Q31	A-3	R127	B-3
C41	B-4	Q32	A-3	R128	B-3
C42	A-4			R129	B-2
C43	B-3	R77	E-5	R130	A-3
C44	B-2	R78	C-3	R131	A-3
C45	B-3	R79	C-3	R132	A-3
C46	A-3	R80	C-2	R133	A-4
C47	A-2	R81	C-2	R134	A-4
C48	A-2	R82	B-4	R135	A-4
C49	A-6	R83	B-4	R136	D-5
C50	E-6	R84	D-2	R137	D-5
C51	E-6	R85	D-3	R138	A-6
C52	D-7	R86	D-2	R139	A-6
C53	D-7	R87	D-2	R140	E-7
C54	E-6	R88	C-2	R141	E-6
		R89	D-3	R142	E-7
CR19	B-2	R90	C-3	R143	E-7
CR20	B-2	R91	C-3	R144	E-6
CR21	B-2	R92	C-2	R145	E-7
CR22	B-2	R93	C-2	R146	D-7
CR23	B-5	R94	B-2	R147	D-7
CR24	B-5	R95	B-2	R148	D-7
CR25	B-5	R96	B-2	R149	D-7
CR26	B-5	R97	B-2	R150	D-7
CR27	C-3	R98	B-2		
CR28	B-2	R99	B-2	T2	B-2
CR29	D-5	R100	C-2		
CR30	A-6	R101	C-2	U11	C-3
CR31	E-7	R102	C-2	U12	C-2
CR32	E-7	R103	E-5	U13	C-2
CR33	D-7	R104	B-5	U14	A-5
		R105	A-4	U15	C-3
K3	B-4	R106	A-4	U16	B-3
K4	B-4	R107	A-4	U17	B-3
K5	B-4	R108	A-4	U18	E-7
K6	C-4	R109	B-5	U19	A-5
		R110	A-6	U20	D-7
L3	A-2	R111	A-5	U21	D-6
L4	A-2	R112	C-4		
		R113	C-4	XA1	F-4
Q18	E-5	R114	C-4		

SEE INSIDE

Figure 8-8
A2 Multiplier Board Ass'y
(C Side Multiplier & AGC Detector)

A2 MULTIPLIER BOARD OPERATION
(Loss Side Multiplier and Unbalance Detector Section).

Loss Side Multiplier.

Loss Side Multiplier produces the product of Loss Side Integrator output (E_L) in A2 and Loss Side Amplifier output in A1. This operation is very similar to C Side Multiplier. Loss Side Amplifier output is sent to Integrator U16 and reference resistor R151. The $\pm E_s$ Generator CR27 and U15 provides plus and minus references through R118 and R121, respectively. The $+E_s$ is switched by FET Switch Q26 and Q27 as U16 input goes to zero during one period of 200kHz Clock. U16 output produces positive and negative going ramps in one clock period. Changing of ramp polarity occurs at the same level of U16 output and sawtooth waveform of Q32 in 200kHz Clock Generator. This is sensed by Comparator Q28, which changes state of U17C and U17B whose output is connected to FET Switch Q26 and Q27 to complete negative feedback loop and also to FET switch Q20 to Q23. U17 is driven in negative domain to match operation of FET Switches and provides waveform modulated to pulse width by Loss Side Amp output in A1.

The $\pm E_L$ Generator U11 accepts Loss Side Integrator output ($+E_L$) and provides $-E_L$. Q19 is temperature compensator for U11. The $+E_L$ is connected to Integrator U12 through R90 and $-E_L$ is connected to U12 through R91 and FET Switch Q20 to Q23 which is switched by timing from U17. U12 integrates the sum of these two inputs. U12 output through Q24 is sampled by applying sampling pulse, issued at each end of sawtooth from T2 in 200kHz Clock Generator, to Sampler (CR19 to CR22) and is stored in C36. Charge stored in C36 maintains input of Buffer Amplifier Q25 and U13. Therefore, U13 output forms staircase which is similar to and 180° out of phase with Loss Side Amp output in A1. Negative feedback loop through R93 operates to cancel result of previous integration. Following stage, U14, is ΩF-D Converter. The gain is one for Function ΩF and is $1000/2\pi f$ for Function D (f is measuring frequency in Hz). The heart of 200kHz Clock Generator is the Blocking Oscillator (Q29, T2 and CR28). This provides two outputs, one is a sampling pulse of 10V peak at T2(1-2) and the other is sawtooth at Q32 emitter.

Unbalance Detector.

Unbalance Detector judges unbalance condition from three sources of information. The first is sensed by U18 and U20 when unknown capacitance is too low compared to C Range setting. The second is by U19 when an error signal always exists on Null Detector. The third is by A2U35 when E_C or E_L exceeds +12V. U18 and CR31 plus CR32 form a Rectifier and the smoothed output is applied to Comparator U20. U20 output goes to L (low level) when the level at U20(3) goes lower than at U20(2), which means that Loss Side Amp output is too small. If an error signal exists, it is rectified by CR29 and fed to Comparator U19. U19(6) goes L when the level at U19(2) exceeds that at U19(3). Either one, when conditioned, drives Gate U21D(11) to H (high level) and also U21B(6) L. Finally, A2U35 output goes to L when E_C or E_L exceed +12V and similarly makes U21A(3) H, and U21B (6) L. Gate U21B is disabled when Function is V or I_L.

A2 Parts Locations under Fold

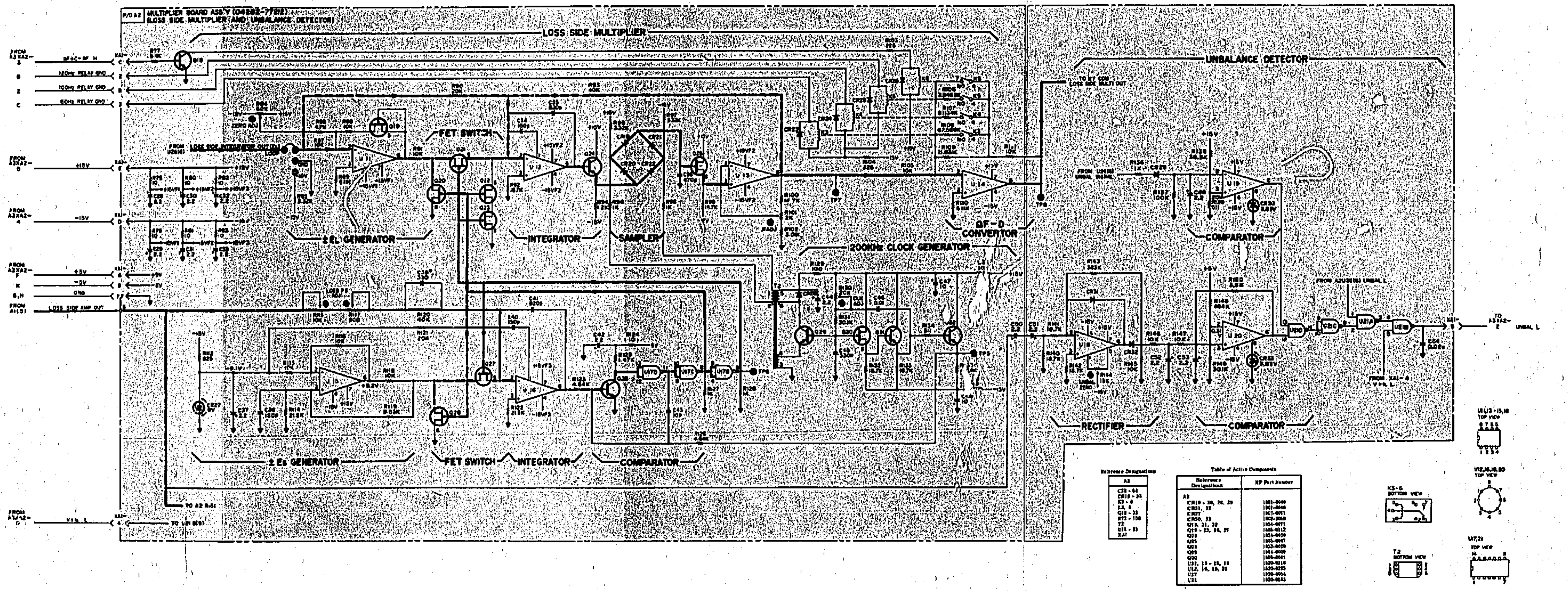
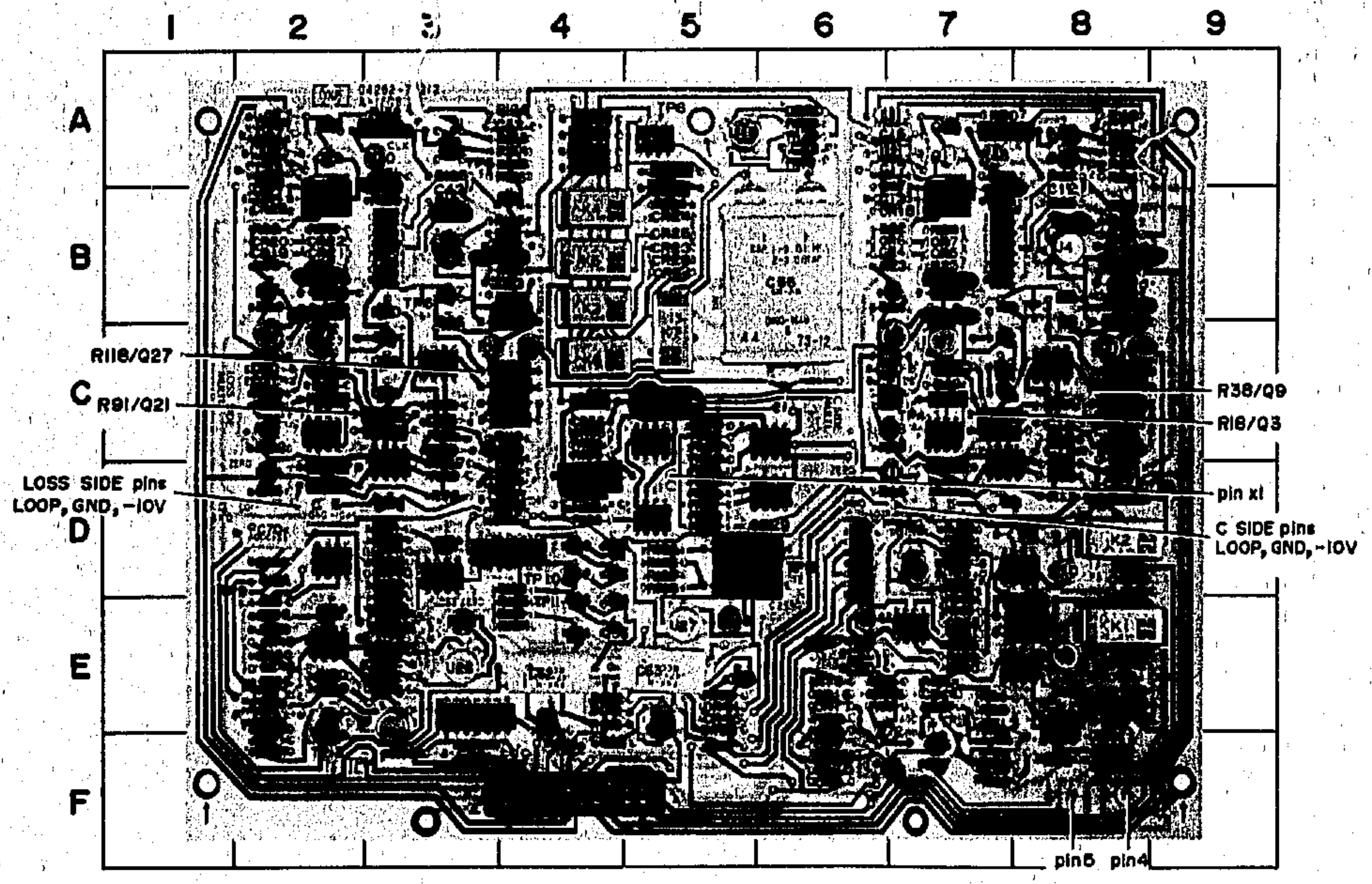


Figure 8-9. A2 Multiplier Board Ass'y. (Loss Side Multiplier and Unbalance Detector)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C55	B-6	Q35	D-4	R179	E-3
C57	C-5	Q36	D-4	R180	D-3
C58	D-4	Q37	D-4	R181	D-3
C59	D-4	Q38	D-4	R182	D-3
C60	D-5	Q39	D-4	R183	D-3
C61	D-5	Q40	D-4	R184	E-4
C62	E-4	Q41	E-4	R185	D-4
C63	E-5	Q42	D-3	R186	E-2
C64	E-3	Q43	E-2	R187	D-3
C65	E-3			R188	E-2
C66	E-3	R151	C-4	R189	E-2
C67	D-4	R152	C-4	R190	E-2
C68	E-2	R153	C-4	R191	E-4
C69	E-2	R154	C-5	R192	D-4
C70	D-2	R155	D-4	R193	E-5
C71	D-3	R156	C-5	R194	E-4
C72	D-3	R157	C-5	R195	E-4
		R158	C-5	R196	E-4
CR34	B-5	R159	D-5		
CR35	C-4	R160	D-5	U22	C-5
CR36	C-4	R161	D-5	U23	D-5
CR37	E-2	R162	D-5	U24	C-6
CR38	E-2	R163	D-5	U25	D-6
CR39	E-3	R164	D-5	U26	E-3
CR40	D-3	R165	D-5	U27	E-5
CR41	D-3	R166	D-5	U28	E-2
CR42	E-2	R167	E-3	U29	E-3
CR43	E-2	R168	E-5	U30	E-3
CR44	E-5	R169	E-2	U31	D-2
CR45	E-5	R170	E-2	U32	D-3
CR46	E-4	R171	E-2	U33	D-4
		R172	E-4	U34	E-2
K7	C-5	R173	E-4	U35	E-5
		R174	E-3		
L5	D-4	R175	E-3	XA1	F-4
		R176	D-2		
Q33	E-4	R177	D-2		
Q34	E-4	R178	D-2		

SEE INSIDE

Figure 8-9
A2 Multiplier Board Ass'y
(Loss Side Multiplier and Unbalance Detector)

A2 MULTIPLIER BOARD OPERATION

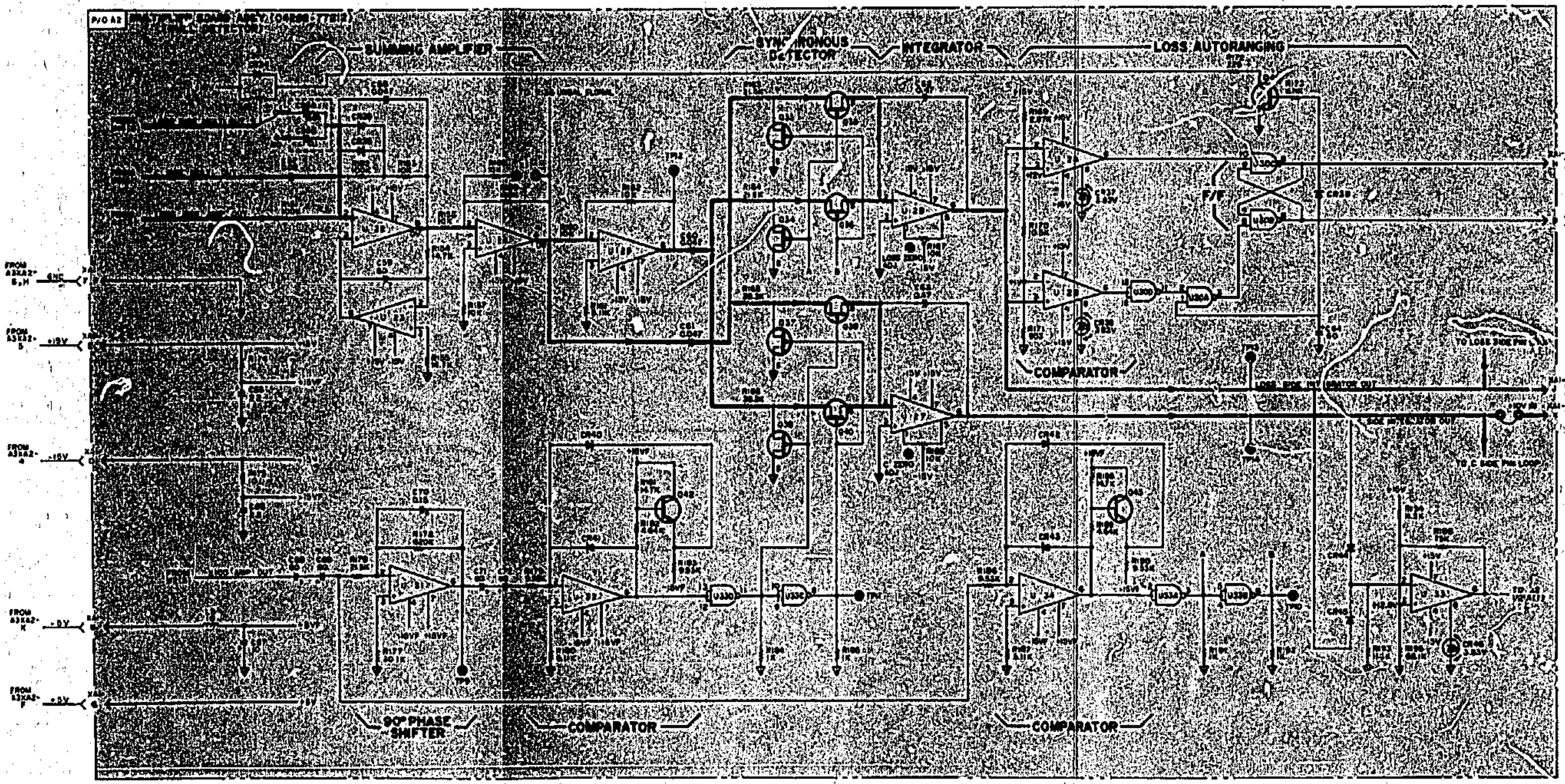
Null Detector Section.

This section contains Summing Amplifier U22 to U24, Synchronous Detectors Q33 to Q40 and Integrators U26 and U27. Also included are Loss Auto Ranging Circuit U28 to U30 and Synchronous Detector Driver U31 to U34.

The three outputs, C Side Multiplier, Loss Side Multiplier and Loss Side Amplifier, are fed to Standard Capacitors C57 and C55 and Standard Resistor R151, respectively. They are summed at summing node of U22(2). U22 detects the summed difference as error and feeds it to U24. CR35 and CR36 work to reduce gain of U22 to prevent saturation during balancing process. U23 is employed to verify zero of dc level at U22(6). U24, which has a gain of 10, amplifies error signal and feeds it to Sync Detectors. One input is fed directly and the other is fed through Inverter U25. The two Sync Detector (FET Switches) are driven by pulses having a 90° phase difference with each other. Therefore, the two Detectors detect in phase and 90° phase different components and feed them to Integrators U26 (Loss Side) and U27 (C Side), respectively. U26 and U27 integrate error signals detected and provide outputs as E_L and E_C.

Loss Auto ranging Circuit selects proper Loss Range from two available ranges. This information is received from Comparators U28 and U29. U28(6) is L when U28(2) is above about +12V. Since U29(6) is H, F/F U30B/C is H at U30(8) and L at U30(6). This means up-ranging is required so Q41 is turned on to energize K7 to connect Standard Capacitor C55B. This operates to reduce U26 output E_L to one-tenth. Additionally, CR39 is turned off and U28A(1) is maintained L which prevents frequent range changing until charge of C64 reaches H. On the other hand, when E_L is below about +1V, U29(3) goes to L. This makes U30B(5) L. Since U30C(10) is H, F/F changes state as U30C(8) is L and U30B(6) is H. This means down-ranging is required so Q41 is turned off to connect C55A. Synchronous Detector Driver circuitry includes 90° Phase Shifter U31 and two comparators U32 and U34. U31 provides a sine wave 90° out of phase with input. U32 produces a square wave output in phase with U31 output. U33D/C is driven in negative domain to match operation of FET Switches. U34 also produces square wave in phase with input. U33A/B are similar to U33C/D.

A2 Parts Locations under Fold



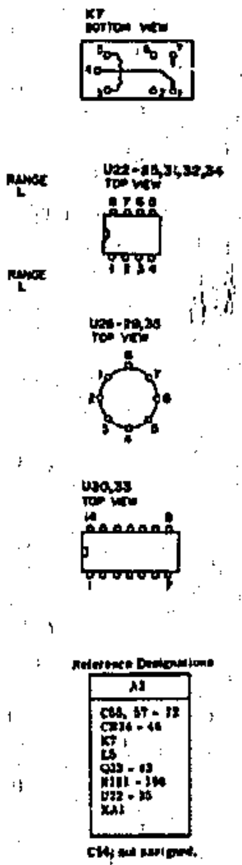
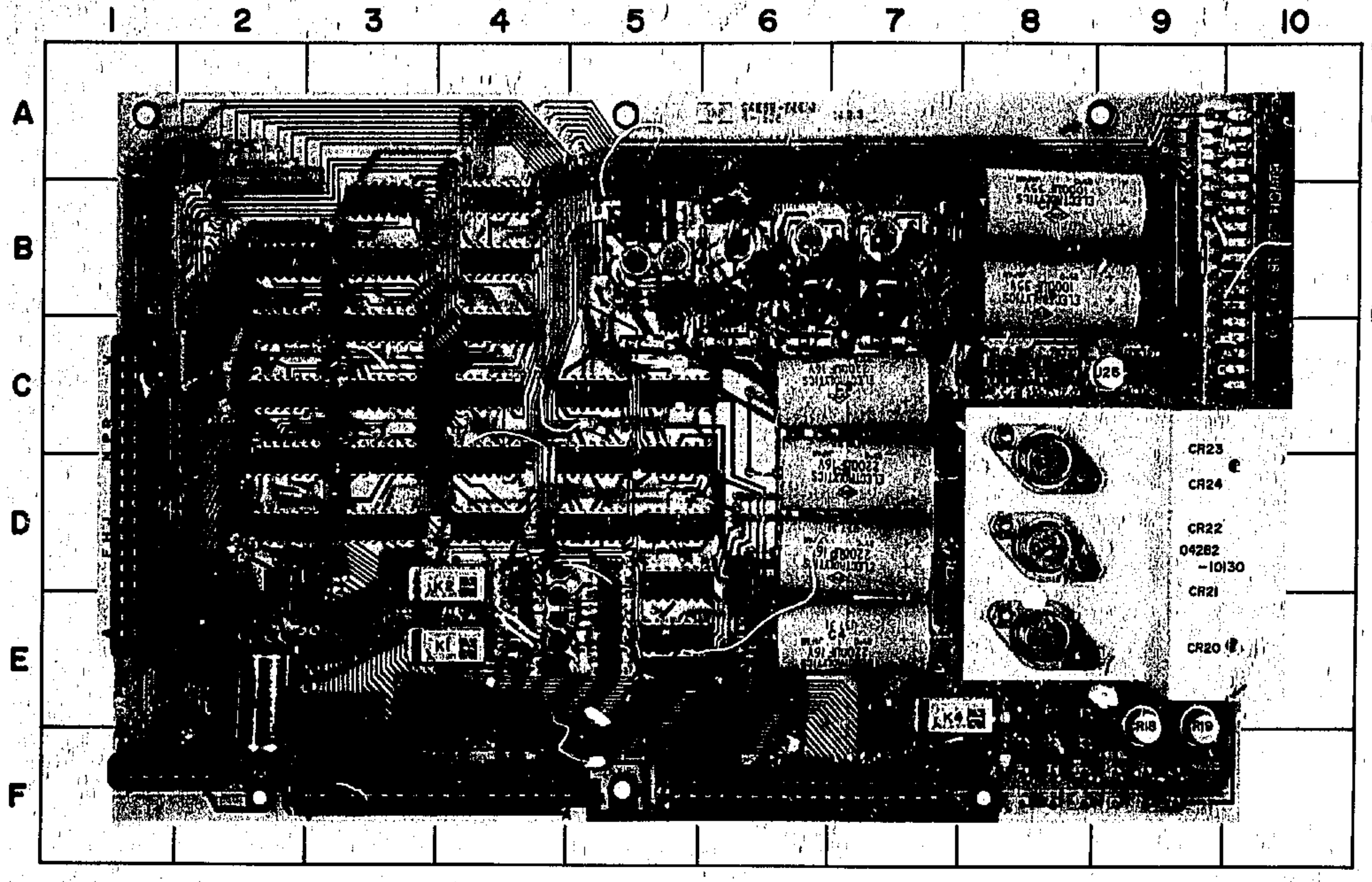
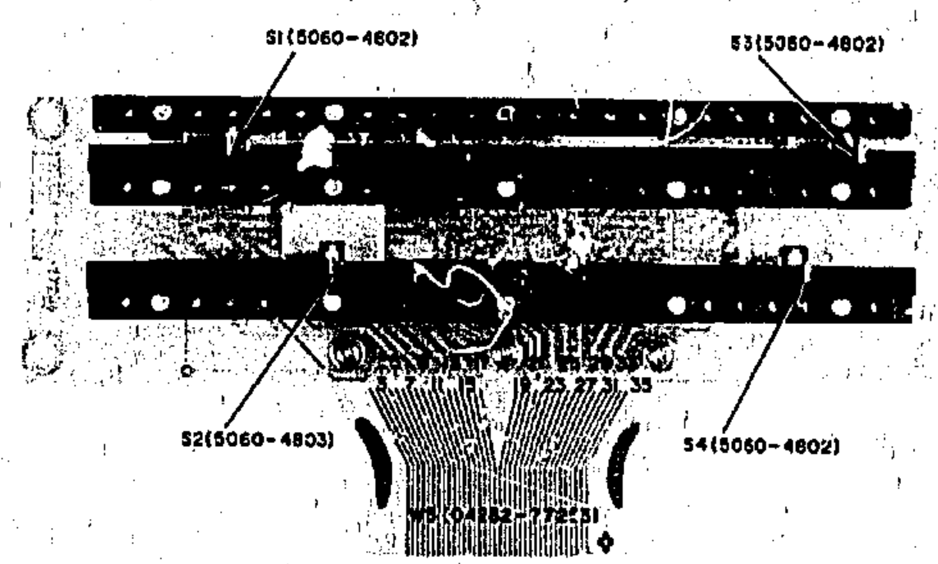


Table of Active Components.

Reference Designation	HP Part Number
A2	
CR34 - 36, 40 - 45	1901-0040
CR37, 38, 46	1902-3081
CR39	1910-0016
Q33 - 40	1855-0133
Q41 - 43	1854-0071
U22 - 25, 31, 32, 34	1820-0228
U26, 27	5080-3021
U28, 29, 35	1820-0223
U30, 33	1820-0054

Figure 8-10. A2 Multiplier Board Ass'y. (Null Detector)





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C20	D-5	R1	E-4	U1	E-5
		R2	E-4	U2	D-5
CR1	E-4	R3	D-4	U3	C-5
CR2	E-3	R4	E-4	U4	D-4
CR3	E-2	[illegible]	D-2	U5	D-5
CR4	D-4	R6	D-2	U6	D-4
CR5	D-5	R7	D-2	U7	C-5
CR6	E-5	R8	E-3	U8	D-5
CR7	D-5	R9	D-4	U9	D-5
CR8	E-5	R10	D-4	U10	D-5
CR9	E-4	R11	D-5	U11	C-2
CR26	D-5	R12	D-5	U12	D-2
		R13	E-5	U13	D-3
K1	E-4	R14	E-5		
K2	D-4	R15	E-5	XA1	F-6
K3	E-2	R16	E-6	XA2	F-3
		R17	E-5	XA3	F-1
Q1	E-4	R18	E-4	XA4	D-1
Q2	E-4	R19	C-9	XA5	B-10
Q3	D-4	R20	B-9		
Q4	D-4	R21	B-2		
Q5	E-4	R52	E-5		
Q6	E-4	R53	D-6		

SEE INSIDE

Figure 8-10
A2 Multiplier Board Ass'y
(Null Detector)

A3 CONTROL BOARD OPERATION

Function Control Section.

This section contains the various logic circuits. For explanatory purposes (in text and in diagrams), H or L after function letter abbreviation shows TTL logic level when that function is enabled, e.g., C H shows that C signal line is at TTL high level when Function C is selected.

Function Remote Gate is enabled to allow Function to be remotely programmed when FUNCTION switch is set to REM. Function Gate provides H (high level) when either one input goes L (low level). When C Function is selected, U5B(4) or U5B(5) go to L and U5B(6) is H. This makes U9C (8) L and C Enable Switch Q6 turns on. Q6 on means that C Side Integrator A2U27 output E_C is connected to DVM input in A4. U5B(6) H also makes U6A(1) L to enable transfer of C Range information.

Similarly, when D or ΩF Function is selected, Q4 is turned on to Loss Side Integrator A2U26 whose output E_L is connected to DVM input. Then U9A(12) becomes L to enable transfer of Loss (D or ΩF) range and units information.

When Functions C-D or C-ΩF are selected, U6B(4) goes to L to enable U10A/D. On the other hand, each negative transition of Busy H signal which comes from A4U13 causes a positive transition is Schmitt U1(6). This positive transition, which occurs at the same time as data transfer pulse, alternately changes F/F U2 state. Assuming U10D(13) is H (U2(9) = L) is equivalent to assuming an independent selection of Function C. The difference is that U10D(13)H makes U9A(12) L. This is required to enable transmission of information of range and unit of Loss (D or ΩF) because the display is Loss while DVM is measuring E_C (capacitance value) and vice versa.

When Function is V, U6A(3) H turns relay driver Q2 on which turns K2 on to connect voltage (V) to DVM input and makes U10B(4) L which completes voltage measurement circuit and also U6D(11) L which enables V Range Gate. Input voltage is attenuated by Voltage Divider R5 to R7 determined by DC BIAS RANGE switch A6S4 setting.

When Function is I_L, U6B(6) H turns relay driver Q1 on which turns K1 on to connect I_L Detector output (E_{IL}) to DVM input and makes U10B(4) L which completed I_L measurement circuit and also U6C(8) L which enables transfer of I_L Range and unit information.

A3 & A6 Parts Locations under Fold

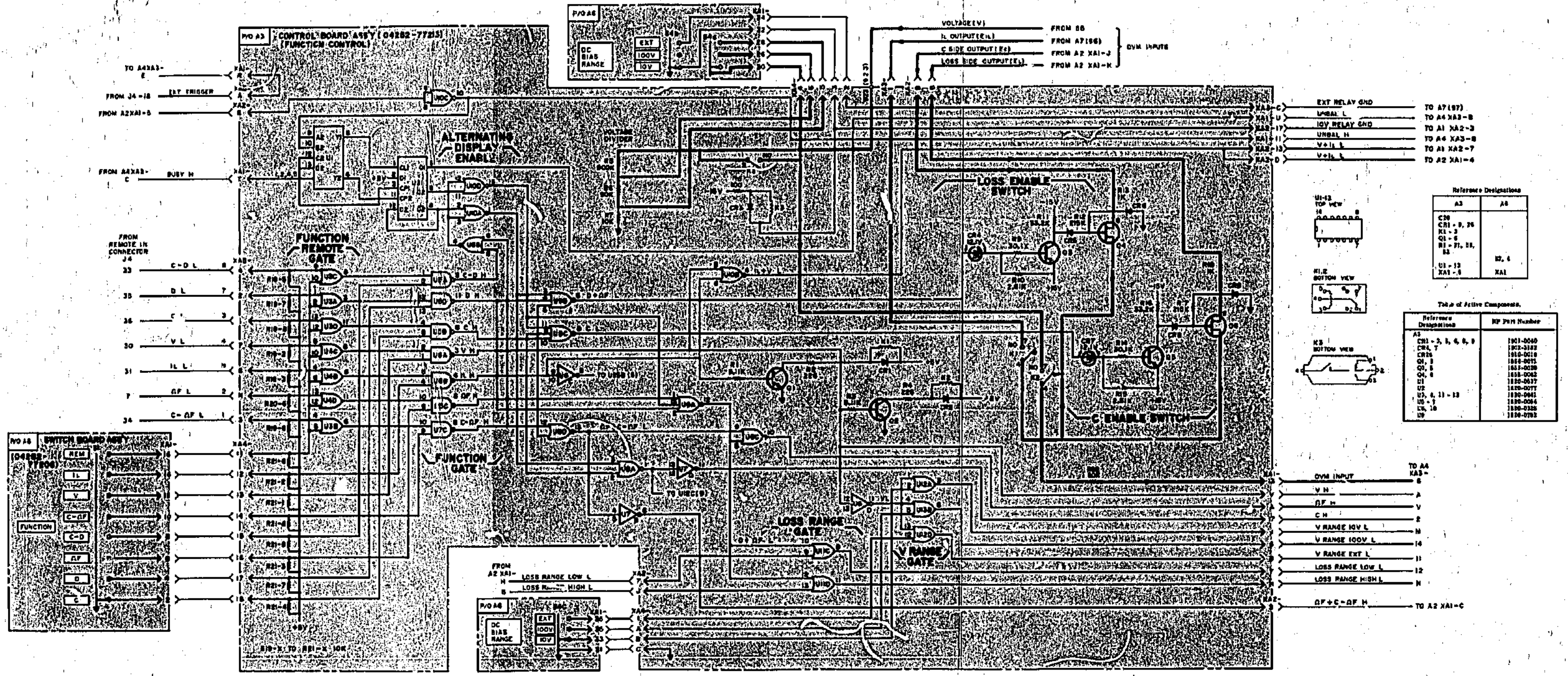
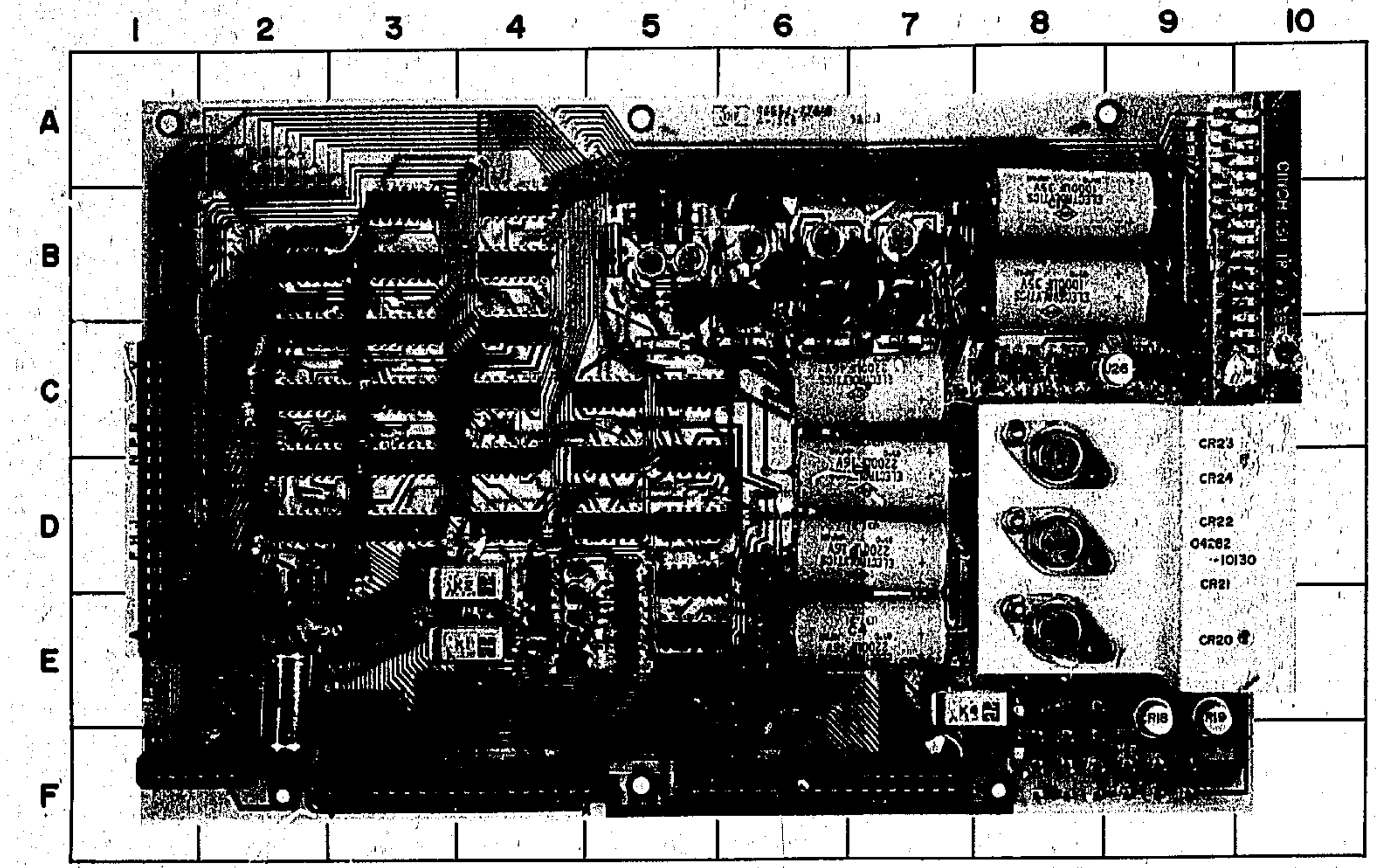
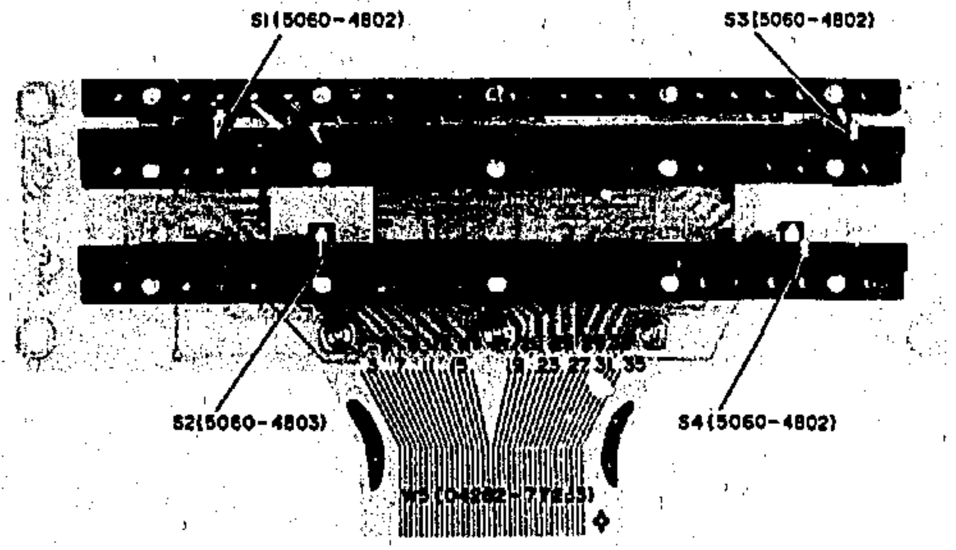


Figure 8-11. A3 Control Board Ass'y. (Function Control)
A6 Switch Board Ass'y.





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
R19	C-9	U12	D-2	U20	B-2
R20	B-9	U13	D-3	U21	B-3
R22	B-9	U14	B-4		
R23	C-1	U15	B-4	XA1	F-6
R24	B-1	U16	C-4	XA2	F-3
		U17	C-4	XA4	D-1
U4	D-4	U18	D-3	XA5	B-10
U11	C-2	U19	B-3		

Figure 8-11
A3 Control Board Ass'y
(Function Control)
A6 Switch Board Ass'y

SEE INSIDE

A3 CONTROL BOARD OPERATION

C Range Control Section.

This section contains C Range Remote Gate, C Range Gate, C Range Display Gate and Open Collector Relay Driver. The Remote Gate is enabled to allow C Range remote program when C RANGE switch is set to REM. C Range Gate is at L (low level) when either input goes L. This drives Open Collector Relay Driver to select a C range. Display Gate is enabled to display appropriate unit and decimal point when Function C is selected.

A3 & A6 Parts Locations under Fold

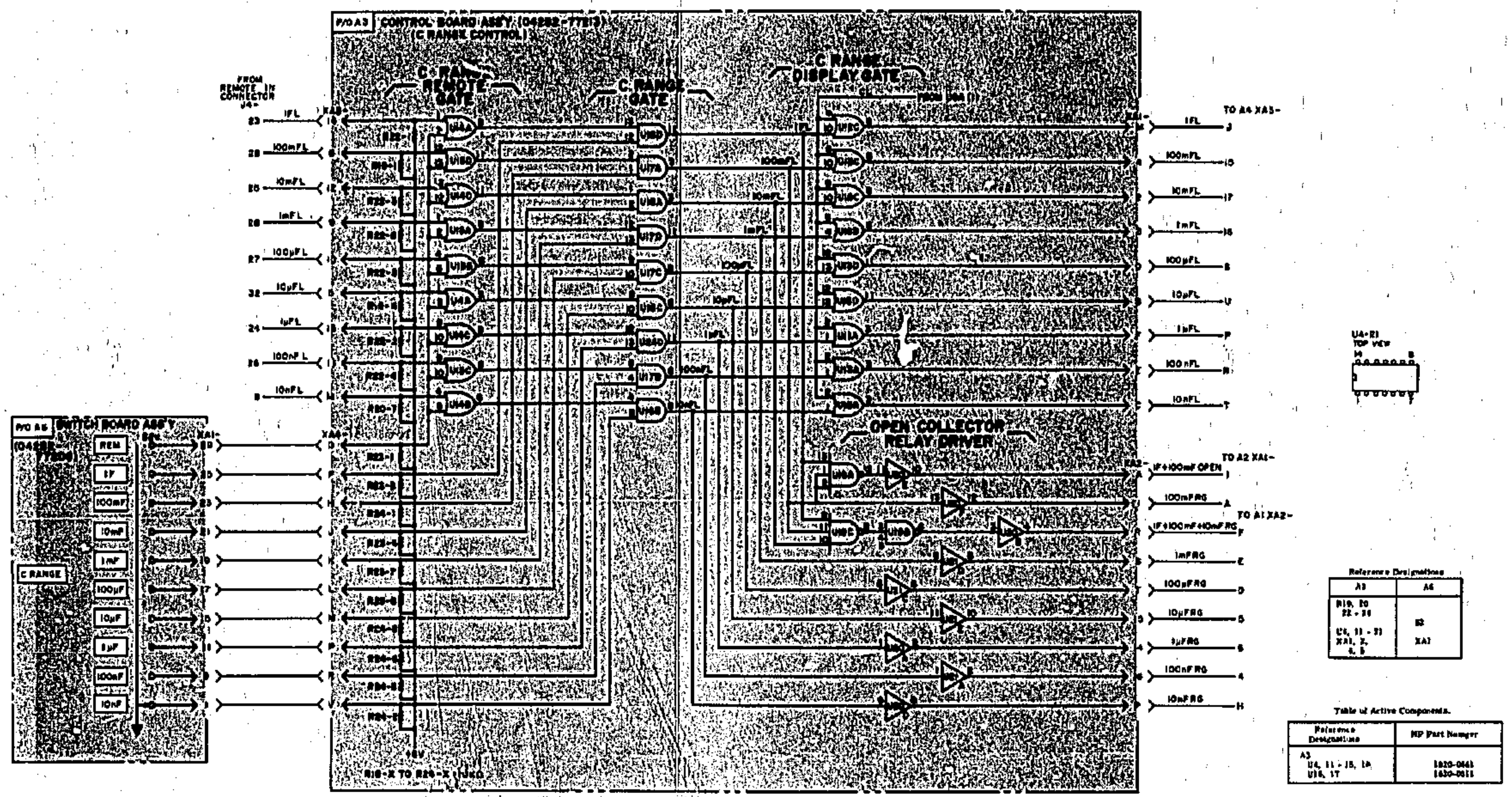
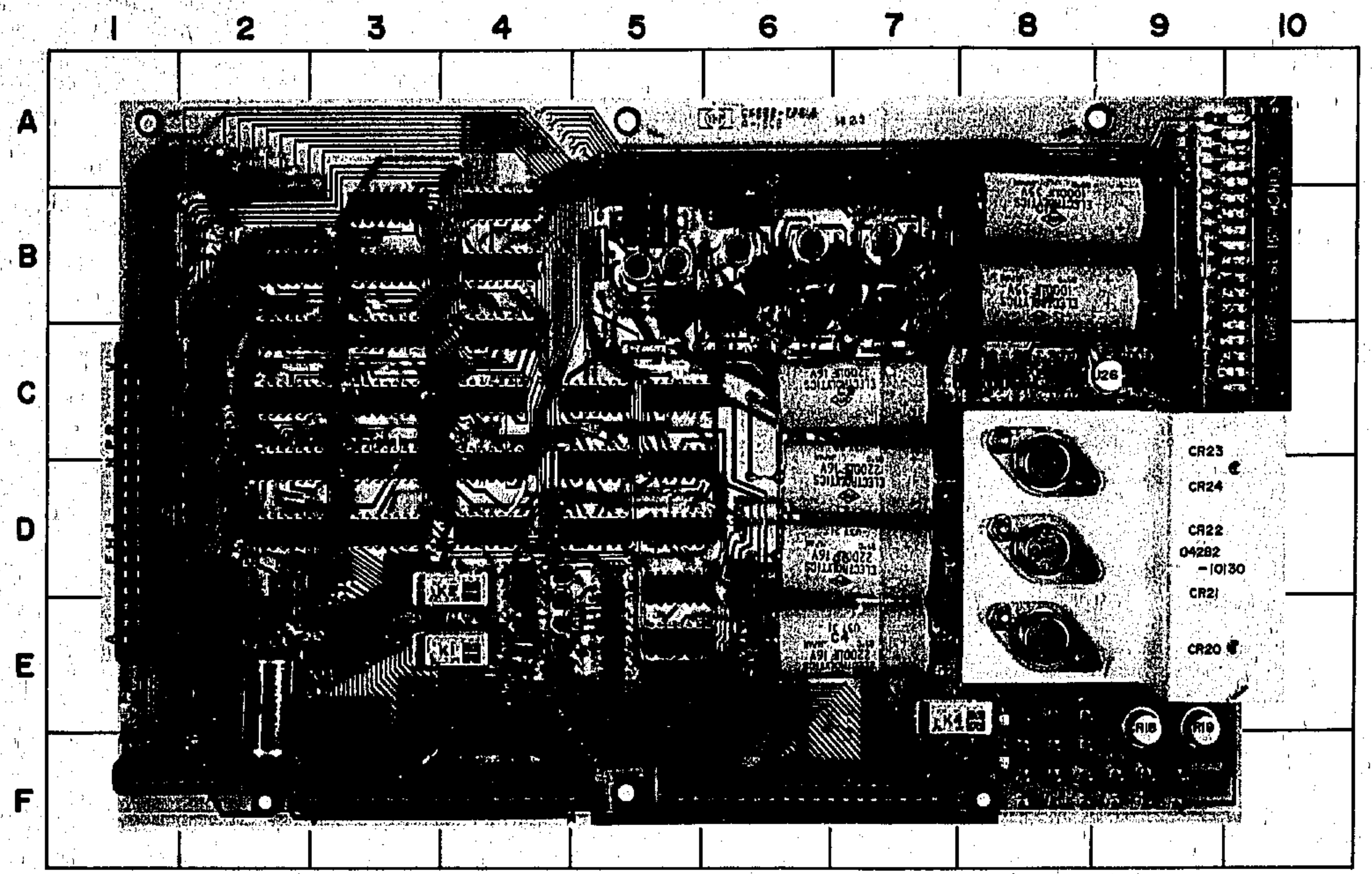
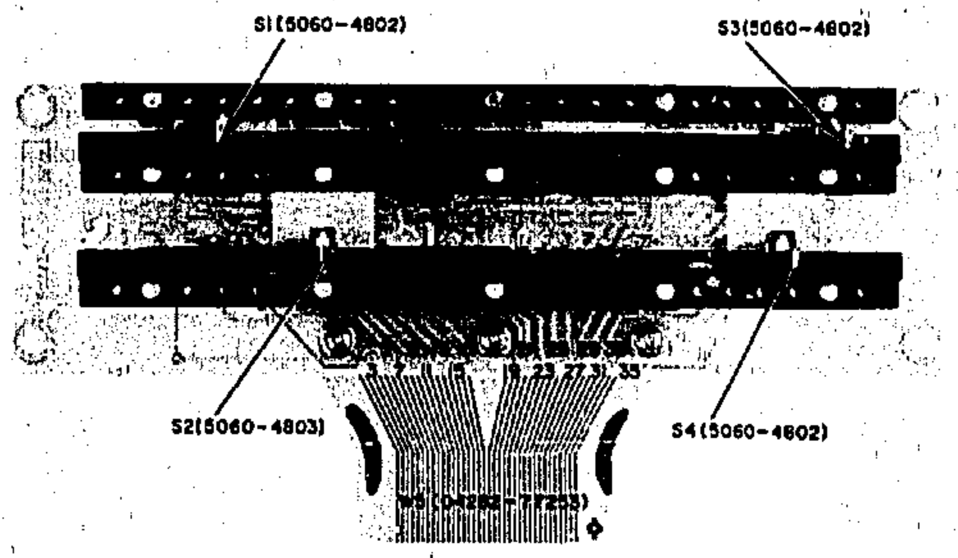


Figure 8-12. A3 Control Board Ass'y. (C Range Control)

A6 Switch Board Ass'y.





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Lod.	Ref. Desig.	Grid. Loc.
C1	B-7	R20	B-9	U11	C-2
C2	B-7	R23	C-1	U12	D-2
C3	C-8	R24	B-1	U22	C-3
		R25	E-2	U23	C-2
		R26	B-7	U24	C-3
CR10	C-8	R27	B-7	U25	D-2
CR11	C-8	R28	C-8	U26	C-9
CR12	C-8	R29	C-8		
CR13	C-8	R30	C-8	XA1	F-6
CR14	C-8	R31	C-8	XA2	F-3
CR15	C-8	R32	C-8	XA3	F-1
CR16	C-9			XA4	D-1
CR17	C-9			XA5	B-10

Figure 8-12
A3 Control Board Ass'y
(C Range Control)
A6 Switch Board Ass'y

SEE INSIDE

A3 CONTROL BOARD OPERATION

I_L Range Control Section.

This section contains I_L Range Remote Gate, I_L Range Gate and I_L Range Display Gate. Remote Gate is enabled to allow I_L Range remote programming when I_L RANGE switch set to REM. I_L Range Gate is at L (low level) when either input goes L. This is used for I_L Range selection in A7. Display Gate is enabled to display appropriate unit and decimal point when Function I_L is selected.

Check Fuse Sensor.

This circuit annunciates when measuring circuit fuse F2 is blown. When F2 blows, measuring signal is applied across R24. This signal is rectified by CR10, CR11 and fed to Comparator U26. U26 provides positive output and CR17 limits it to TTL high level.

A3 & A6 Parts Locations under Fold

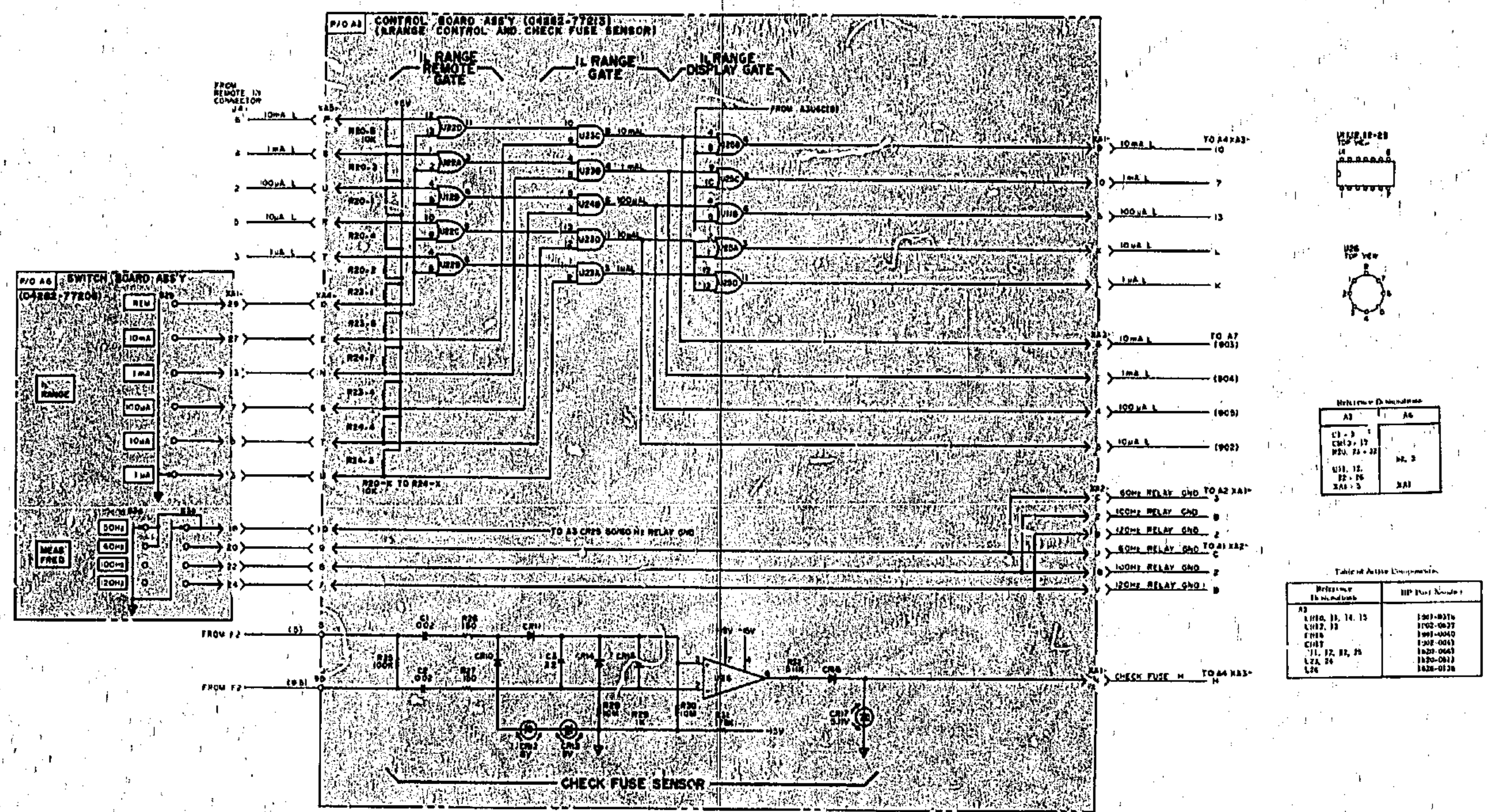
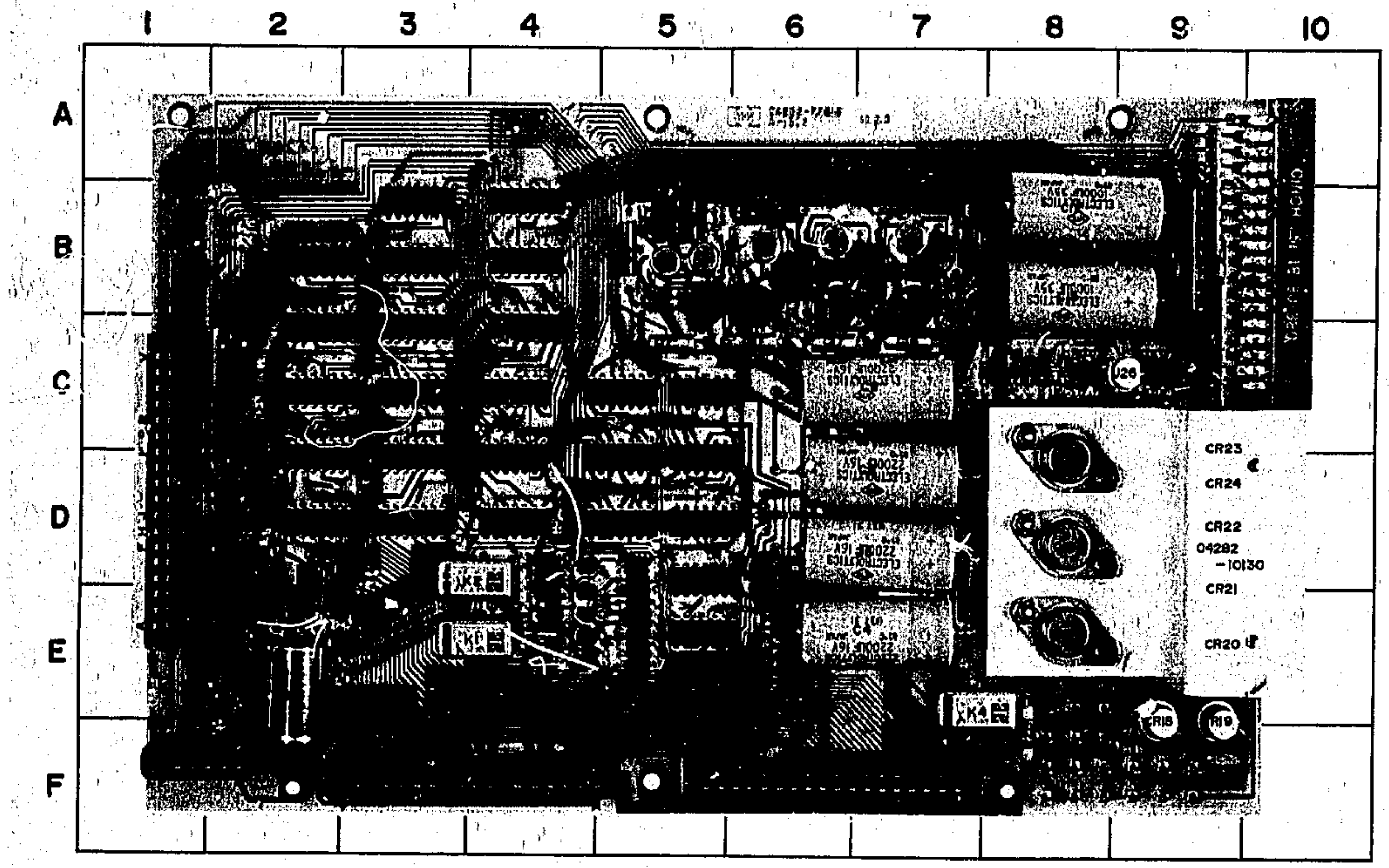


Figure 8-13. A3 Control Board Ass'y. (I_L Range Control and Check Fuse Sensor)
A6 Switch Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C4	E-7	CR22	D-10	R42	B-7
C5	D-7	CR23	C-10	R43	B-7
C6	B-5	CR24	D-10	R44	B-7
C7	C-5	CR25	E-7	R45	B-7
C8	D-7			R46	B-6
C9	C-7	K4	E-[illegible]	R47	B-7
C10	B-6			R48	B-6
C11	C-6	Q7	B-5	R49	B-7
C12	B-8	Q8	E-8	R50	E-8
C13	B-7	Q9	C-8	R51	E-7
C14	C-7	Q10	D-8		
C15	B-8			U27	B-5
C16	B-6	R33	B-5	U28	B-6
C17	C-6	R34	B-5	U29	B-7
C18	F-8	R35	B-5	U30	B-6
C19	F-8	R36	B-5		
		R37	B-5	XA1	F-6
CR18	E-9	R38	B-6	XA2	F-3
CR19	E-9	R39	B-6	XA3	F-1
CR20	E-9	R40	B-6	XA4	D-1
CR21	D-9	R41	B-6	XA5	B-10

Figure 8-13

A3 Control Board Ass'y

(I_L Range Control and Check Fuse Sensor)

A6 Switch Board Ass'y

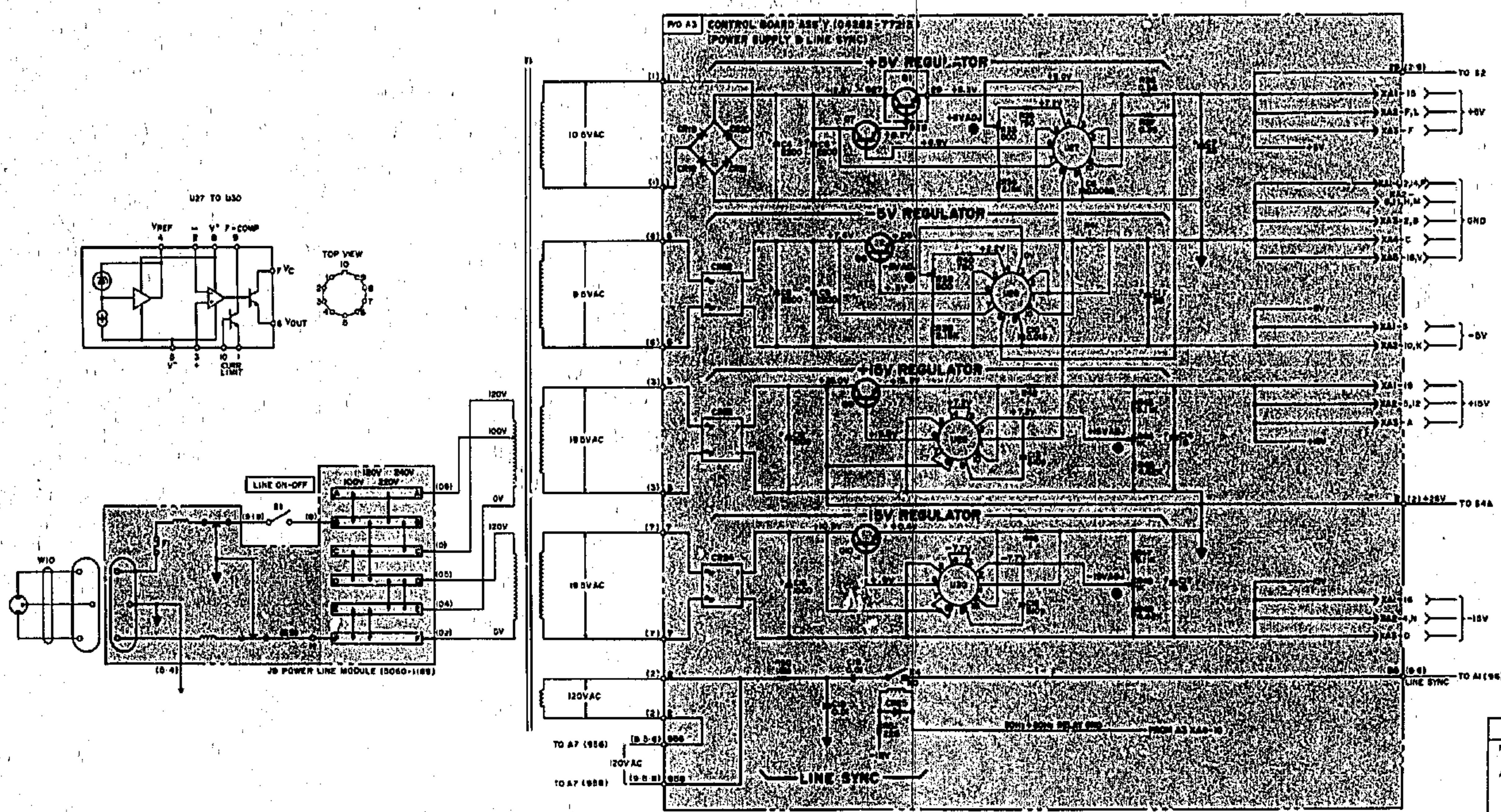
SEE INSIDE

A3 CONTROL BOARD OPERATION

Power Supply Section.

This section contains four regulated dc sources, +5V, -5V, +15V and -15V and one non-regulated dc source, +26V. Also included is an ac 120V source sent to Leakage Current Board A7 (Option 001). The +15V regulator output is used in +5V regulator and the +5V output is used in -5V regulator. A3 also furnishes the Line Synchronous signal which is taken from Relay K4. The four dc regulators are very similar. Only +5V Regulator is described. Rectifier CR18 to CR21 is bridge type rectifier. Series Regulator Q1 is placed on main chassis to enhance radiation of heat. Voltage Controller U27 has a reference and current limiter in itself. Its equivalent circuit is shown as an inset on the schematic (Figure 8-14). Control signals appear at U27(6) and are fed to Q1 through Q7. Current limiting signal is taken from R36 and R37.

A3 Parts Locator under Fold



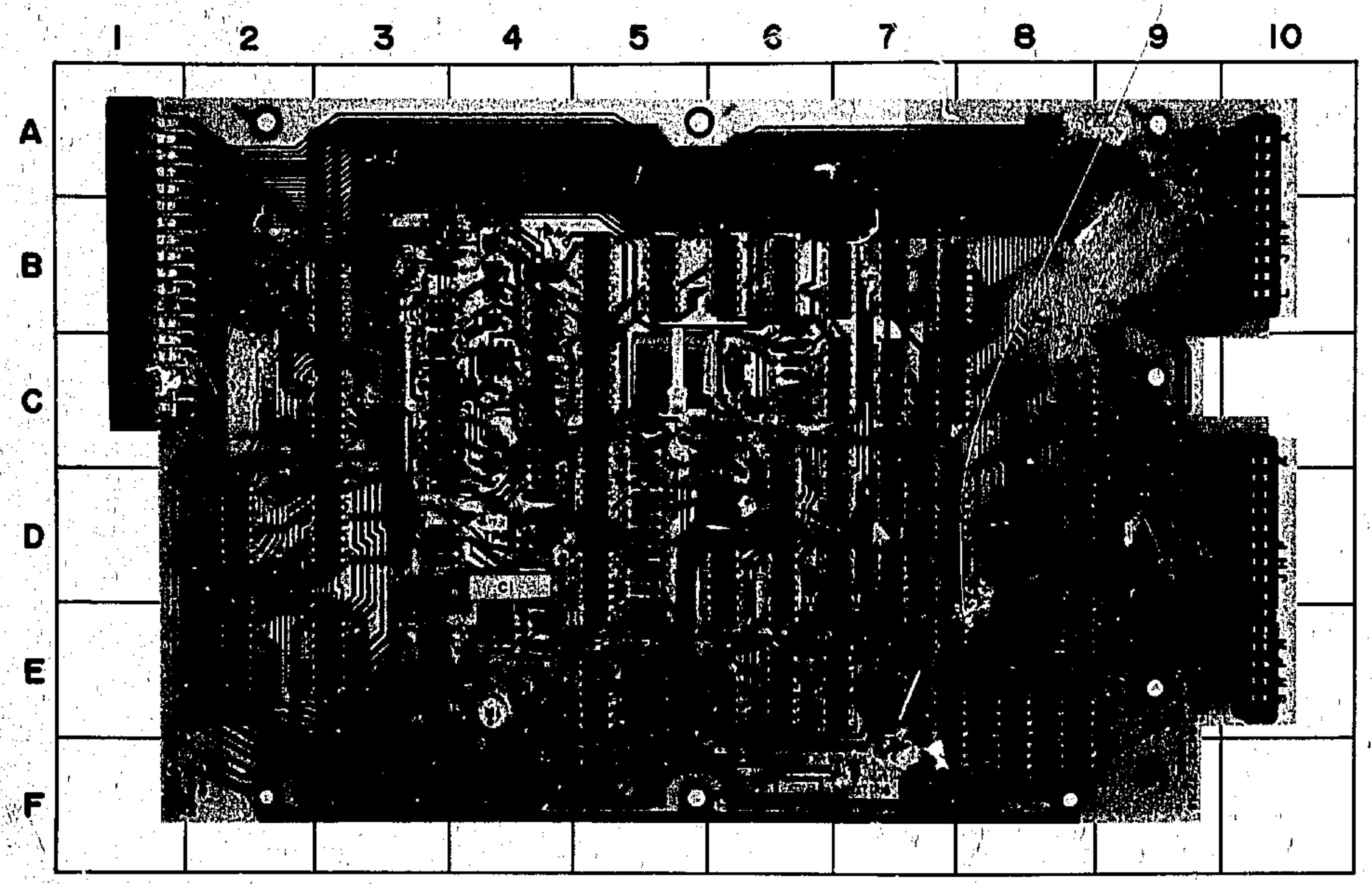
Reference Designations

NO PREFIX	A3
	C4 - 19
	CR16 - 35
F1	
J9	
	K4
Q1	Q7 - 10
	R33 - 61
S1	
T1	
	U27 - 30
W10	
	XA3 - 5

Table of Active Components.

Reference Designations	HP Part Number
No Prefix	
Q1	1854-0063
A3	
CR16 - 21	1901-0418
CR22 - 24	1901-0237
CR25	1901-0040
Q7	1854-0039
Q8 - 10	1854-0072
U27 - 30	1820-0196

Figure 8-14. A3 Control Board Ass'y. (Power Supply & Line Sync.)
J9 Power Line Module.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	D-4	R1	E-4	R34	C-6
C2	D-4	R2	E-4	R35	C-6
C3	E-5	R3	E-4	R36	C-6
C4	E-5	R4	E-3	R37	C-6
C5	C-6	R5	E-4	R36	D-4
C6	C-6	R6	E-4	R39	E-4
C7	B-4	R7	D-4	R40	D-4
C8	D-4	R8	D-4	R41	D-3
C9	D-4	R9	D-5	R42	E-4
C10	C-4	R10	D-5	R43	D-4
C11	C-4	R11	D-5	R44	C-4
		R12	E-5	R45	C-4
CR1	E-4	R13	E-5	R46	C-4
CR2	E-4	R14	D-5	R47	C-4
CR3	E-4	R15	E-5	R48	C-4
CR4	E-4	R16	D-5	R49	C-4
CR5	D-4	R17	E-5	R50	C-4
CR6	B-4	R18	E-5	R51	C-4
CR7	B-4	R19	E-4	R52	D-4
CR8	C-4	R20	E-4	R53	D-4
CR9	C-4	R21	C-4		
CR10	D-4	R22	C-4	U1	E-4
CR11	E-4	R23	B-4	U2	E-4
		R24	C-4	U3	C-4
Q1	D-5	R25	D-4	U4	C-5
Q2	E-5	R26	C-4	U5	B-5
Q3	B-4	R27	C-4	U6	B-5
Q4	B-4	R28	C-4	U7	B-6
Q5	B-4	R29	C-4	U8	B-6
Q6	B-4	R31	C-4	U9	B-7
Q7	C-4	R32	B-4	U10	C-7
Q8	C-4	R33	B-4		
Q9	D-4			XA3	F-3
				Y1	C-5

Figure 8-14
A3 Control Board Ass'y
(Power Supply & Line Sync)
J9 Power Line Module

SEE INSIDE

A4 DVM BOARD OPERATION

Pulse Width Modulation (PWM) Section.

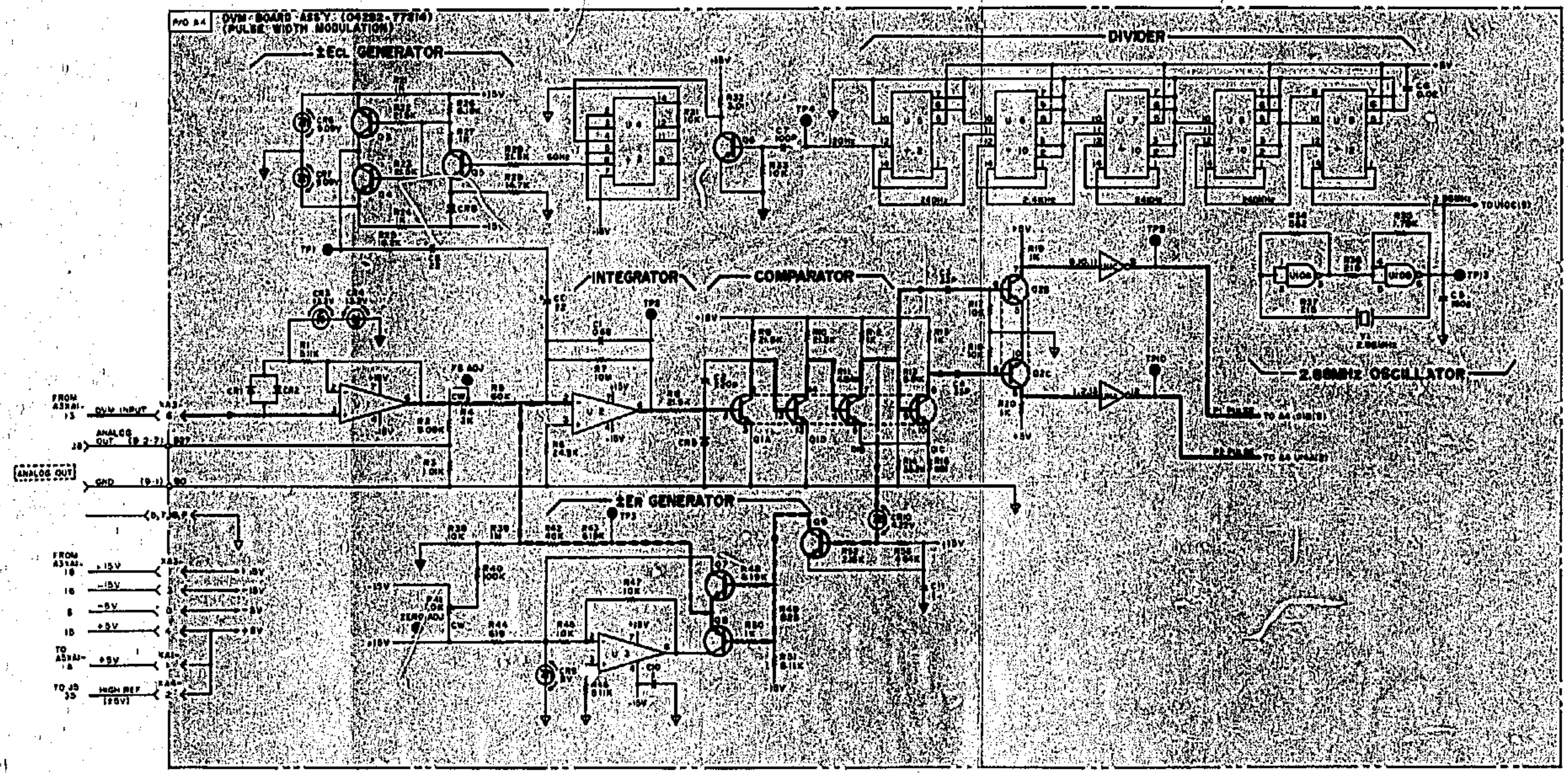
This section is employed to convert input voltage to time interval, which is accomplished by an $\pm E_{CL}$ Generator, an E_R Generator, an Integrator and a Comparator.

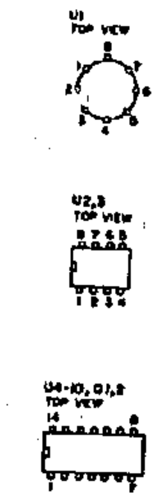
The $\pm E_{CL}$ Generator Q3 to Q5 and CR6/7 provide a 60Hz clock signal to determine the period of integration. The clock signal is obtained by dividing a 2.88MHz Crystal Oscillator output by 48,000 through Dividers U4 to U9. Q6 converts TTL level to negative level to fit Q5 drive requirements. Q3 and Q4 are switched alternately by Q5 and provide a symmetrical square wave whose frequency is 60Hz and whose amplitude is ±9.09V referred to CR6/7. The $\pm E_R$ Generator, whose duty cycle is determined by input voltage and whose frequency is 60Hz, provides ±9V referred to CR9 by alternately switching Q7 and Q8. Integrator U2 receives two inputs $\pm E_{CL}$ and $\pm E_R$ plus another input which is either E_C, E_L, V or E_{IL} (unknowns).

When E_{CL} and E_R are positive, the most rapid negative going ramp is produced at U2(6). When this ramp reaches zero, Comparator Q1A is turned off and a positive pulse (called P1) occurs at U11C(8). This also turns Q9 off to connect minus reference ($-E_R$) to U2(2) through Q8. Since the sum of three inputs is still positive, U2(6) continues to produce a slowed down negative going ramp until 60Hz clock changes to $-E_{CL}$. Then U(6) changes to the most rapid positive going ramp and, when crossing zero point, turns Q1A on. At this point a positive pulse (called P2) is produced at U11A(12). Q9 is also turned on to connect positive reference ($+E_R$) through Q7 to U2(2). The slowed down negative going ramp continues until 60Hz clock changes to $+E_{CL}$. This completes one cycle which has created P1 and P2 Pulses whose interval represents unknown input voltage.

Analog output is Impedance Converter U1 output divided by 10 and produces 1V output for a 10V input.

A4 Parts Locations under Fold





Reference Designations

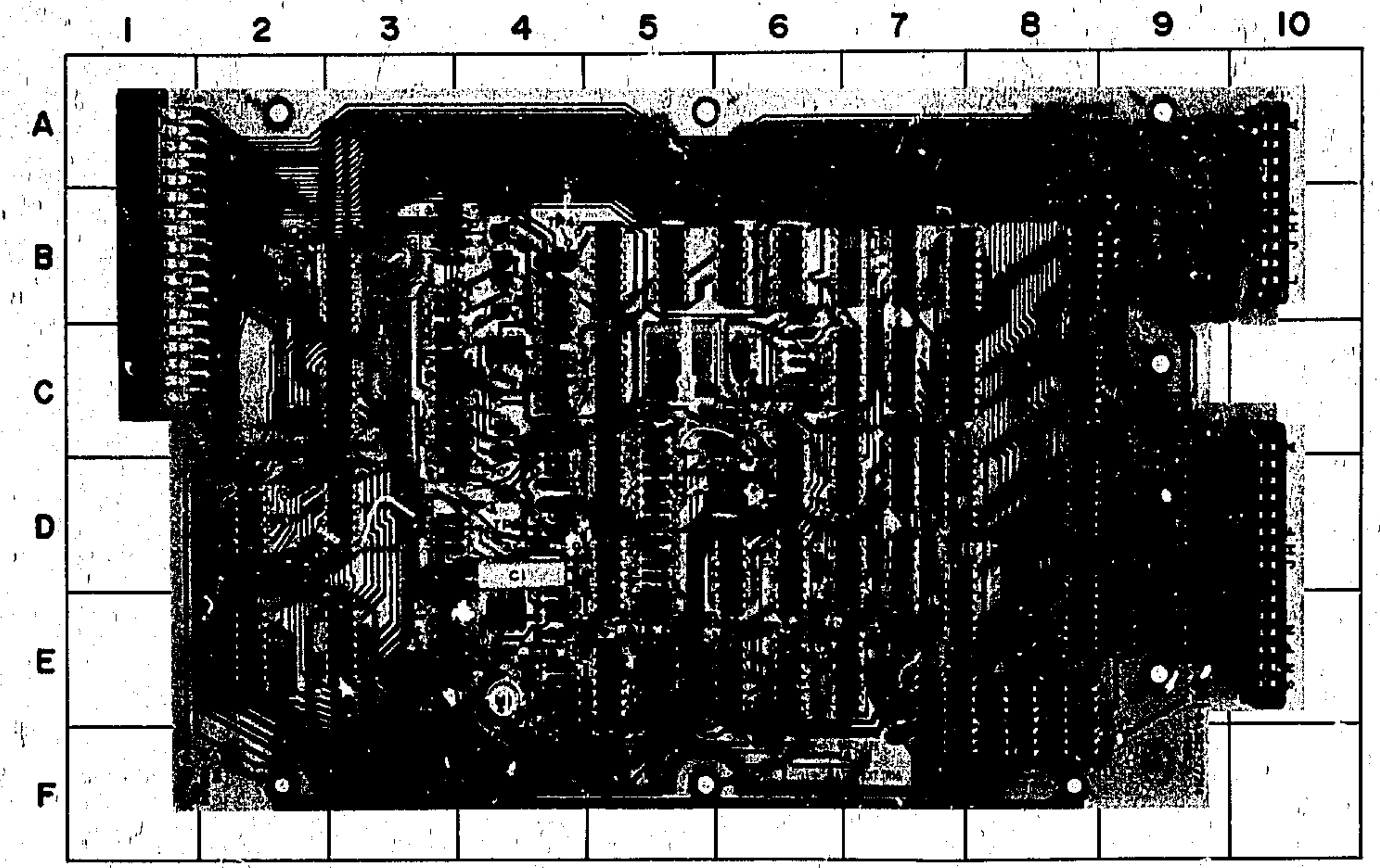
A4
C1 - 11
CR1 - 10
Q1 - 9
R1 - 53
U1 - 10
XA3
Y1

R30, not assigned.

Table of Active Components.

Reference Designations	HP Part Number
A4	
CR1, 2	1901-0376
CR3, 4	1902-3193
CR5, 6	1901-0040
CR6, 7, 8	1902-3150
CR10	1902-3070
Q1, 2	1858-0013
Q3, 5, 9	1853-0036
Q4, 6, 7	1854-0215
Q8	1853-0020
U1	5060-3621
U2, 3	1820-0493
U4	1820-1104
U5, 9	1820-0054
U6 - 8	1820-0600
U10	1820-0081
Y1	0410-0207

Figure 8-15. A4 DVM Board Ass'y. (Pulse Width Modulation)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C12	C-6	R54	D-6	R74	B-9
C13	C-6	R55	C-6	R75	B-9
C14	C-6	R56	E-4	R104	F-6
C15	E-5	R57	E-4	R105	B-9
C16	E-4	R58	E-4	U10	C-7
C17	D-6	R59	E-4	U11	E-6
C18	D-6	R60	D-5	U12	D-6
C19	D-6	R61	C-5	U13	D-6
C20	E-7	R62	C-5	U14	E-7
C21	E-6	R63	D-5	U15	E-6
C22	D-7	R64	D-5	U16	D-6
		R65	C-5	U17	D-7
CR11	F-4	R66	D-5	U18	D-7
		R67	D-5	U19	E-8
Q2	E-5	R68	D-5	U20	E-8
Q12	D-5	R69	C-6	U21	B-3
Q13	A-9	R70	E-7		
Q14	B-9	R71	E-6	XA1	B-10
Q15	B-9	R72	B-4	XA2	D-
Q16	B-9	R73	E-9	XA3	F-
Q17	B-9			XA4	B-[illegible]

SEE INSIDE

Figure 8-1?
A4 DVM Board Ass'y
(Pulse Width Modulation)

A4 DVM BOARD OPERATION

Control Logic Section.

This section includes Rate Generator, Timing Pulse Generator and various Gates. Rate Generator Q2A/D is astable MV whose period is variable from 0.3 to 2.0 seconds with RATE control.

The positive transition at U12(8) driven internally or externally causes positive transition at U13(6) or negative transition at U13(1) which holds H (high level) or L (low level) for about 80ms, respectively. They are Busy H or L and indicate busy period for one reading. Timing Pulse Generator Q12 provides negative Set Pulse at the beginning of busy period and positive Transfer Pulse and negative Print Command at the end of busy period.

When Set Pulse is issued, Dual F/F U15(13) and U17(13) are set to H and Counter U27 to U31 are set to zero. P1 Pulse Gate U11B enabled by U11B(3, 4) H allows acceptance of P1 Pulse. P2 Pulse Gate U14A is closed by U17 (12) L. P1 Pulse makes U15(9) H and opens Clock Gate U10C. At this point, the 2.88MHz Clock passes through U10C and goes into ÷2 Counter U18 whose output is applied to Counter U27. When Counters U27 to U31 count 8,000, U17(1) goes H and 12,000 counts of Counters returns U17(1) to L (Counter is reset to zero by itself). This negative transition makes U17(12) H and opens P2 Pulse Gate U14A. Then P2 Pulse appears at U14A(2) and makes U15(9) L to close U10C. Counters hold result which represents input voltage of PWM (Pulse Width Modulation) section. Negative transition of U15(9) also makes U15(13) L to close U11B. Above description is for positive input.

For negative input, since P2 Pulse occurs before the completion of half a period of 60Hz clock signal (before Counters count 12,000), P2 Pulse Gate U14A is closed but Gate U14D is opened. P2 Pulse passing through Gates U14D/C resets Counters.Counter again begin to count and is reset to zero by itself at 12,000 counts (after half period of 60Hz Clock from P2 Pulse). Under above conditions, next P1 Pulse is applied to U15(5). This makes U15(9) L and closes Clock Gate U10C and also P1 Pulse Gate U11B. Counters hold result which represents input voltage.

Bottom half of Dual F/F U17 provides polarity assignment. This is accomplished by checking which pulses (P1 or P2) are coincident with negative transition at U15(9) which is applied to U17(5). When P1 Pulse occurs, a negative transition at U17(5) transfers momentary H at U17(7) to U17(9) L. U17(9) L means positive input. Similarly, if a P2 Pulse occurs, it makes U17(9) H which means negative input.

U16 which forms F/F and Gates is Overload Detector. In an overload condition, P1 and P2 Pulses are not issued because of saturation of PWM section. Therefore, U15(13) remains H for one reading period after Set Pulse. When Busy L changes to H at the end of busy period, Gate U16(3) goes to L whose signal is Overload, F/F U16C/D stores this signal and U16D(11) provides Blanking L signal to blank display. This F/F is employed to keep display blanked until end of next busy period.

A4 Parts Locations under Fold

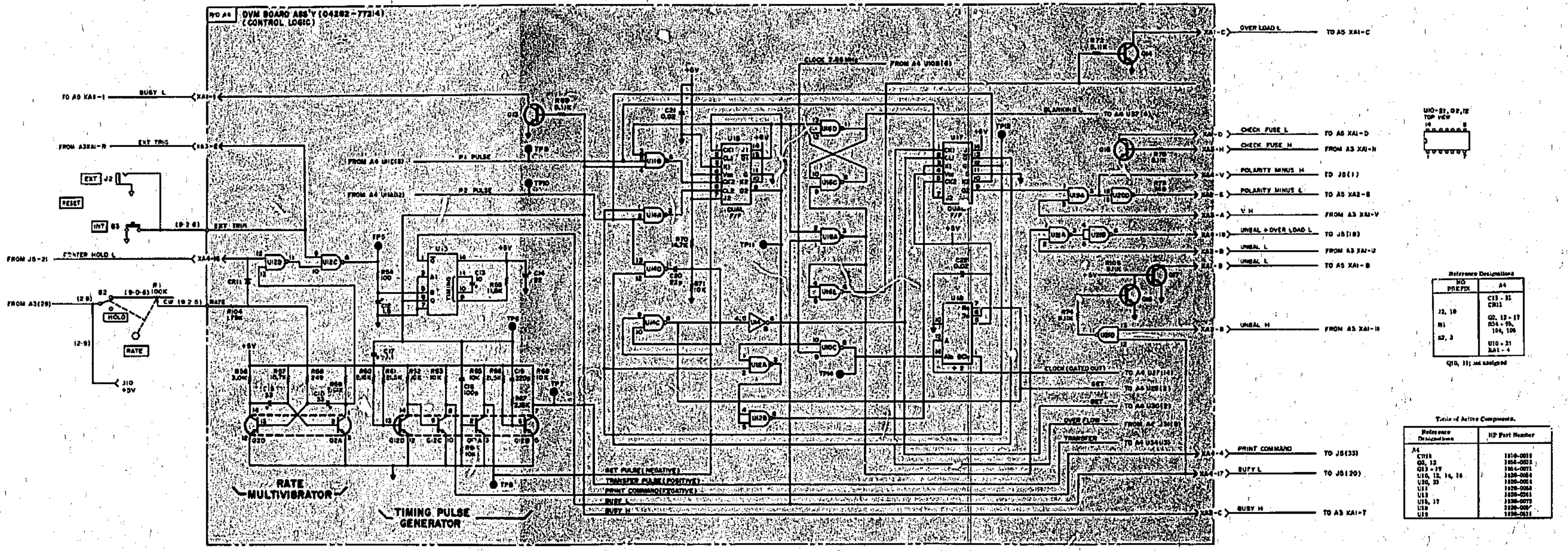
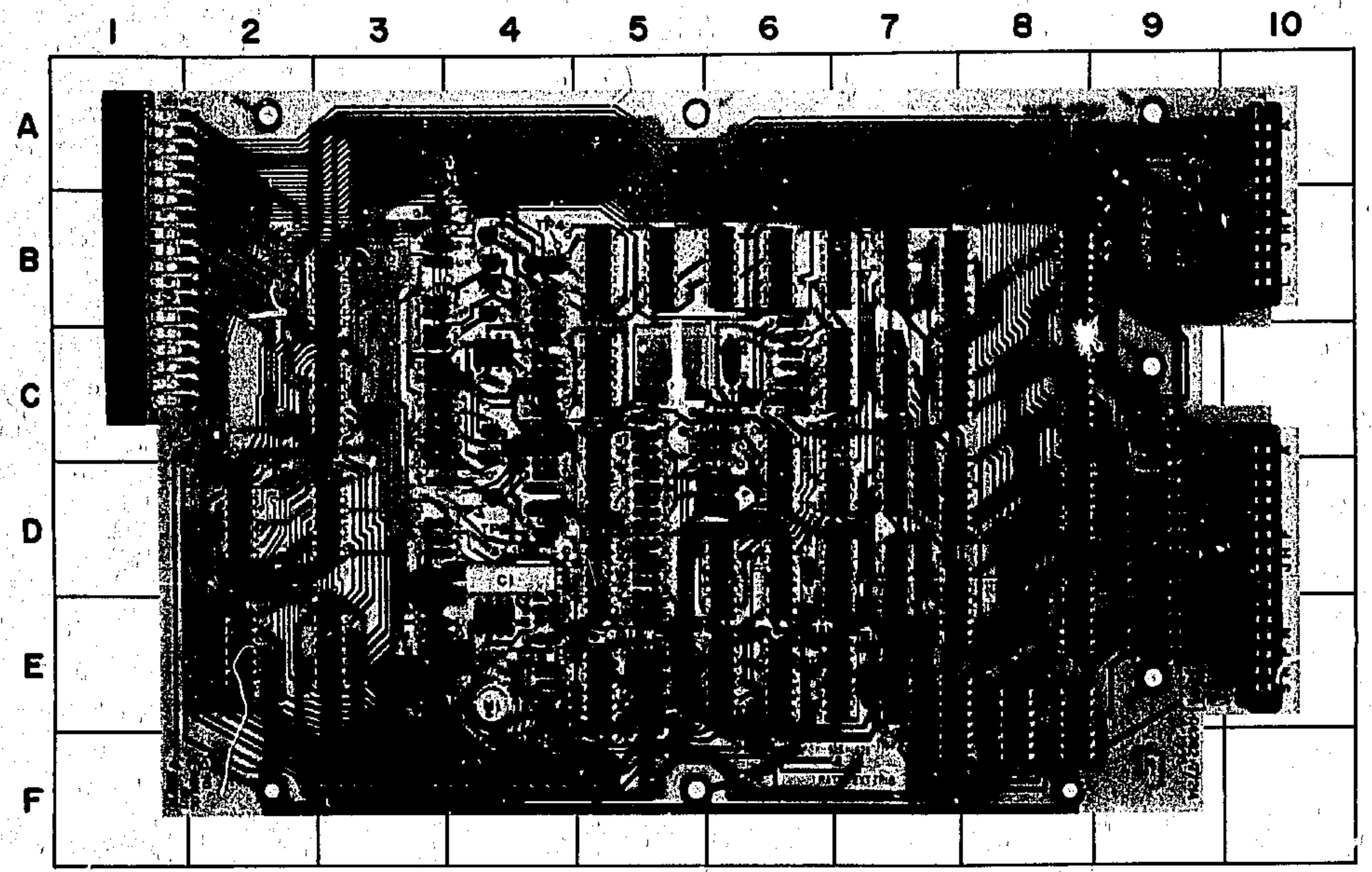


Figure 8-16. A4 DVM Board Ass'y. (Control Logic)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
U21	B-3	U24	C-3	XA1	B-10
U22	E-2	U25	D-2	XA3	F-3
U23	E-3	U26	D-3	XA4	B-1

SEE INSIDE

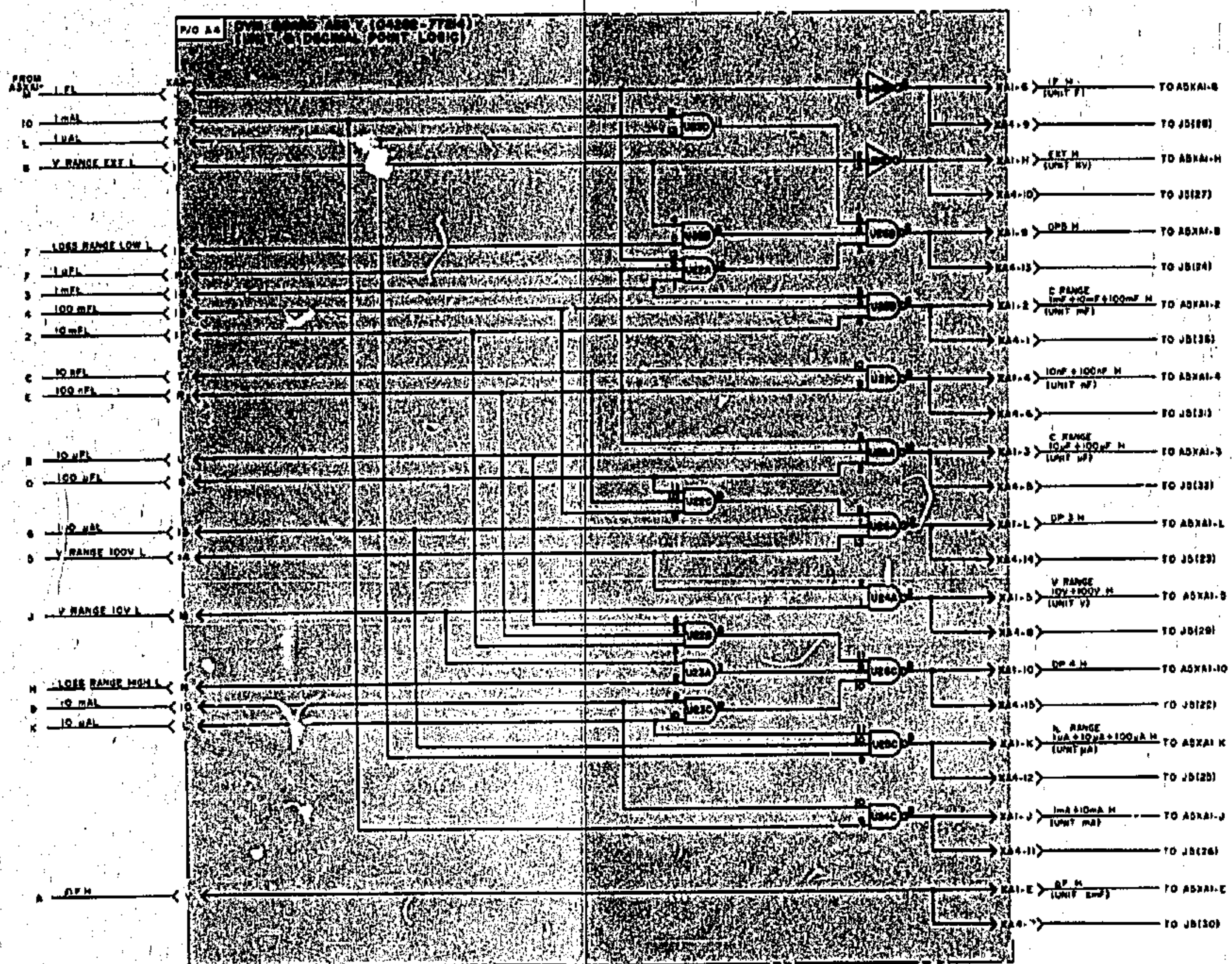
Figure 8-16
A4 DVM Board Ass'y
(Control Logic)

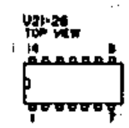
A4 DVM BOARD OPERATION

Unit and Decimal Point Logic Section.

This section converts unit and decimal point information obtained from combination of Function and Range settings to appropriate individual information. For example, when Function C and Range 1mF are selected, U25B(6) and U26 (6) go to H which means that unit is "mF" and decimal point is positioned at DP5. Same information is sent to DIGITAL OUT J5 connector.

A4 Parts Locations under Fold





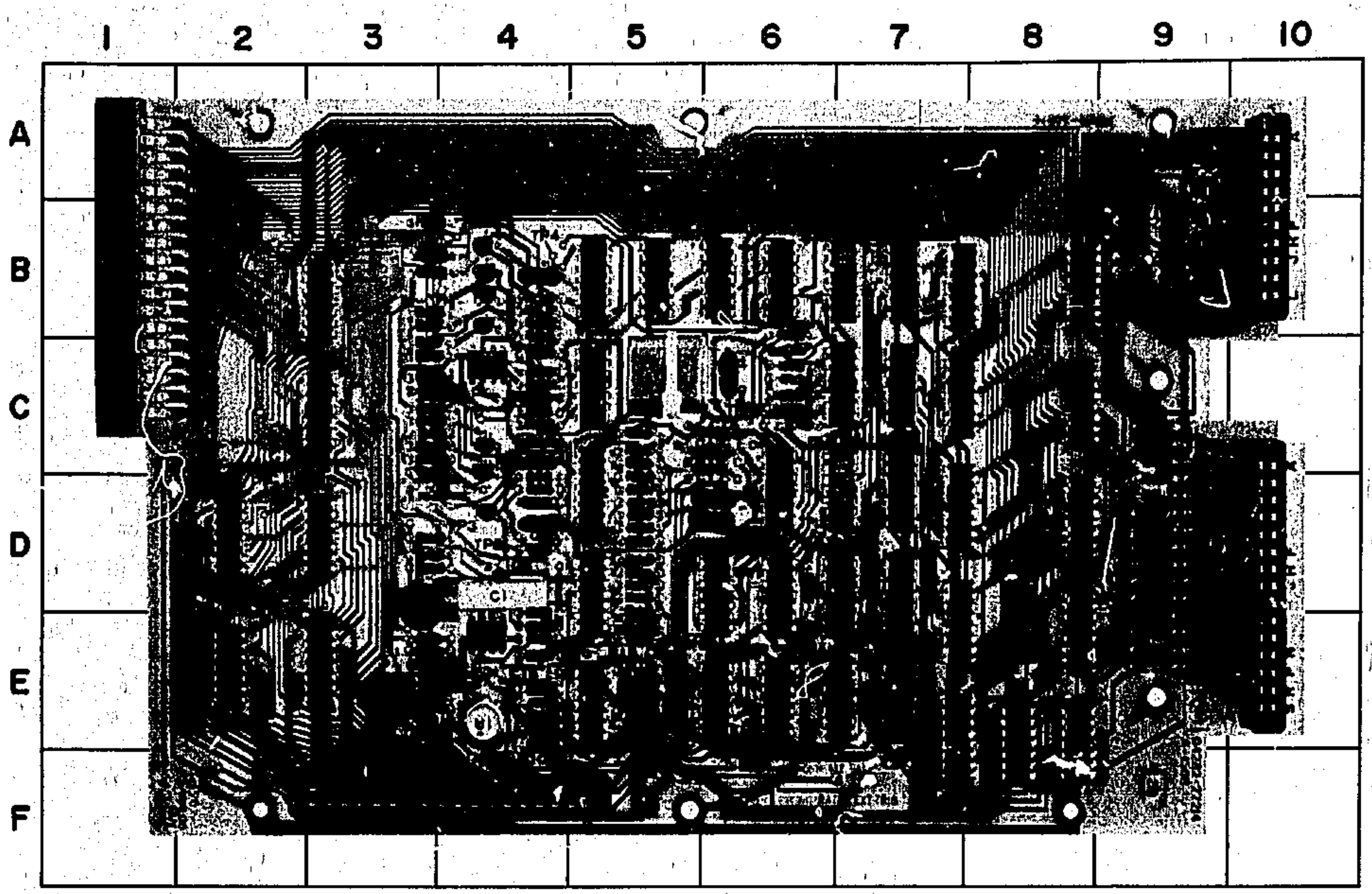
Reference Designations

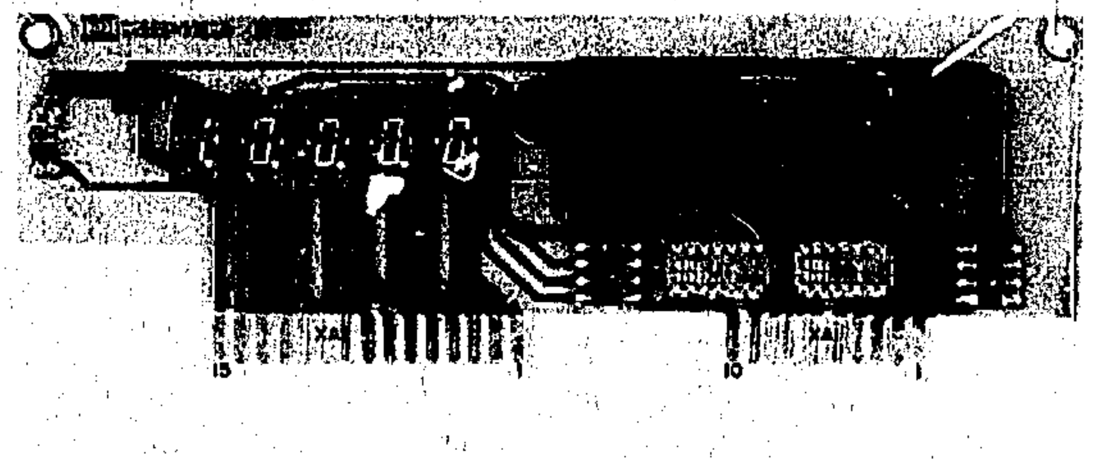
A4
U21 - 26 XA1, 3, 4

Table of Active Components

Reference Designations	HP Part Number
A4	
U21, 24	1820-0054
U22	1820-0072
U23	1820-0511
U25, 26	1820-0368

Figure 8-17. A4 DVM Board Ass'y. (Unit & Decimal Point Logic)





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C23	C-7	R90	D-9	U27	B-7
C24	F-7	R91	D-9	U28	C-7
		R92	D-9	U29	D-7
R76	C-9	R93	D-9	U30	D-7
R77	C-9	R94	D-9	U31	E-7
R78	D-9	R95	D-9	U32	B-8
R79	C-9	R96	D-9	U33	D-8
R80	C-9	R97	E-9	U34	D-8
R81	C-9	R98	D-9	U35	E-8
R82	D-9	R99	E-9	U36	C-8
R83	D-9	R100	E-9	U37	B-8
R84	D-9	R101	D-9	U38	C-8
R85	D-9	R102	E-9	U39	D-7
R86	D-9	R103	E-9	U40	E-7
R87	D-9				
R88	D-9	U19	E-8	XA2	D-10
R89	D-9	U20	E-8	XA3	F-3

SEE INSIDE

Figure 8-17
A4 DVM Board Ass'y
(Unit & Decimal Point Logic)

A4 DVM BOARD OPERATION

Counter, Buffer Storage and Decoder Circuits.

These circuits form three stages and are connected in cascade. Counter U27 to U31 consists of three different counters. U27 to U29 are decade counters, U30 is ÷4 counter and U31 is ÷3 counter, for a total maximum counting capacity of 11,999. Counter U27 to U31 is reset to zero by Set Pulse at beginning of busy period. Then Counter continues to count 2.88MHz Clock divided by two while Clock Gate U10C opens. During this period, Counter provides overflow signal at U31(9) which goes to H at 8,000 counts and returns to L at 12,000 counts. When Clock Gate U10C is closed, Counter holds result which is BCD and which represents input voltage.

Next stage is Buffer Storage U32 to U35 whose input is BCD output from Counter and whose output is previous data. The transfer between input and output is performed by Transfer Pulse issued at end of each busy period. Therefore, Buffer Storage holds data transferred for one reading period. Input for U32 to U34 is up to 9 decimal numbers and for U35 is up to 11 (to allow overranging). U19B/C and U20A/B are employed to take up this carry and enable display for overranging digit. U36, 1st Digit Enable, sends U32 output to Decoder when Function is C. In other functions, all four lines hold H to blank 1st digit.

Buffer Storage output is connected to Decoder and DIGITAL OUT J5 connector. Decoder U37 to U40 in last stage is BCD to seven segment decoder. Decoder enables to display appropriate number according to input BCD.

A5 DISPLAY BOARD OPERATION

This Assembly contains Seven Segment Numeric Display DS1 to DS4, Polarity and Overrange Display DS5, Annunciators DS6 to DS11, Rate Annunciator DS12, Unit Display DS13 to DS21 and Inverters U1 and U2. DS1 to DS5 are LED including decimal point each segment of which illuminates when corresponding pin is L (low level). Decimal point is valid only in DS3 to DS5. DS6 to DS11 light when the line is L and indicate that displayed data is invalid. DS12 is single LED which illuminates for busy period. DS13 to DS21 display measuring unit when the line is H (high level) because inputs are inverted by Inverters U1 and U2.

A4 & A5 Parts Locations under Fold

SECTION VII
MANUAL CHANGES AND OPTIONS

7-1. OPTIONS.

7-2. Options are standard modifications performed on -hp- instruments at the factory. Option 001 for Leakage Current Measurements is a currently available option. Operating instructions and other option 001 information are covered in manual corresponding to that for standard instrument.

7-3. SPECIAL INSTRUMENTS.

7-4. "Specials" are standard -hp- instruments that are modified according to customer specifications. A separate insert sheet is included with the manual for special instruments having electrical changes. Make the changes specified in addition to any other changes that are necessary.

7-5. MANUAL CHANGES.

7-6. This manual applies direcly to the Model 4282A with serials prefixed 1515. The following paragraphs explain how to adapt this manual to apply to later instruments with higher serial prefix, or earlier instruments with 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.

7-7. LATER INSTRUMENT: If the serial prefix of your Model 4282A is above 1515, refer to a separate "Manual Changes" sheet supplied with this manual. Locate the serial prefix of your instrument and make the indicated changes.

7-8. EARLIER INSTRUMENTS.
(Backdating Changes):
If the serial prefix of your Model 4282A is below 1515, refer to Table 7-1 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 7-1. Manual Backdating Changes.

Serial Prefix or Number	Make Changes
1319J00170 and below	1

CHANGE 1

Page 6-2, Table 6-2,
A1: Change to HP Part No. 04262-77201; BOARD ASSY:OSCILLATOR.

Pages 6-2 thru 6-4, Table 6-2,
Delete following parts,

A1C29 thru C33, R109 thru R120 and U13 thru U15.

Add following parts,

A1C24: HP Part No. 0180-01C6; CAPACITOR:FXD 60µF ±20% 6VDC TA-SOLID.
A1C25: HP Part No. 0180-0374; CAPACITOR:FXD 10µF ±10% 20VDC TA SOLID.
A1CR29 thru C32: HP Part No. 1901-0040; DIODE SWITCHING SI 30V MAX VRM 50MA.
A1K13 and K14: HP Part No. 0490-0226; RELAY REED.
A1Q11: HP Part No. 1853-0051; TRANSISTOR:PNP SI.
A1Q12 and Q13: HP Part No. 1854-0071; TRANSISTOR:NPN SI.
A1R64: HP Part No. 2100-2655; RESISTOR:VAR TRMR 100kΩ 10% C.
A1R73 and R74: HP Part No. 0686-2045; RESISTOR:FXD 200kΩ5% .5W CC TUBULAR.
A1R75: HP Part No. 0698-4406; RESISTOR:FXD 115Ω 1% .125W F.
A1R76: HP Part No. 0698-3454; RESISTOR:FXD 215kΩ 1% .125W F TUBULAR.
A1R77: HP Part No. 0698-3460; RESISTOR:FXD 422kΩ 1% .125W F TUBULAR.
A1R78 and R81: HP Part No. 0757-0453; RESISTOR:FXD 30.1kΩ 1% .125W F TUBULAR.
A1R79 and R82: HP Part No. 0757-0467; RESISTOR:FXD 121kΩ 1% .125W F TUBULAR.
A1R80: HP Part No. 0757-0444; RESISTOR:FXD 12.1kΩ 1% .125W F TUBULAR.
A1U10: HP Part No. 1826-0092; IC:LIN OP. AMPL DUAL.

Page 6-3, Table 6-2 and page 8-11, Figure 8-6,
Delete A1CR50 and CR51.

Page 6-3, Table 6-2,
A1K7: Change to HP Part No. 0490-0226; RELAY REED.

Page 6-4, Table 6-2,
A1R62: Change to HP Part No. 0698-2218; RESISTOR:FXD 33.5kΩ 1% .125W MET FLM.
A1R63: Change to HP Part No. 2100-2216; RESISTOR:VAR 5kΩ ±10% .5W CER.
A1R88: Change to HP Part No. 2100-2060; RESISTOR:VAR 50Ω 20% CER.

Page 8-13, Figure 8-7,
Change Figure 8-7 partially as shown in Figure 7-1.

Page 8-11, Figure 8-6 (in Table of Active Components),
Delete CR50 and 51; 1902-3059.
Change Q10 to 1854-0071

Page 8-13, Figure 8-7 (in Table of Active Components),
Add Q11; 1853-0051, Q12 and Q13; 1854-0071, U10; 1826-0092, CR29 thru 32; 1901-0040.

Page 6-5, Table 6-2,
A2: Change to HP Part No. 04262-77202; BOARD ASSY:MULTIPLIER.

Page 6-6, Table 6-2,
A2CR15: Change to HP Part No. 1902-0184; DIODE:VREG 16.2V VZ .4W MAX.

Page 6-8, Table 6-2,
A2R74: Change to HP Part No. 0757-0199; RESISTOR:FXD 21.5kΩ 1% .125W F TUBULAR.
A2R75: Change to HP Part No. 0698-3454; RESISTOR:FXD 215kΩ 1% .125W F TUBULAR.

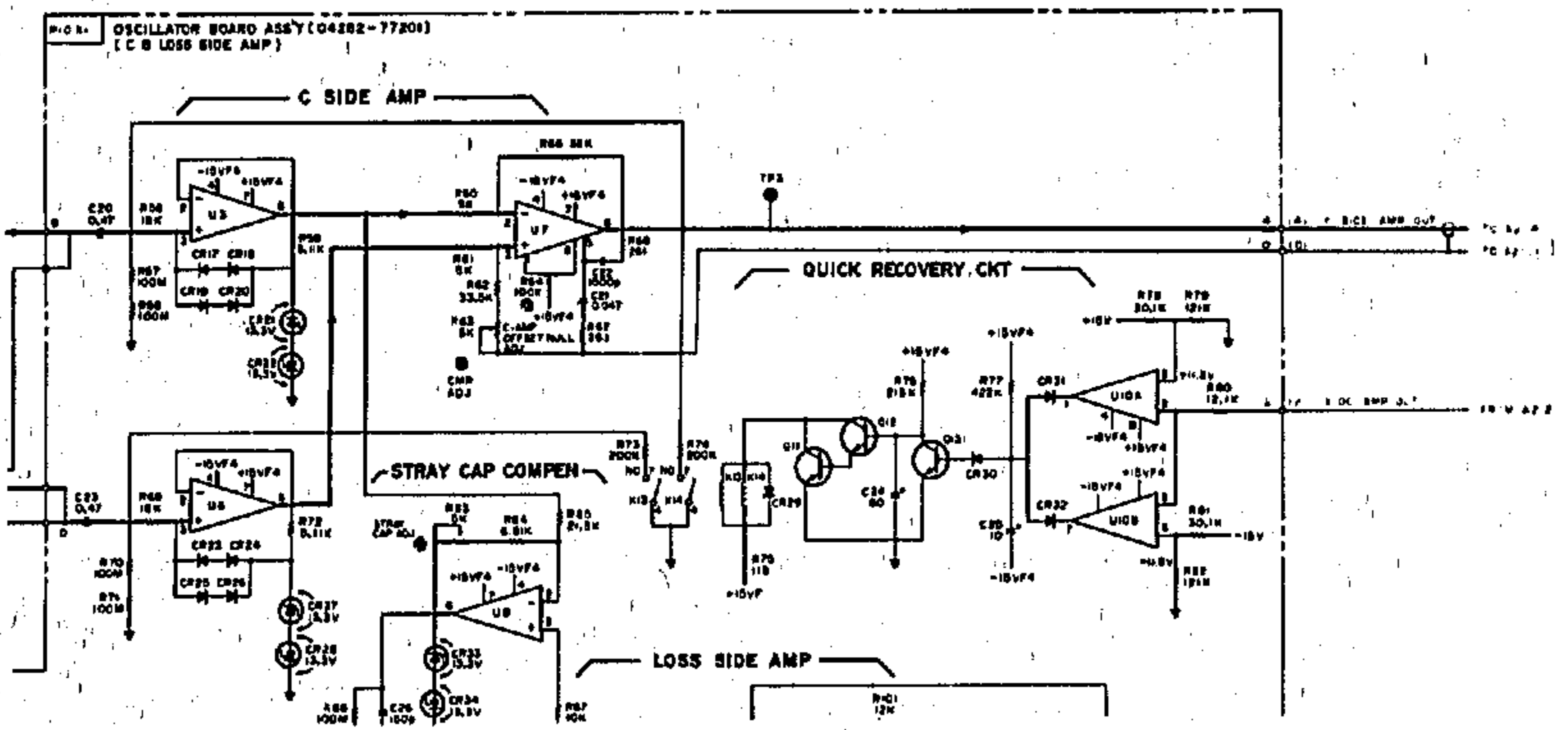

OSCILLATOR BOARD ASS'Y (04282-77201)
(C & LOSS SIDE AMP)
C SIDE AMP
QUICK RECOVERY CKT
STRAY CAP COMPEN
LOSS SIDE AMP

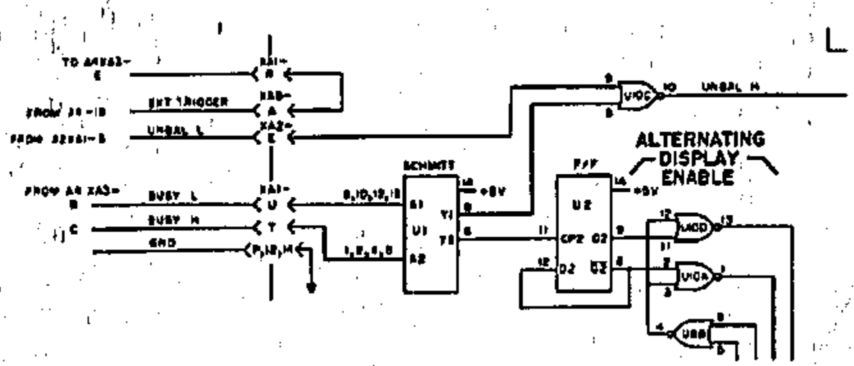
Figure 7-1.

Page 8-15, Figure 8-8,
Change Figure 8-8 partially as follows:

Page 8-15, Figure 8-8 (in Table of Active Components),
CR15: Change to 1902-0184.

Page 6-10, Table 6-2,
A3: Change to HP Part No. 04282-77203; BOARD ASSY:CONTROL.

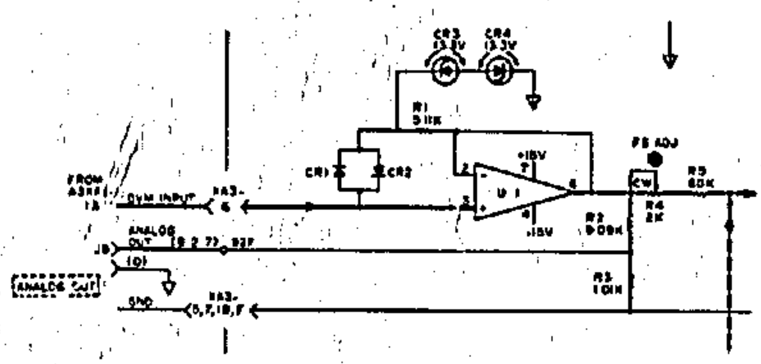
Page 8-21, Figure 8-11,
Change Figure 8-11 partially as follows:



Page 8-21, Figure 8-11 (in Table of Active Components),
Delete CR26.

Pages 6-12 through 6-14, Table 6-2,
A4: Change to HP Part No. 04282-77204; BOARD ASSY:DVM.
A4R58: Change to HP Part No. 0698-4431; RESISTOR:FXD 2.05kΩ 1% .125W F TUBULAR.
Delete following parts,
A4CR11, Q17, R104 and R105.

Page 8-29, Figure 8-15,
Change Figure 8-15 partially as follows:



Page 5-13, paragraph 5-54,
Replace with following paragraphs.

5-54. High Capacitance Ranges Adjustment (A1, A2).

5-55. This adjustment uses a standard capacitor (SOSHIN TM 520-C). Proceed as follows:

a. Set 4282A to same as paragraph 5-31 step a except set C RANGE to 10mF.

b. Set SOSHIN TM 520-C to 10mF.

c. Connect 16035A Test Leads to UNKNOWN connector.

d. Twist two current leads with each other (at lead five times) and also twist the two voltage lead together (see paragraph 3-34) and connect to SOSHIN TM-520-C.

e. Adjust 4282A display for certified 10mF capacitance value with A1R88 (10mF Range Adj.).

f. Set C RANGE and SOSHIN TM 520-C to 1F.

g. Adjust 4282A display for certified 1F capacitance value with A2R10 (1F Full-Scale Adj.).

Page 8-31, Figure 8-16,
Change Figure 8-16 partially as shown in Figure 7-2.

Page 8-31, Figure 8-16 (in Table of Active Components),
Delete CR11 and Q17.

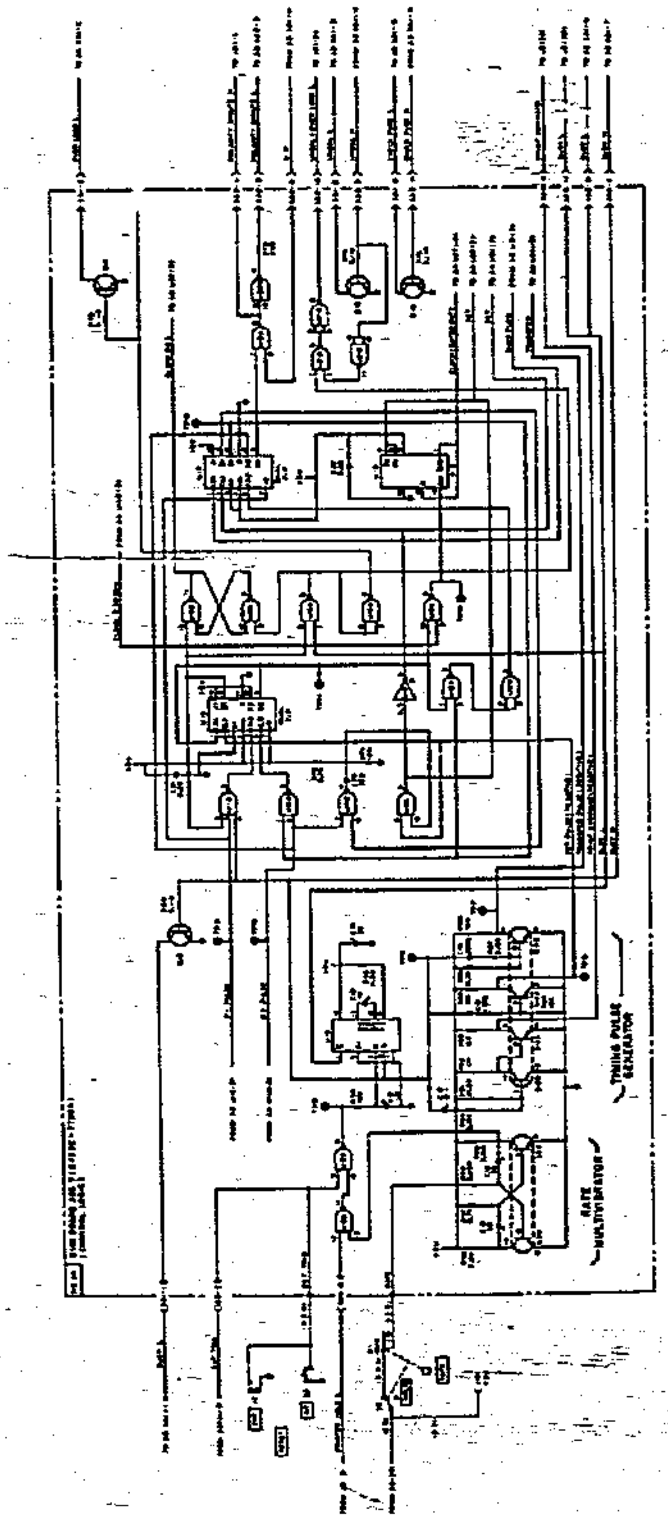


Figure 7-2.

SECTION VIII
CIRCUIT DIAGRAMS

8-1. INTRODUCTION.

8-2. This section includes the following:

a. General Notes for Schematic Diagrams.

b. Block Diagram.

c. Schematic Diagrams and part location illustrations.

d. Circuit Operations.

8-3. The Block Diagram or schematic diagrams can be unfolded and used with any other portion of the manual.

Resistance is in ohms, capacitance is in microfarads and inductance is in microhenries unless otherwise noted.

P/O = part of.

* Asterisk denotes a factory-selected value. Value shown is typical. Capacitors may be omitted or resistors jumpered.

L or H after signal name means the line goes to low or high level, respectively, when the signal is enabled.

R G (RELAY GROUND) or OPEN after signal name means the line is grounded or open, respectively, when the signal is enabled.

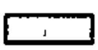
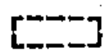
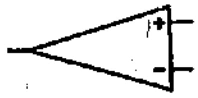
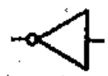
	Screwdriver adjustment.		Panel control.
	Encloses front panel designations.		Encloses rear panel designation.
	AND gate.		NAND gate.
	OR gate.		NOR gate.
	Exclusive OR gate.		Operational amplifier.
	Non-inverting.		Inverting.
	Assembly circuit common.		Floating circuit common.
	Chassis ground.		Protective ground.

Figure 8-1. Schematic Diagram Notes (sheet 1 of 2).

Circuit assembly borderline.

Other assembly borderline.

Heavy line with arrows indicates path and direction of main signal.

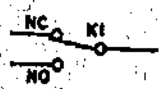
Heavy dashed line with arrows indicates path and direction of main feedback.

Wiper moves toward CW with clockwise rotation of control as viewed from shaft or knob.

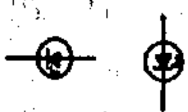
Shows location and number of test point.

(9-4-7) Encloses wire color code. Code used (MIL-STD-681) is the same as resistor color code. First number identifies the base color, second number the wider stripe, and third number identifies narrower stripe (e.g., 947 denotes white base, yellow wide stripe and violet narrow stripe).

A1 (5) Shows square pin number used in circuit assembly [e.g., A1(5) denotes pin 5 in A1 assembly].



Indicates NC are normally closed contacts and NO are narmally open contacts when relay K1 is not energized.


Voltage regulator (breakdown diode).

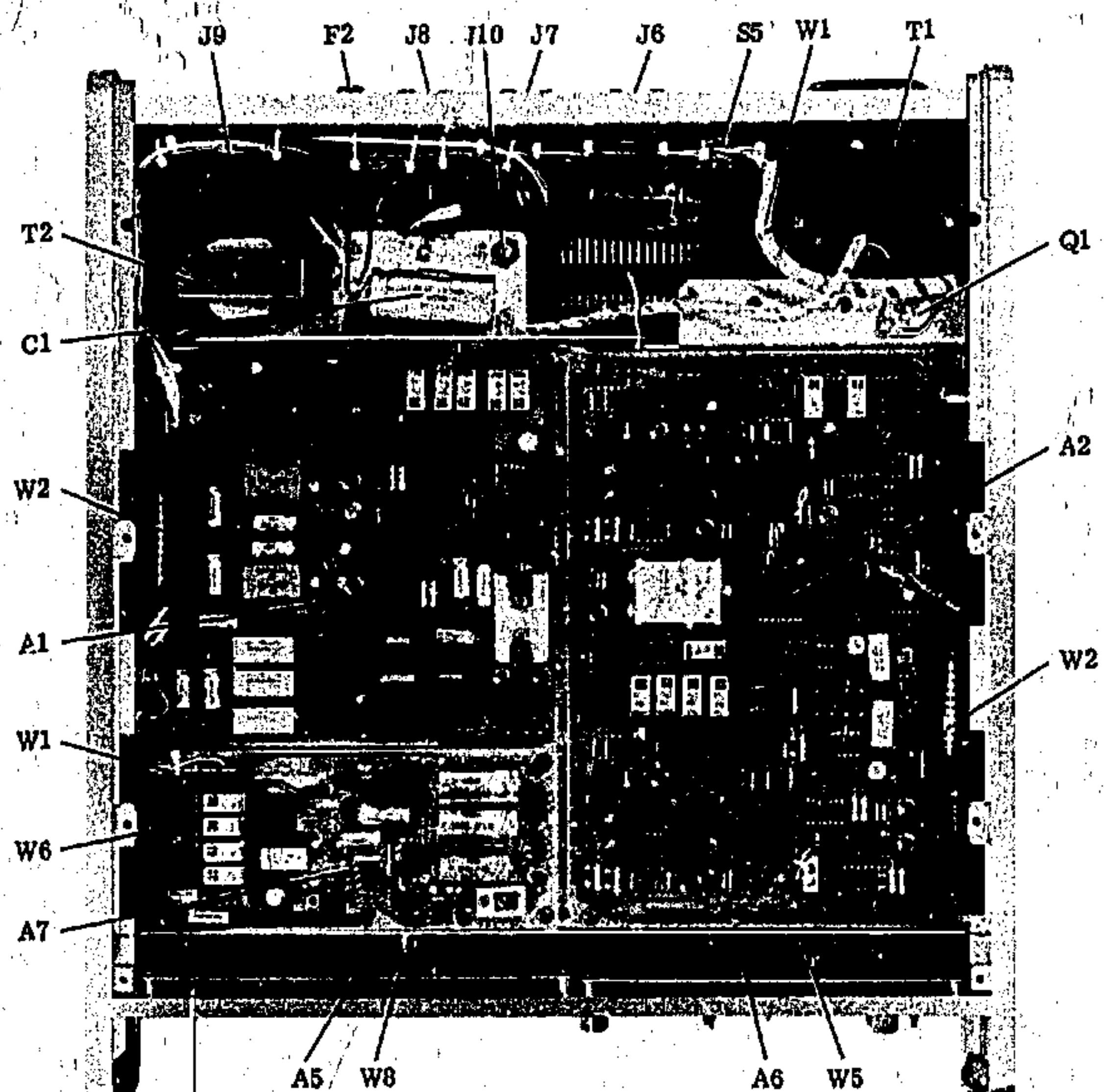

Field Effect transistor (FET) with N-type base.


FET with P-type base.


Tunnel diode.


Light emitting diode (LED).

Figure 8-1. Schematic Diagram Notes (sheet 2 of 2).



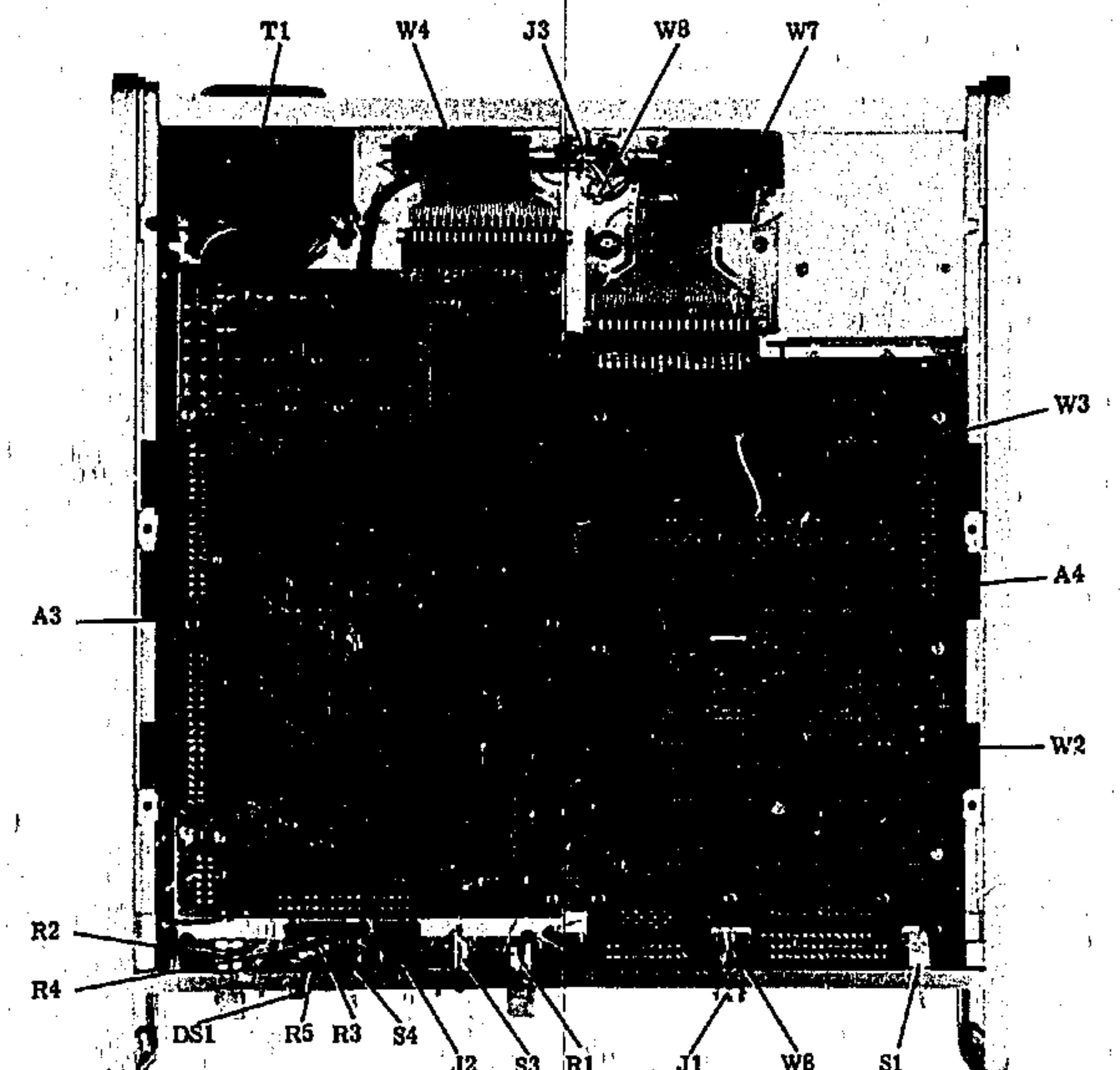


Figure 8-2. Assembly Location.

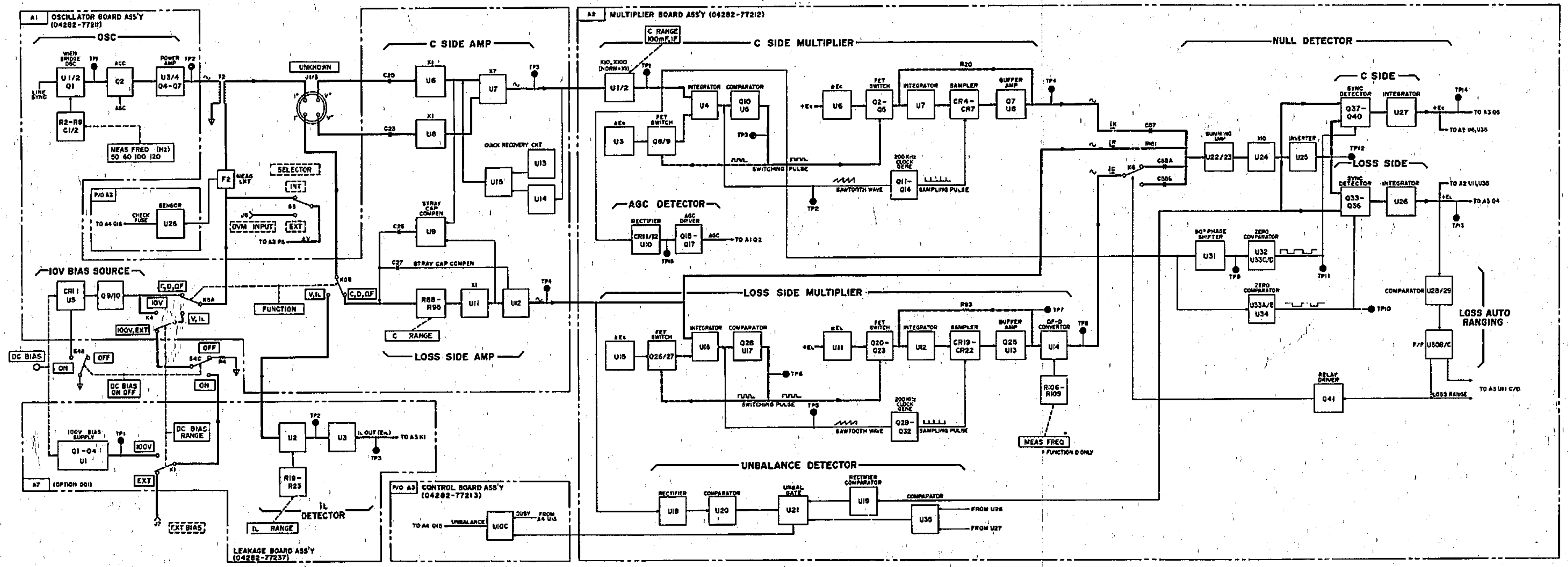


Figure 8-3. Block Diagram - Bridge Section.

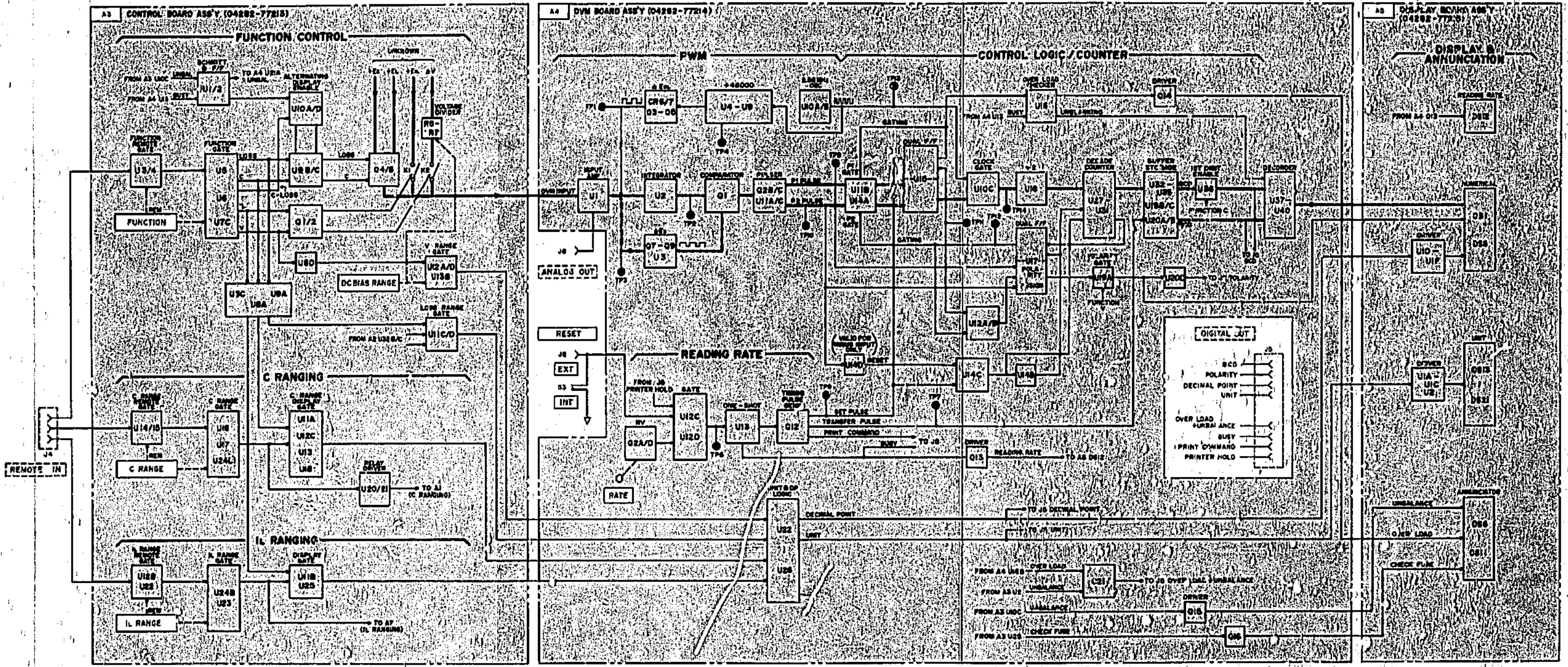


Figure 8-4. Block Diagram - Logic Section.

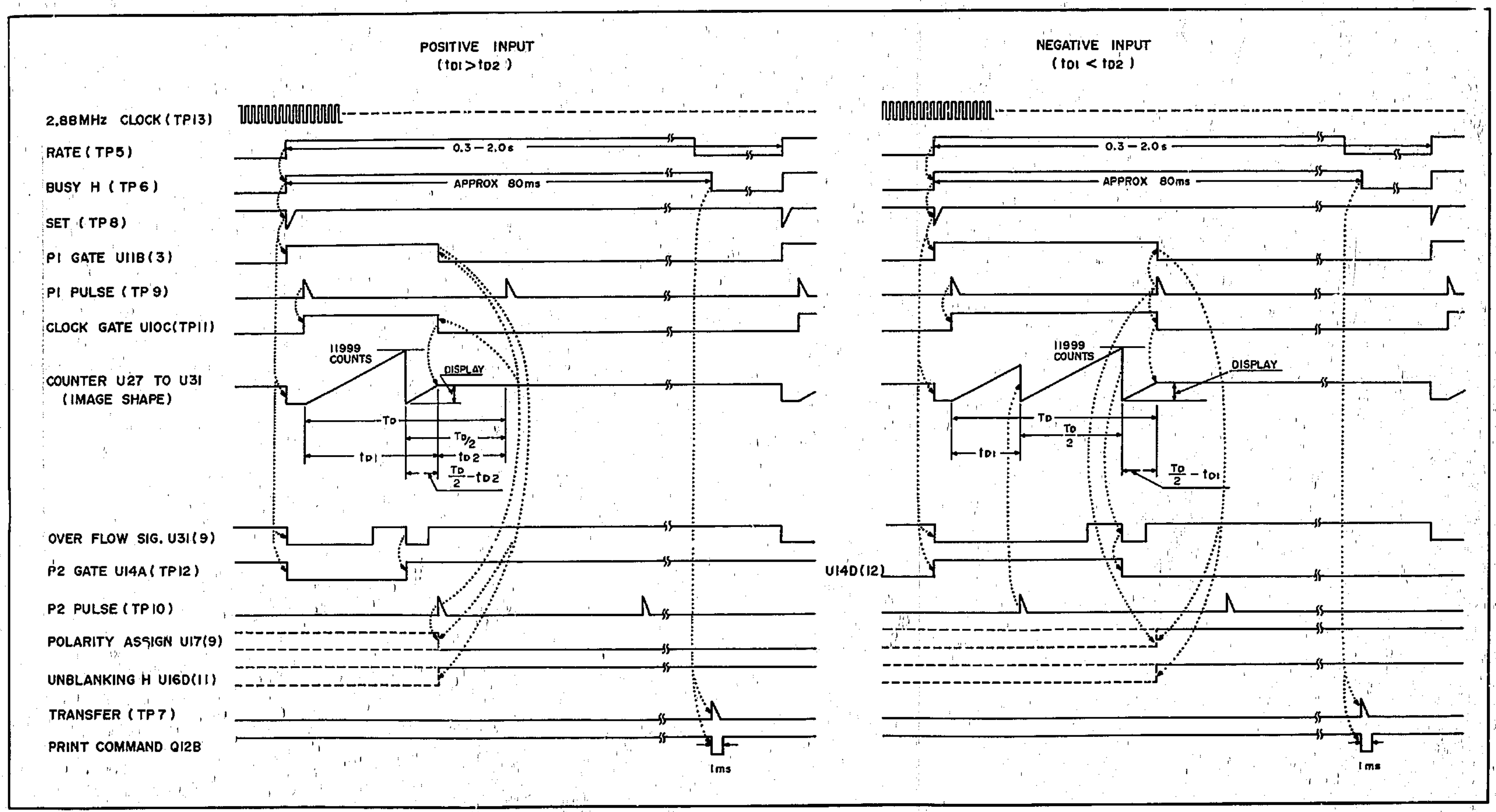
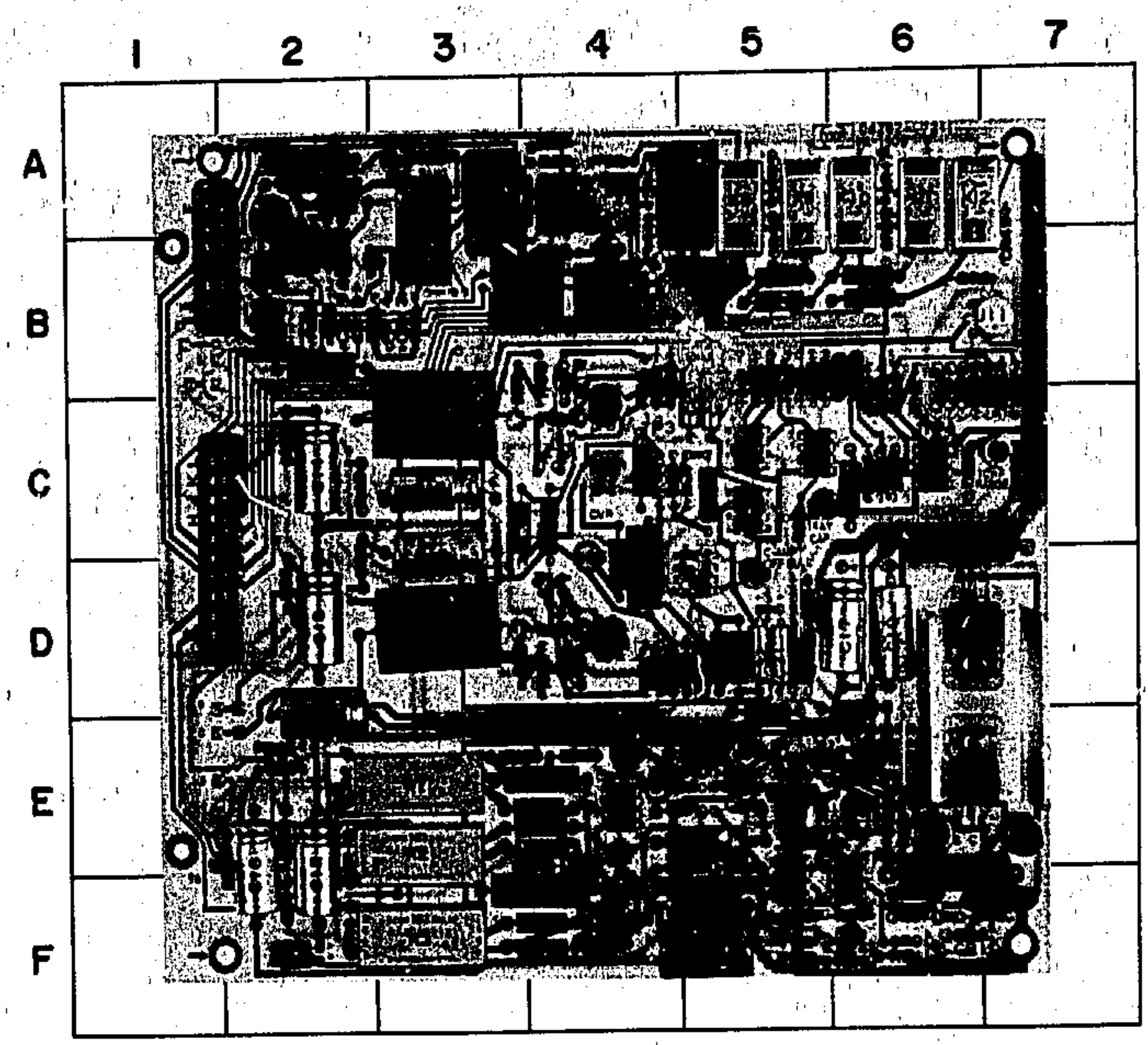


Figure 8-5. DVM Timing Diagram.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	F-5	C14	C-2	CR8	F-6	K3	F-3	Q10	A-2	R12	E-5	R25	E-6	R38	A-2	R51	E-2
C2	F-5	C15	C-3	CR9	F-6	K4	A-3			R13	F-4	R26	E-5	R39	B-2	R52	D-2
C3	E-5	C16	E-2	CR10	F-6	K5	A-3	R1	F-2	R14	E-4	R27	E-6	R40	B-2	R53	D-2
C4	E-5	C17	D-6	CR11	B-2			R2	E-4	R15	E-4	R28	F-6	R41	B-3		
C5	F-5	C18	D-2	CR12	A-2	Q1	E-4	R3	E-4	R16	E-4	R29	E-6	R42	B-2	U1	F-4
C6	E-5	C19	C-3	CR13	B-3	Q2	E-5	R4	F-4	R17	E-5	R30	E-6	R43	B-3	U2	E-4
C7	E-5			CR14	B-3	Q3	F-6	R5	F-5	R18	E-4	R31	F-6	R44	E-5	U3	F-5
C8	F-7	CR1	E-2	CR15	B-2	Q4	E-6	R6	E-4	R19	E-4	R32	F-6	R45	E-6	U4	F-6
C9	B-2	CR2	E-2	CR16	B-2	Q5	E-7	R7	E-4	R20	F-6	R33	F-6	R46	E-2	U5	B-2
C10	D-6	CR3	F-3	CR50	F-2	Q6	E-6	R8	F-4	R21	F-6	R34	D-6	R47	E-2		
C11	E-5	CR4	E-5	CR51	F-2	Q7	D-6	R9	F-4	R22	F-5	R35	B-2	R48	C-2	XA1	B-1
C12	E-2	CR5	E-3			Q8	B-2	R10	E-4	R23	F-5	R36	B-2	R49	C-2	XA2	C-1
C13	E-2	CR6	E-5	K1	E-3	Q9	B-2	R11	E-4	R24	F-6	R37	A-2	R50	E-1		
		CR7	F-6	K2	E-3												

SEE INSIDE

Figure 8-5
DVM Timing Diagram

A1 OSCILLATOR BOARD OPERATION

Measuring Signal Generator.

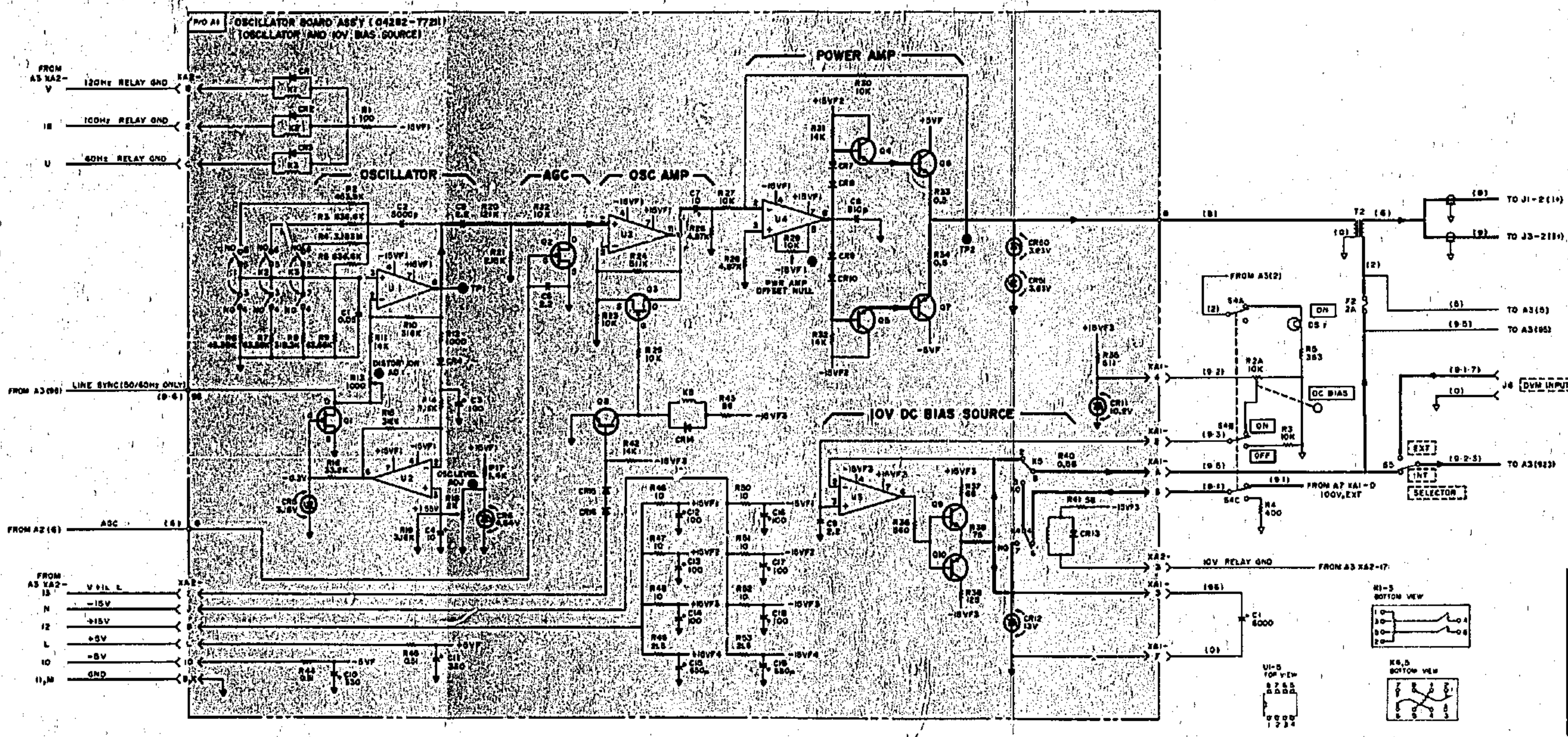
This section is the signal source of Bridge and consists of an oscillator, amplifier and power amplifier. The oscillator employs the Wien Bridge technique and provides four measuring frequencies of 50, 60, 100 and 120Hz. Selection and determination of frequency are done by relays K1, K2 and K3 which select R2 through R9 in combination with C1 and C2. FET Q1 is driven by U2 whose input is difference between Peak Detector CR4 output and reference voltage established by CR6. Q1 operates to maintain voltage ratio at U1(2) at one twenty first of voltage at U1(6) (because, for example, C1 is ten times of C2, R9 is one tenth of R5 at 50Hz setting, and so on). Output at U1(6) can be changed or maintained by potentiometer R18. When MEAS FREQ switch is set to 50 or 60Hz, line synchronous signal is applied to Q1 drain to synchronize frequency to line frequency.

AGC(Q2) only operates when C range is set to 100mF or 1F. On these two ranges, range is determined not by changing range resistances but by increasing amplifier A2U1, U2 gain from 1 to 10 or to 100. Amplifiers could be saturated depending upon unknown values. To prevent this, appropriate AGC signals reduce measuring signal level. Amplifier U3 amplifies oscillator signal to furnish sufficient drive to Power Amplifier. Both Q2 and Q3 turn on when function is set to V or I_L (option 001) which operate to extinguish oscillator signal. The Power Amplifier, which is comprised of U4 and Q4 through Q7, has unity gain and the capability to feed maximum signal current of about 660mA (equivalent to 1A) through transformer T2 which has a turns ratio of three to two. Q4, Q6 and Q5, A7 form a complementary push-pull circuit.

10V DC Bias Source.

A 10 volts DC Bias Source is provided by reference diode CR11, differential amplifier U5 and power amplifier Q9 and Q10. Bias voltage is controlled by DC BIAS control R2A. Maximum current is about 100mA.

A1 Parts Locations under Fold



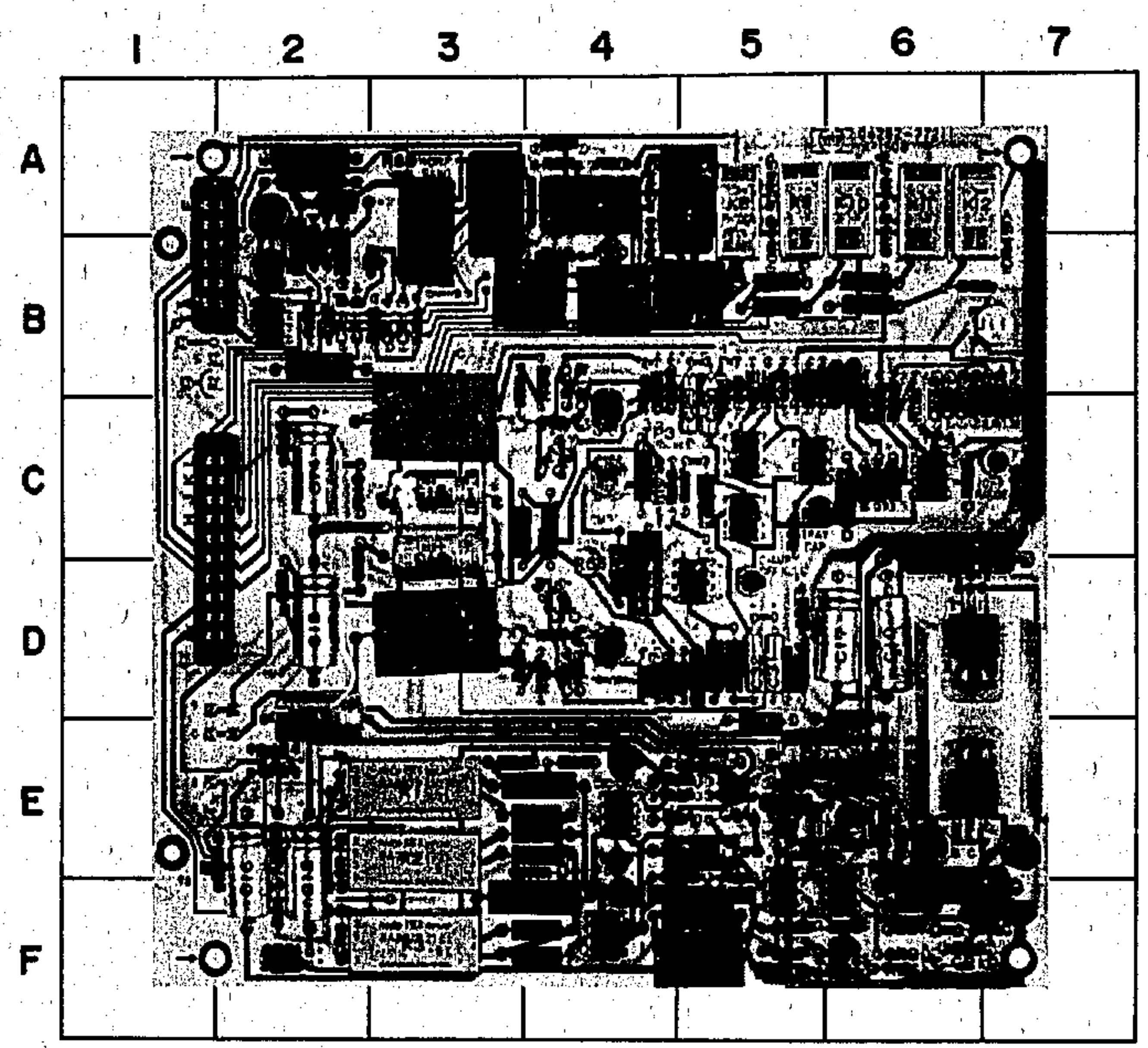
Reference Designations

NO PREFIX	A1
C1 DS1 F2 J6 R2 - 5 S4, 5 T2	C1 - 19 CR1 - 16, 50, 51 K1 - 5 Q1 - 10 R1 - 53 U1 - 5 XA1, 2

Table of Active Components.

Reference Designations	HP Part Number
A1	
CR1 - 4, 7 - 10	1901-0040
CR13 - 16	1901-0040
CR5	1902-3036
CR50, 51	1902-3059
CR6	1902-3082
CR11	1902-3183
CR12	1902-0643
Q1	1855-0087
Q2, 3	1855-0081
Q4, 9	1854-0090
Q5	1853-0051
Q6	1854-0127
Q7	1853-0106
Q8	1853-0020
Q10	1853-0051
U1 - 5	1820-0216

Figure 8-6. A1 Oscillator Board Ass'y. (Oscillator and 10V Bias Source)



PARTS LOCATOR

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C20	C-3	CR20	B-4	CR34	D-5	CR48	A-6	Q11	D-5	R63	D-5	R78	B-5	R92	B-5	R107	B-5
C21	D-5	CR21	C-4	CR35	B-6	CR49	B-7	Q12	D-5	R64	B-4	R79	B-5	R93	B-5	R108	A-3
C22	C-5	CR22	C-4	CR36	B-7			Q13	D-5	R66	C-4	R80	B-5	R94	B-6		
C23	D-3	CR23	D-4	CR37	B-6	K5	A-2			R67	D-5	R81	B-5	R95	B-6	U6	C-4
C24	D-5	CR24	D-4	CR38	B-6	K6	A-4	R43	B-3	R68	C-5	R82	B-5	R96	B-7	U7	C-5
C25	D-5	CR25	D-4	CR39	B-7	K7	A-5	R54	A-4	R69	D-4	R83	C-5	R97	B-7	U8	D-4
C26	B-6	CR26	D-4	CR40	B-7	K8	A-5	R55	A-4	R70	D-3	R84	C-5	R98	B-6	U9	C-5
C27	B-6	CR27	D-4	CR41	C-6	K9	A-5	R56	C-4	R71	D-4	R85	B-5	R99	B-6	U10	C-5
C28	C-6	CR28	D-4	CR42	C-6	K10	A-6	R57	C-3	R72	D-4	R86	B-5	R100	B-6	U11	B-7
		CR29	D-4	CR43	A-4	K11	A-6	R58	B-4	R73	D-3	R87	B-5	R101	B-6	U12	C-6
CR14	B-3	CR30	D-5	CR44	B-4	K12	A-7	R59	B-4	R74	C-3	R88	A-3	R103	C-6		
CR17	C-4	CR31	C-5	CR45	A-5	K13	C-4	R60	C-5	R75	D-4	R89	B-4	R104	C-7	XA1	B-1
CR18	C-4	CR32	C-5	CR46	A-5	K14	C-4	R61	D-5	R76	C-5	R90	B-4	R105	C-7		
CR19	B-4	CR33	D-5	CR47	A-6			R62	D-5	R77	C-5	R91	B-5	R106	C-6		

MEASURING CIRCUIT OPERATION

C, D, and ΩF Measurements.

Both UNKNOWN connectors J1 (front) and J3 (rear) each have the two current terminals and the two voltage terminals required for Four-Terminal operation. Measuring current from T2 appears at current terminal I^+ and flows through unknown to current terminal I^- into the range resistors in A1. Voltage terminals detect voltage across unknown and send it to C Side Amplifier in A1. When dc bias is superimposed, dc bias is fed from A1XA1-A and applied to unknown through T2. Quick action fuse F2 (2A) works to protect measuring circuit from excessive current. If fuse blows, measuring signal becomes input of Check Fuse Sensor in A3.

V (Voltage) Measurement.

When FUNCTION is set to V, voltage across unknown is connected to DVM Board (A4) through Control Board (A3). Both external input voltage and biasing voltages up to 600V are measureable. Selection is made with DVM INPUT SELECTOR switch S5.

I_L Measurement (Option 001).

When FUNCTION is set to I_L or V and DC BIAS ON-OFF switch S4 to ON, dc bias is fed from A1XA1-A and applied to unknown through current lead I^+. Leakage current through unknown is connected to A1XA1-6 and fed to Leakage Current Board (A7) through current lead I^-. A7 assembly converts this current to voltage. When S4 is set to OFF, discharge resistor R4 is connected to unknown.

SEE INSIDE

Figure 8-6
A1 Oscillator Board Ass'y
(Oscillator and 10V Bias Source)

A1 OSCILLATOR BOARD OPERATION
(C and Loss Side Amplifier Section).

C Side Amplifier.

The C side Amplifier contains two Impedance Converters U6 and U8 plus Amplifier U7. The impedance converters, whose inputs are connected to voltage terminals V^+ or V^-, provide high input impedance so as not to affect unknown. Amplifier U7 amplifies voltage across unknown seven times and sends an output opposite in phase to Multiplier Board A2. CR17 to CR22 and CR23 to CR28 form a protective circuit for large changes of dc bias. U13 to U15 provides negative feed back loop for stable dc offset nulling.

Loss Side Amplifier.

The Loss Side Amplifier includes C Range resistors R88 to R95, Impedance Converter U11 and Amplifier U12. Measuring signal goes to ground through current lead I^- and selected C Range Resistor. Impedance Converter U11 sends voltage across C Range resistor to Amplifier U12. U12 amplifies U11 output and provides an output in phase with measuring current which is sent to Multiplier Board A2.

Stray Capacitance Compensation Circuit.

Differential amplifier U9 and C26 compensate for stray capacitance between measuring leads and C27 compensates for stray capacitance of C Range Resistors.

A1 Part Locations under Fold

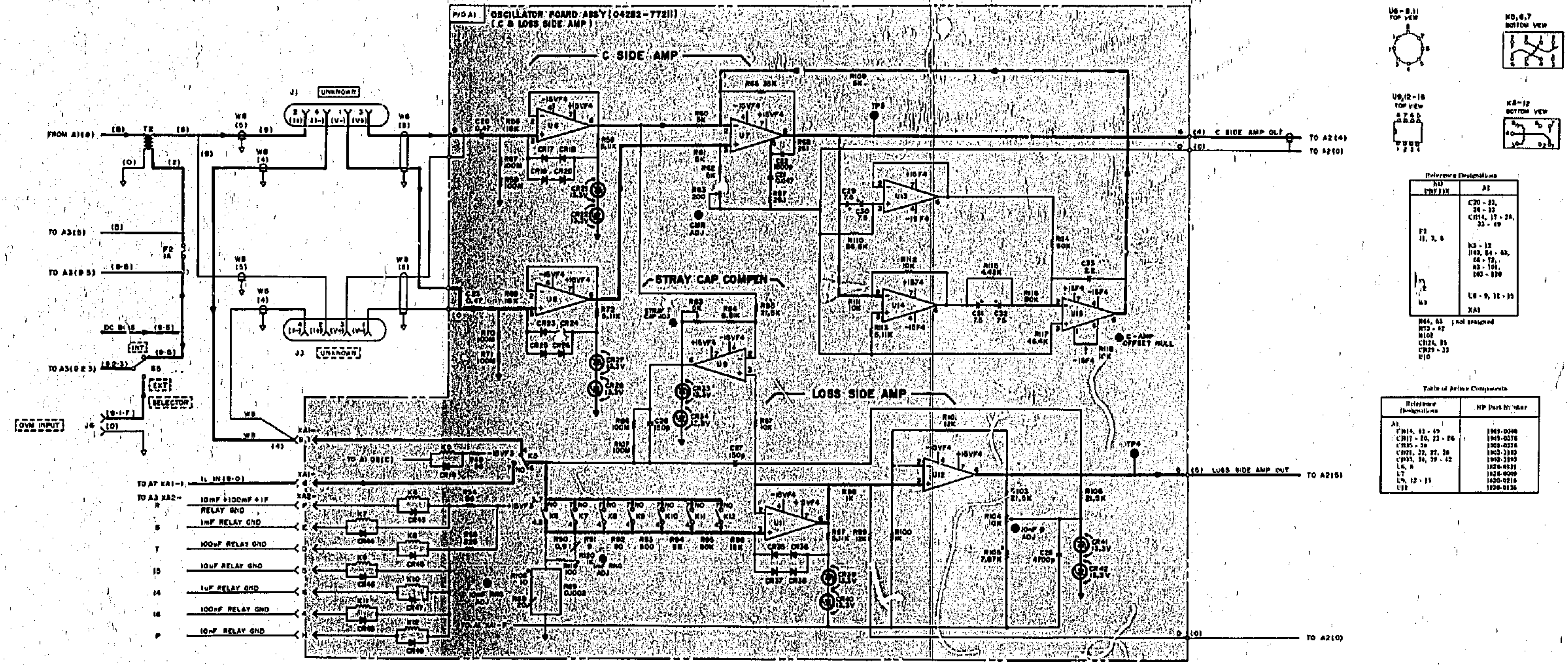
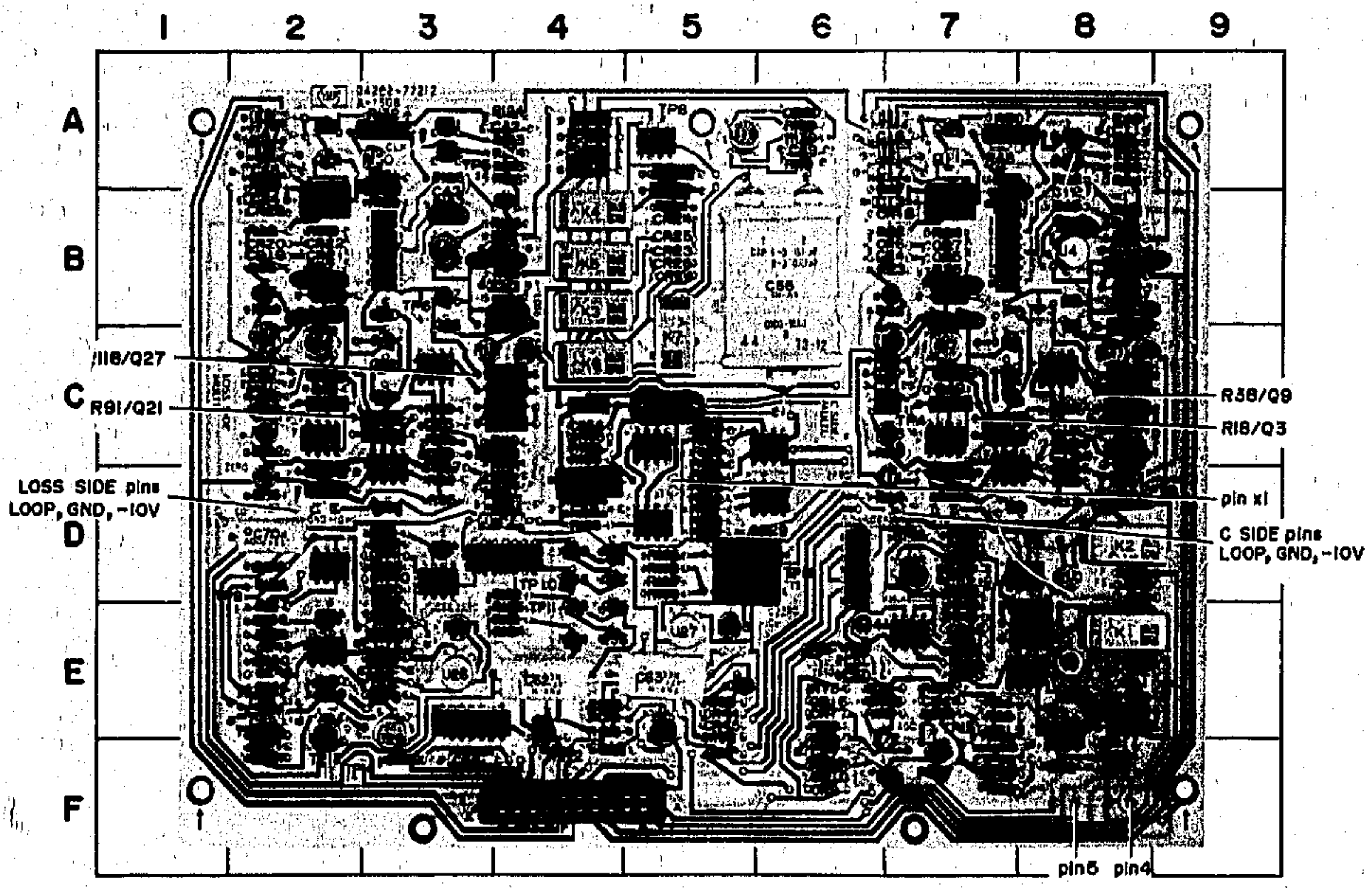


Figure 8-7. A1 Oscillator Board Ass'y. (C & Loss Side Amp)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	E-8	Q4	C-7	R39	C-8
C2	D-7	Q5	C-7	R40	B-8
C3	B-7	Q6	C-6	R41	B-8
C4	C-7	Q7	B-6	R42	B-8
C5	B-7	Q8	B-8	R43	A-8
C6	D-8	Q9	B-8	R44	B-8
C7	D-8	Q10	B-8	R45	B-8
C8	C-2	Q11	A-7	R46	B-7
C9	B-8	Q12	A-7	R47	B-6
C10	B-8	Q13	A-8	R48	A-7
C11	A-8	Q14	A-8	R49	B-7
C12	B-8	Q15	E-7	R50	A-7
C13	B-6	Q16	F-6	R51	A-8
C14	B-7	Q17	F-7	R52	A-8
C15	A-7			R53	A-8
C16	A-6	R1	E-8	R54	C-8
C17	A-6	R2	D-8	R55	C-6
C18	C-8	R3	E-8	R56	B-8
C19	C-8	R4	E-8	R57	C-8
C20	C-6	R5	E-8	R58	C-6
C21	C-6	R6	E-8	R59	B-8
C22	B-8	R7	D-8	R60	F-8
C23	B-8	R8	E-8	R61	E-8
C24	D-8	R9	D-7	R62	F-8
C25	E-7	R10	D-8	R63	F-8
C26	F-7	R11	D-6	R64	E-7
C27	E-6	R12	D-6	R65	E-7
		R13	D-7	R66	F-7
CR1	E-8	R14	D-7	R67	E-7
CR2	E-8	R15	D-8	R68	F-7
CR3	D-8	R16	D-8	R69	E-7
CR4	B-6	R17	C-7	R70	E-6
CR5	B-7	R18	C-7	R71	E-6
CR6	B-6	R19	C-7	R72	E-6
CR7	B-7	R20	C-7	R73	E-6
CR8	C-8	R21	B-7	R74	E-6
CR9	F-6	R22	B-6	R75	E-6
CR10	F-6	R23	B-6	R76	F-6
CR11	E-8	R24	B-6		
CR12	E-8	R25	B-7	T1	B-7
CR13	E-7	R26	B-6		
CR14	E-7	R27	C-6	U1	E-7
CR15	E-6	R28	C-6	U2	D-7
CR16	E-6	R29	C-6	U3	C-8
CR17	E-6	R30	C-8	U4	B-8
CR13	B-6	R31	C-8	U5	B-7
		R32	C-8	U6	C-7
K1	E-8	R33	D-8	U7	C-7
K2	D-8	R34	C-8	U8	C-7
		R35	D-8	U10	E-8
Q1	D-7	R36	C-8		
Q2	B-7	R37	C-8	XA1	F-4
Q3	C-7	R38	C-8		

SEE INSIDE

Figure 8-7

A1 Oscillator Board Ass'y
(C & Loss Side Amp)

A2 MULTIPLIER BOARD OPERATION
(C Side Multiplier and AGC Detector Section).

C Side Multiplier.

The C Side Multiplier, shown in top section of schematic Figure 8-8, produces the product of C Side Amplifier output in A1 and C Side Integrator output (E_C) in A2. Amplifiers U1 and U2 (x10 and x100) have a gains of 1 below a C Range 10mF and increase their gains to 10 on 100mF range and to 100 on 1F range. U2 output is applied to integrator U4. The $\pm E_S$ Generator CR8 and U3 provide plus and minus references through R38 and R37, respectively. The $+E_S$ is switched by FET Switch Q8 and Q9 as U4 input goes to zero during one period of 200kHz clock. U4 output produces both positive and negative going ramps during one clock period. Changing of ramp polarity occurs at the same level of U4 output and sawtooth waveform of Q14 in 200kHz Clock Generator. This is sensed by Comparator Q10, which changes state of U5C and U5B whose output is connected to FET Switch Q8 and Q9 (to complete negative feedback loop) and also to FET switch Q2 to Q5. U5 is driven in negative domain to match action of FET Switches and provides a waveform modulated to pulse width by U2 output.

The $\pm E_C$ Generator U6 accepts C Side Integrator output ($+E_C$) and develops $-E_C$. Q1 is temperature compensator for U6. The $+E_C$ is connected to Integrator U7 through R17 and the $-E_C$ is connected to U7 through R18 and FET Switch Q2 to Q5 which is switched by timing from U5. U7 integrates the sum of these two inputs. U7 output through Q6 is sampled by applying sampling pulse issued at each end of sawtooth from T1 in 200kHz Clock Generator to Sampler (CR4 to CR7) and is stored in C5. Charge stored in C5 maintains input to Buffer Amplifier Q7 and U8. Therefore, U8 output forms staircase which is similar to and in phase with C Side Amp output in A1. Negative feedback loop through R20 operates to cancel result of previous integration. The heart of 200kHz Clock Generator is the Blocking Oscillator (Q11, T1 and CR18). This provides two outputs, one is sampling pulse of 10V peak at T1 (1-2) and the other is sawtooth at Q14 emitter.

AGC Detector.

AGC Detector, shown on bottom section of schematic Figure 8-8, provides a valid signal only when C Range is 100mF or 1F to reduce Oscillator signal level in A1 according to conditions of U1 and U2. On the other ranges, U2 output never exceeds about 7Vrms but on two ranges the 7Vrms may be exceeded which saturates U1 and U2 due to increased gain. Rectifier CR11 and CR12 and U10 rectifies U2 output and sends it to Smoothing Circuit and again to AGC Driver Q16. Q16 emitter level is normally negative and goes towards positive when U2 output increases. Q17 is on when Function is V or I_L to break out Oscillator signal in A1.

A2 Parts Locations under Fold

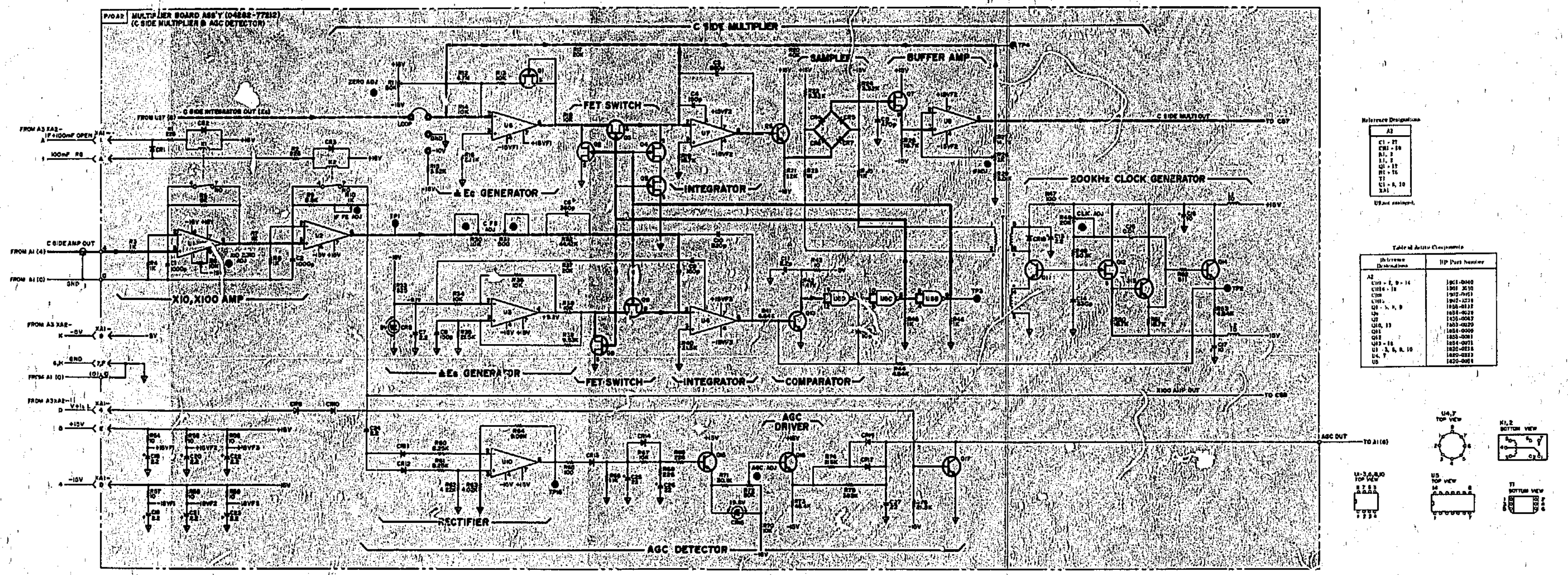
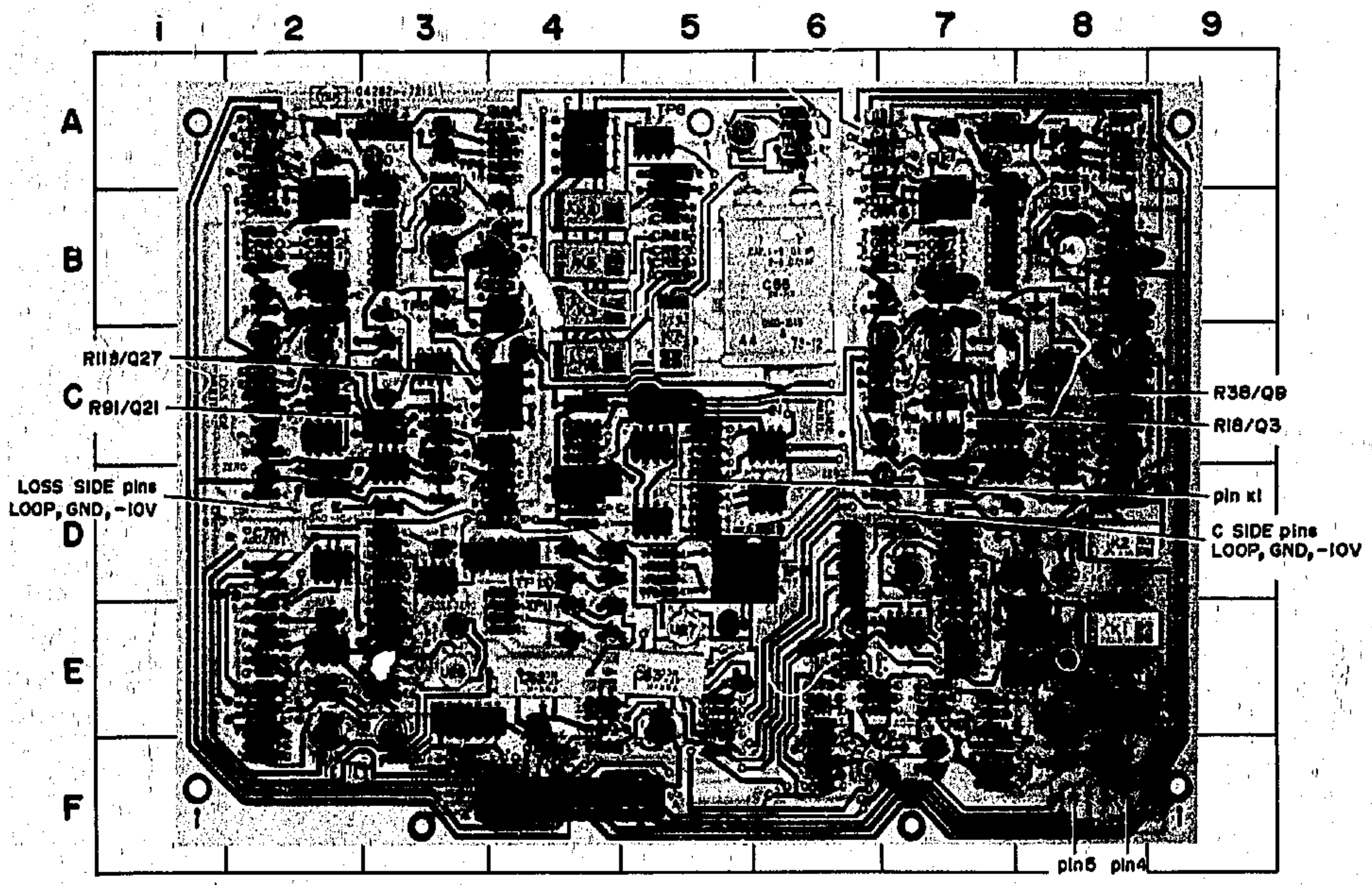


Figure 8-8. A2 Multiplier Board Ass'y.
(C Side Multiplier & AGC Detector)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C28	C-3	Q19	D-3	R115	C-4
C29	C-3	Q20	B-3	R116	C-4
C30	C-2	Q21	C-3	R117	C-3
C31	C-2	Q22	C-3	R118	C-4
C32	B-4	Q23	C-3	R119	C-4
C33	B-4	Q24	C-2	R120	B-4
C34	C-2	Q25	B-2	R121	C-4
C35	B-2	Q26	B-3	R122	B-4
C36	B-2	Q27	B-3	R123	D-4
C37	D-4	Q28	B-4	R124	A-4
C38	C-4	Q29	A-2	R125	A-3
C39	B-4	Q30	A-2	R126	A-4
C40	B-3	Q31	A-3	R127	B-3
C41	B-4	Q32	A-3	R128	B-3
C42	A-4			R129	B-2
C43	B-3	R77	E-5	R130	A-3
C44	B-2	R78	C-3	R131	A-3
C45	B-3	R79	C-3	R132	A-3
C46	A-3	R80	C-2	R133	A-4
C47	A-2	R81	C-2	R134	A-4
C48	A-2	R82	B-4	R135	A-4
C49	A-6	R83	B-4	R136	D-5
C50	E-6	R84	D-2	R137	D-5
C51	E-6	R85	D-3	R138	A-6
C52	D-7	R86	D-2	R139	A-6
C53	D-7	R87	D-2	R140	E-7
C54	E-6	R88	C-2	R141	E-6
		R89	D-3	R142	E-7
CR19	B-2	R90	C-3	R143	E-7
CR20	B-2	R91	C-3	R144	E-6
CR21	B-2	R92	C-2	R145	E-7
CR22	B-2	R93	C-2	R146	D-7
CR23	B-5	R94	B-2	R147	D-7
CR24	B-5	R95	B-2	R148	D-7
CR25	B-5	R96	B-2	R149	D-7
CR26	B-5	R97	B-2	R150	D-7
CR27	C-3	R98	B-2		
CR28	B-2	R99	B-2	T2	B-2
CR29	D-5	R100	C-2		
CR30	A-6	R101	C-2	U11	C-3
CR31	E-7	R102	C-2	U12	C-2
CR32	E-7	R103	E-5	U13	C-2
CR33	D-7	R104	B-5	U14	A-5
		R105	A-4	U15	C-3
K3	B-4	R106	A-4	U16	B-3
K4	B-4	R107	A-4	U17	B-3
K5	B-4	R108	A-4	U18	E-7
K6	C-4	R109	B-5	U19	A-5
		R110	A-6	U20	D-7
L3	A-2	R111	A-5	U21	D-6
L4	A-2	R112	C-4		
		R113	C-4	XA1	F-4
Q18	E-5	R114	C-4		

SEE INSIDE

Figure 8-8
A2 Multiplier Board Ass'y
(C Side Multiplier & AGC Detector)

A2 MULTIPLIER BOARD OPERATION
(Loss Side Multiplier and Unbalance Detector Section).

Loss Side Multiplier.

Loss Side Multiplier produces the product of Loss Side Integrator output (E_L) in A2 and Loss Side Amplifier output in A1. This operation is very similar to C Side Multiplier. Loss Side Amplifier output is sent to Integrator U16 and reference resistor R151. The $\pm E_S$ Generator CR27 and U15 provides plus and minus references through R118 and R121, respectively. The $+E_S$ is switched by FET Switch Q26 and Q27 as U16 input goes to zero during one period of 200kHz Clock. U16 output produces positive and negative going ramps in one clock period. Changing of ramp polarity occurs at the same level of U16 output and sawtooth waveform of Q32 in 200kHz Clock Generator. This is sensed by Comparator Q28, which changes state of U17C and U17B whose output is connected to FET Switch Q26 and Q27 to complete negative feedback loop and also to FET switch Q20 to Q23. U17 is driven in negative domain to match operation of FET Switches and provides waveform modulated to pulse width by Loss Side Amp output in A1.

The $\pm E_L$ Generator U11 accepts Loss Side Integrator output ($+E_L$) and provides $-E_L$. Q19 is temperature compensator for U11. The $+E_L$ is connected to Integrator U12 through R90 and $-E_L$ is connected to U12 through R91 and FET Switch Q20 to Q23 which is switched by timing from U17. U12 integrates the sum of these two inputs. U12 output through Q24 is sampled by applying sampling pulse, issued at each end of sawtooth from T2 in 200kHz Clock Generator, to Sampler (CR19 to CR22) and is stored in C36. Charge stored in C36 maintains input of Buffer Amplifier Q25 and U13. Therefore, U13 output forms staircase which is similar to and 180° out of phase with Loss Side Amp output in A1. Negative feedback loop through R93 operates to cancel result of previous integration. Following stage, U14, is ΩF-D Converter. The gain is one for Function ΩF and is $1000/2\pi f$ for Function D (f is measuring frequency in Hz). The heart of 200kHz Clock Generator is the Blocking Oscillator (Q29, T2 and CR28). This provides two outputs, one is a sampling pulse of 10V peak at T2(1-2) and the other is sawtooth at Q32 emitter.

Unbalance Detector.

Unbalance Detector judges unbalance condition from three sources of information. The first is sensed by U18 and U20 when unknown capacitance is too low compared to C Range setting. The second is by U19 when an error signal always exists on Null Detector. The third is by A2U35 when E_C or E_L exceeds +12V. U18 and CR31 plus CR32 form a Rectifier and the smoothed output is applied to Comparator U20. U20 output goes to L (low level) when the level at U20(3) goes lower than at U20(2), which means that Loss Side Amp output is too small. If an error signal exists, it is rectified by CR29 and fed to Comparator U19. U19(6) goes L when the level at U19(2) exceeds that at U19(3). Either one, when conditioned, drives Gate U21D(11) to H (high level) and also U21B(6) L. Finally, A2U35 output goes to L when E_C or E_L exceed +12V and similarly makes U21A(3) H, and U21B (6) L. Gate U21B is disabled when Function is V or I_L.

A2 Parts Locations under Fold

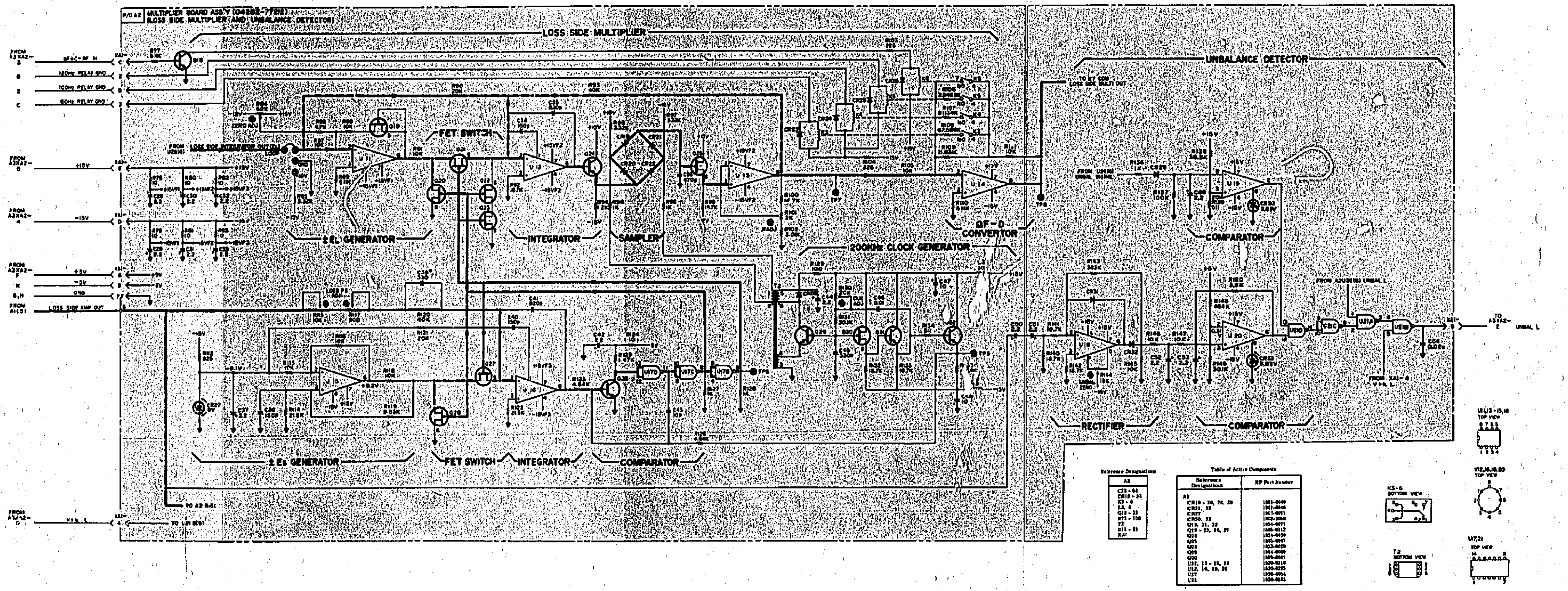
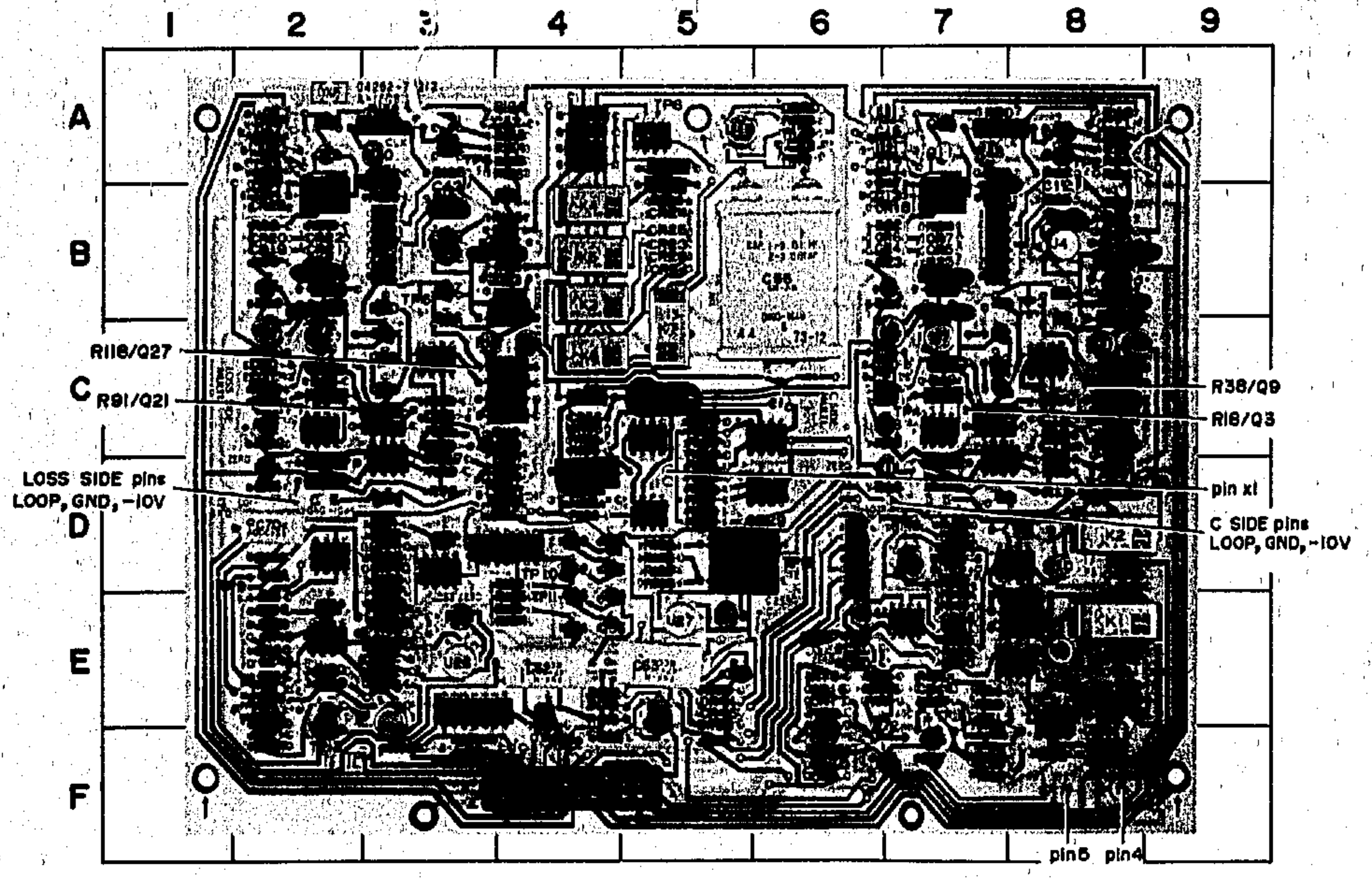


Figure 8-9. A2 Multiplier Board Ass'y. (Loss Side Multiplier and Unbalance Detector)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C55	B-6	Q35	D-4	R179	E-3
C57	C-5	Q36	D-4	R180	D-3
C58	D-4	Q37	D-4	R181	D-3
C59	D-4	Q38	D-4	R182	D-3
C60	D-5	Q39	D-4	R183	D-3
C61	D-5	Q40	D-4	R184	E-4
C62	E-4	Q41	E-4	R185	D-4
C63	E-5	Q42	D-3	R186	E-2
C64	E-3	Q43	E-2	R187	D-3
C65	E-3			R188	E-2
C66	E-3	R151	C-4	R189	E-2
C67	D-4	R152	C-4	R190	E-2
C68	E-2	R153	C-4	R191	E-4
C69	E-2	R154	C-5	R192	D-4
C70	D-2	R155	D-4	R193	E-5
C71	D-3	R156	C-5	R194	E-4
C72	D-3	R157	C-5	R195	E-4
		R158	C-5	R196	E-4
CR34	B-5	R159	D-5		
CR35	C-4	R160	D-5	U22	C-5
CR36	C-4	R161	D-5	U23	D-5
CR37	E-2	R162	D-5	U24	C-6
CR38	E-2	R163	D-5	U25	D-6
CR39	E-3	R164	D-5	U26	E-3
CR40	D-3	R165	D-5	U27	E-5
CR41	D-3	R166	D-5	U28	E-2
CR42	E-2	R167	E-3	U29	E-3
CR43	E-2	R168	E-5	U30	E-3
CR44	E-5	R169	E-2	U31	D-2
CR45	E-5	R170	E-2	U32	D-3
CR46	E-4	R171	E-2	U33	D-4
		R172	E-4	U34	E-2
K7	C-5	R173	E-4	U35	E-5
		R174	E-3		
L5	D-4	R175	E-3	XA1	F-4
		R176	D-2		
Q33	E-4	R177	D-2		
Q34	E-4	R178	D-2		

SEE INSIDE

Figure 8-9
A2 Multiplier Board Ass'y
(Loss Side Multiplier and Unbalance Detector)

A2 MULTIPLIER BOARD OPERATION

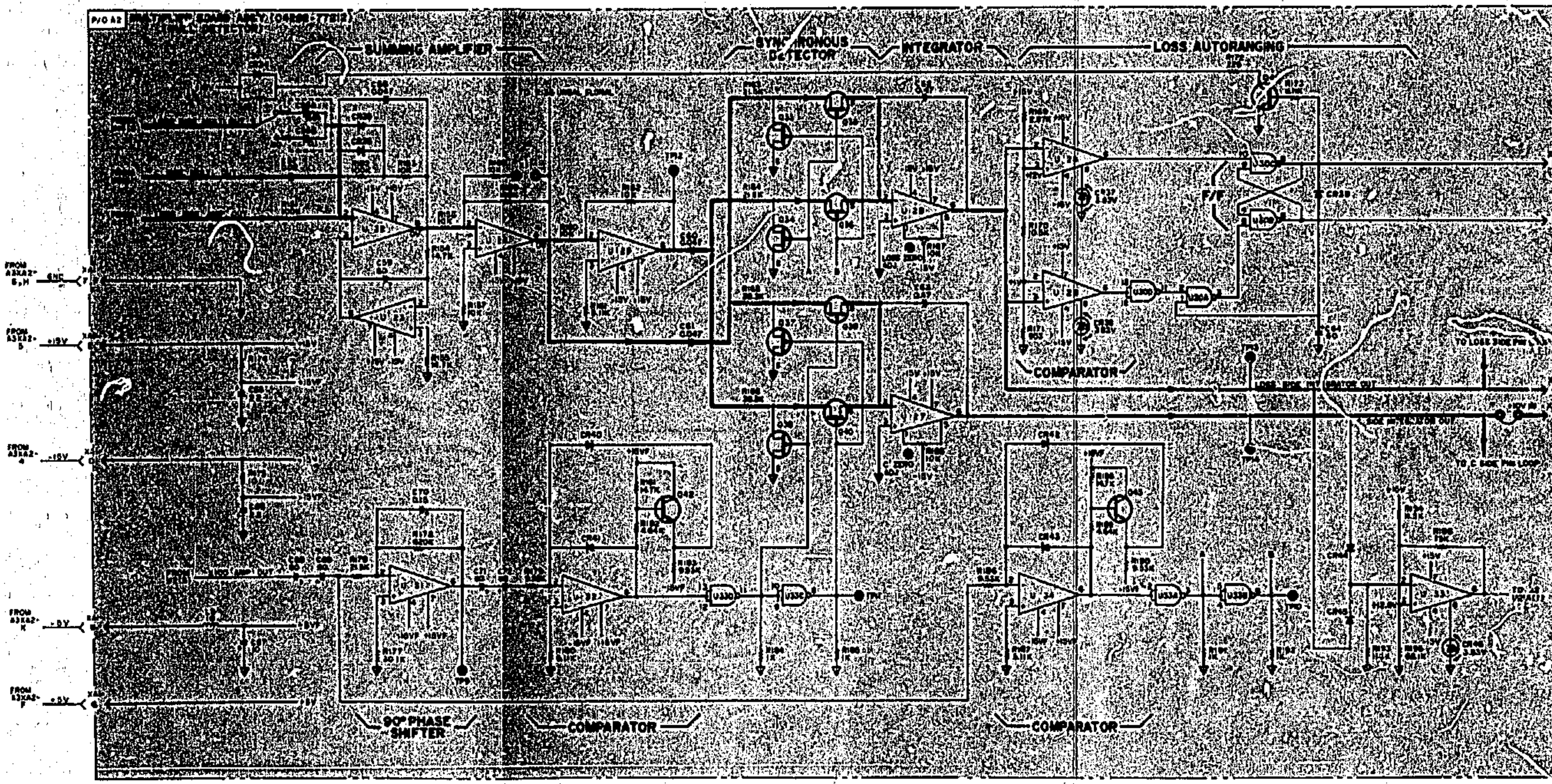
Null Detector Section.

This section contains Summing Amplifier U22 to U24, Synchronous Detectors Q33 to Q40 and Integrators U26 and U27. Also included are Loss Auto Ranging Circuit U28 to U30 and Synchronous Detector Driver U31 to U34.

The three outputs, C Side Multiplier, Loss Side Multiplier and Loss Side Amplifier, are fed to Standard Capacitors C57 and C55 and Standard Resistor R151, respectively. They are summed at summing node of U22(2). U22 detects the summed difference as error and feeds it to U24. CR35 and CR36 work to reduce gain of U22 to prevent saturation during balancing process. U23 is employed to verify zero of dc level at U22(6). U24, which has a gain of 10, amplifies error signal and feeds it to Sync Detectors. One input is fed directly and the other is fed through Inverter U25. The two Sync Detector (FET Switches) are driven by pulses having a 90° phase difference with each other. Therefore, the two Detectors detect in phase and 90° phase different components and feed them to Integrators U26 (Loss Side) and U27 (C Side), respectively. U26 and U27 integrate error signals detected and provide outputs as E_L and E_C.

Loss Auto ranging Circuit selects proper Loss Range from two available ranges. This information is received from Comparators U28 and U29. U28(6) is L when U28(2) is above about +12V. Since U29(6) is H, F/F U30B/C is H at U30(8) and L at U30(6). This means up-ranging is required so Q41 is turned on to energize K7 to connect Standard Capacitor C55B. This operates to reduce U26 output E_L to one-tenth. Additionally, CR39 is turned off and U28A(1) is maintained L which prevents frequent range changing until charge of C64 reaches H. On the other hand, when E_L is below about +1V, U29(3) goes to L. This makes U30B(5) L. Since U30C(10) is H, F/F changes state as U30C(8) is L and U30B(6) is H. This means down-ranging is required so Q41 is turned off to connect C55A. Synchronous Detector Driver circuitry includes 90° Phase Shifter U31 and two comparators U32 and U34. U31 provides a sine wave 90° out of phase with input. U32 produces a square wave output in phase with U31 output. U33D/C is driven in negative domain to match operation of FET Switches. U34 also produces square wave in phase with input. U33A/B are similar to U33C/D.

A2 Parts Locations under Fold



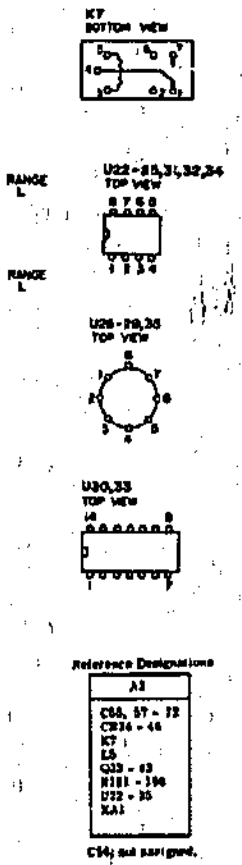
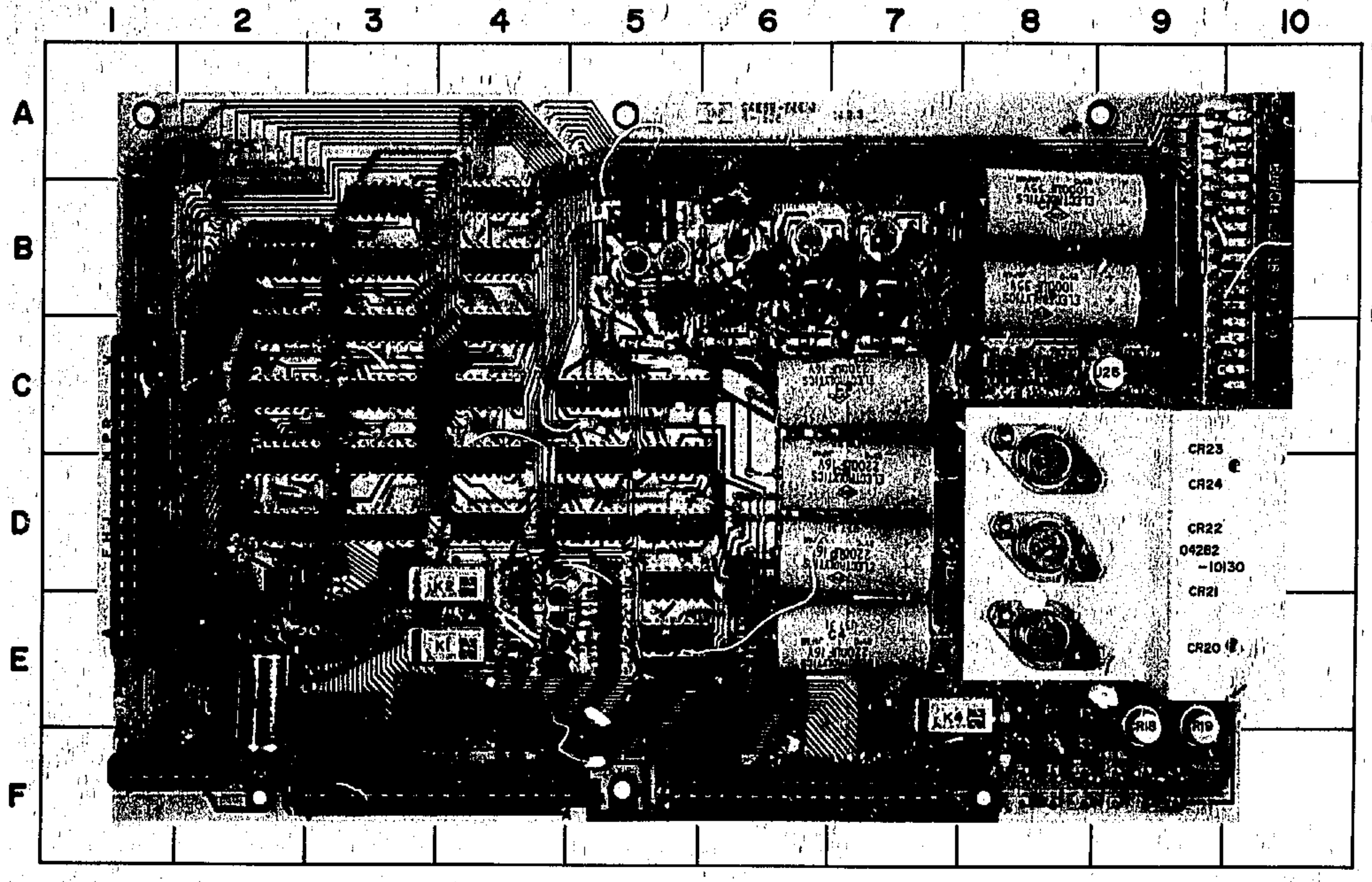
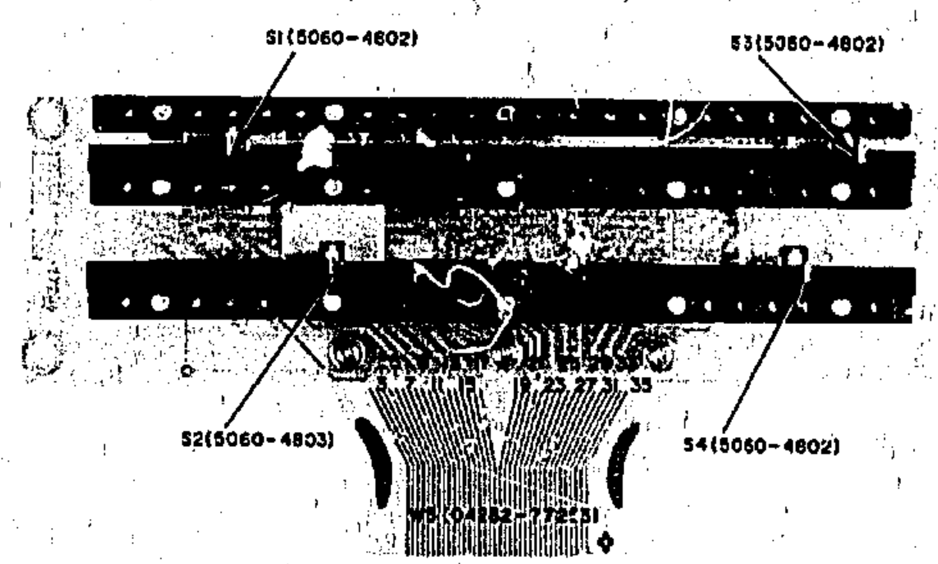


Table of Active Components.

Reference Designation	HP Part Number
A2	
CR34 - 36, 40 - 45	1901-0040
CR37, 38, 46	1902-3081
CR39	1910-0016
Q33 - 40	1855-0233
Q41 - 43	1854-0071
U22 - 25, 31, 32, 34	1820-0224
U26, 27	5080-3831
U28, 29, 35	1820-0223
U30, 33	1820-0054

Figure 8-10. A2 Multiplier Board Ass'y. (Null Detector)





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C20	D-5	R1	E-4	U1	E-5
		R2	E-4	U2	D-5
CR1	E-4	R3	D-4	U3	C-5
CR2	E-3	R4	E-4	U4	D-4
CR3	E-2	R[illegible]	D-2	U5	D-5
CR4	D-4	R6	D-2	U6	D-4
CR5	D-5	R7	D-2	U7	C-5
CR6	E-5	R8	E-3	U8	D-5
CR7	D-5	R9	D-4	U9	D-5
CR8	E-5	R10	D-4	U10	D-5
CR9	E-4	R11	D-5	U11	C-2
CR26	D-5	R12	D-5	U12	D-2
		R13	E-5	U13	D-3
K1	E-4	R14	E-5		
K2	D-4	R15	E-5	XA1	F-6
K3	E-2	R16	E-[illegible]	XA2	F-3
		R17	E-5	XA3	F-1
Q1	E-4	R18	E-4	XA4	D-1
Q2	E-4	R19	C-9	XA5	B-10
Q3	D-4	R20	B-9		
Q4	D-4	R21	B-2		
Q5	E-4	R52	E-5		
Q6	E-4	R53	D-6		

SEE INSIDE

Figure 8-10
A2 Multiplier Board Ass'y
(Null Detector)

A3 CONTROL BOARD OPERATION

Function Control Section.

This section contains the various logic circuits. For explanatory purposes (in text and in diagrams), H or L after function letter abbreviation shows TTL logic level when that function is enabled, e.g., C H shows that C signal line is at TTL high level when Function C is selected.

Function Remote Gate is enabled to allow Function to be remotely programmed when FUNCTION switch is set to REM. Function Gate provides H (high level) when either one input goes L (low level). When C Function is selected, U5B(4) or U5B(5) go to L and U5B(6) is H. This makes U9C (8) L and C Enable Switch Q6 turns on. Q6 on means that C Side Integrator A2U27 output E_C is connected to DVM input in A4. U5B(6) H also makes U6A(1) L to enable transfer of C Range information.

Similarly, when D or ΩF Function is selected, Q4 is turned on to Loss Side Integrator A2U26 whose output E_L is connected to DVM input. Then U9A(12) becomes L to enable transfer of Loss (D or ΩF) range and units information.

When Functions C-D or C-ΩF are selected, U6B(4) goes to L to enable U10A/D. On the other hand, each negative transition of Busy H signal which comes from A4U13 causes a positive transition is Schmitt U1(6). This positive transition, which occurs at the same time as data transfer pulse, alternately changes F/F U2 state. Assuming U10D(13) is H (U2(9) = L) is equivalent to assuming an independent selection of Function C. The difference is that U10D(13)H makes U9A(12) L. This is required to enable transmission of information of range and unit of Loss (D or ΩF) because the display is Loss while DVM is measuring E_C (capacitance value) and vice versa.

When Function is V, U6A(3) H turns relay driver Q2 on which turns K2 on to connect voltage (V) to DVM input and makes U10B(4) L which completes voltage measurement circuit and also U6D(11) L which enables V Range Gate. Input voltage is attenuated by Voltage Divider R5 to R7 determined by DC BIAS RANGE switch A6S4 setting.

When Function is I_L, U6B(6) H turns relay driver Q1 on which turns K1 on to connect I_L Detector output (E_{IL}) to DVM input and makes U10B(4) L which completed I_L measurement circuit and also U6C(8) L which enables transfer of I_L Range and unit information.

A3 & A6 Parts Locations under Fold

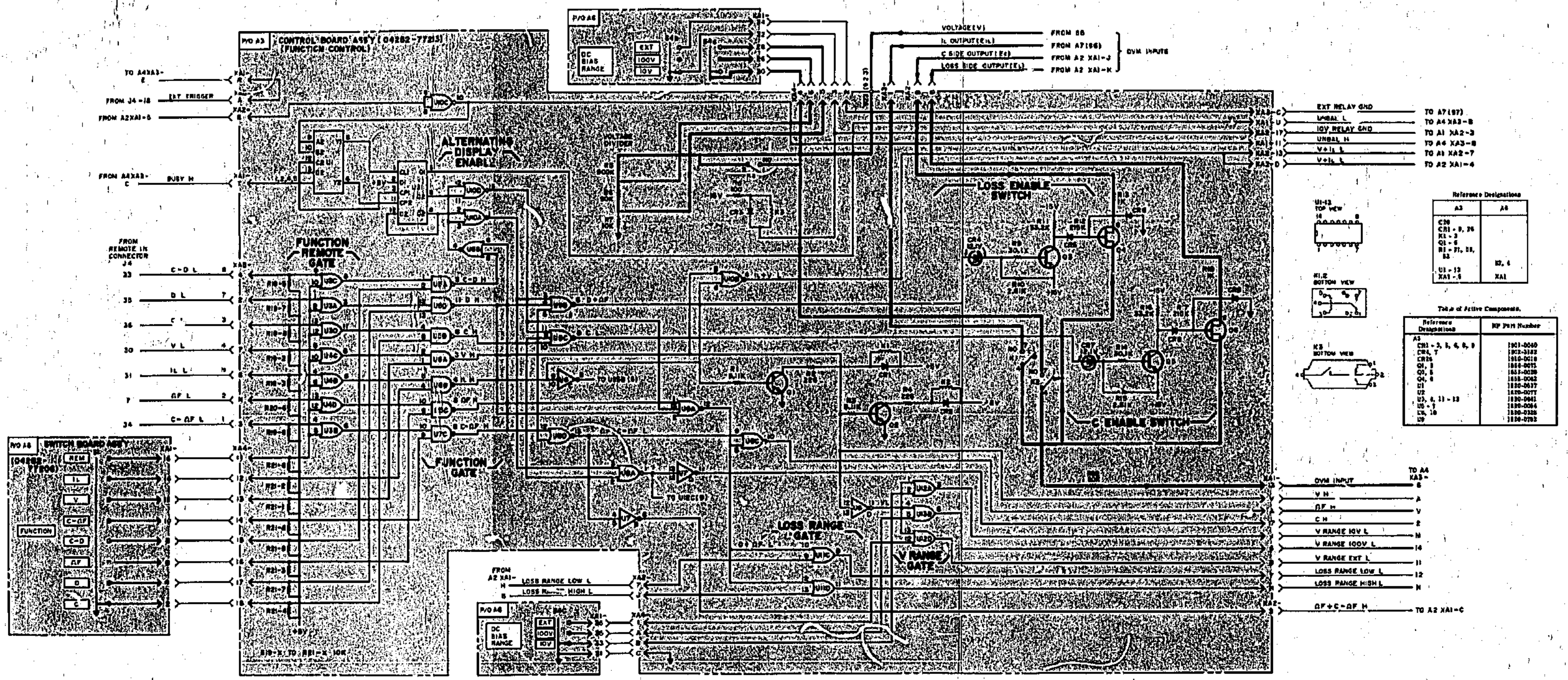
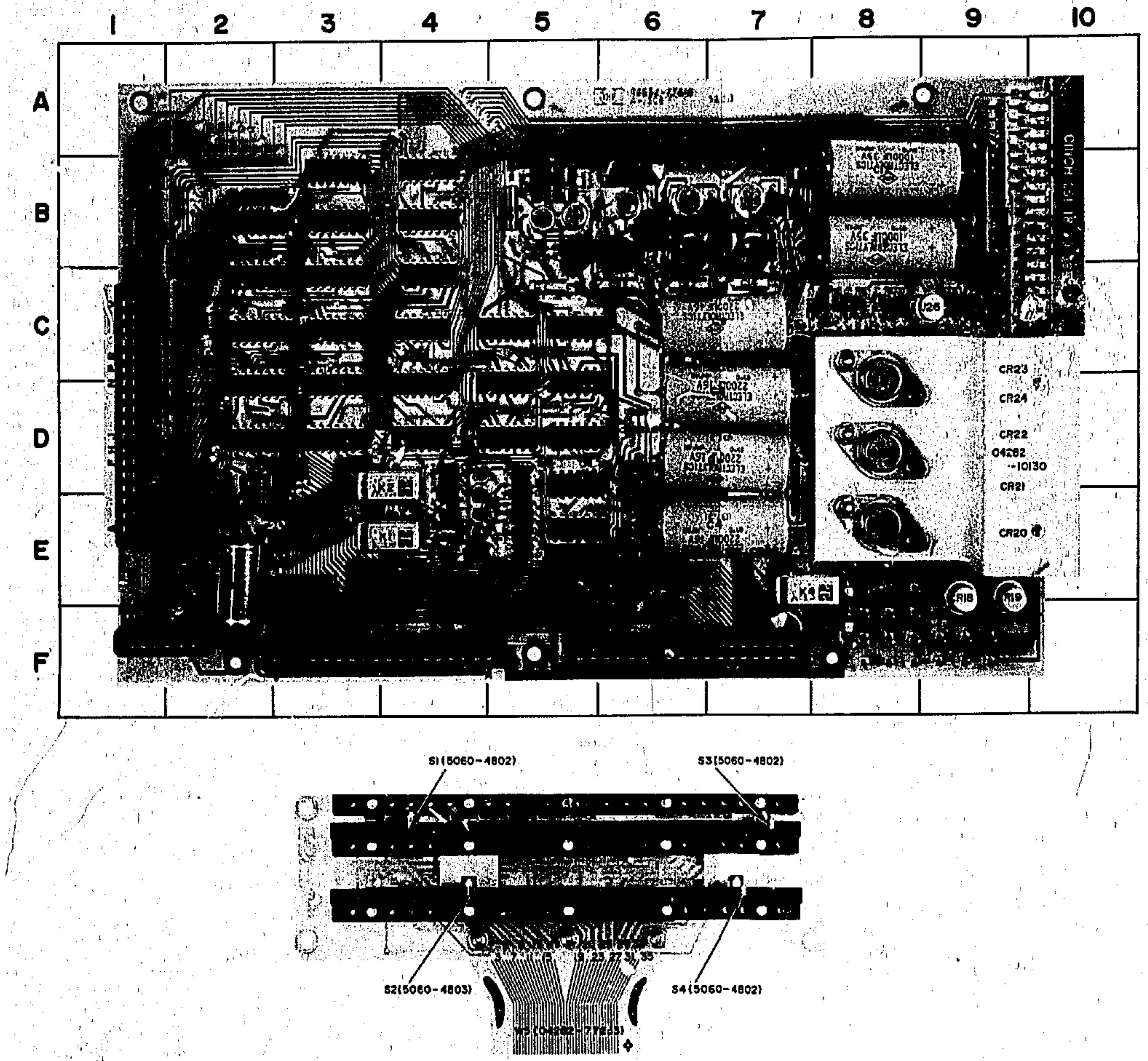


Figure 8-11. A3 Control Board Ass'y. (Function Control)

A6 Switch Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
R19	C-9	U12	D-2	U20	B-2
R20	B-9	U13	D-3	U21	B-3
R22	B-9	U14	B-4		
R23	C-1	U15	B-4	XA1	F-6
R24	B-1	U16	C-4	XA2	F-3
		U17	C-4	XA4	D-1
U4	D-4	U18	D-3	XA5	B-10
U11	C-2	U19	B-3		

Figure 8-11
A3 Control Board Ass'y (Function Control)
A6 Switch Board Ass'y

SEE INSIDE

A3 CONTROL BOARD OPERATION

C Range Control Section.

This section contains C Range Remote Gate, C Range Gate, C Range Display Gate and Open Collector Relay Driver. The Remote Gate is enabled to allow C Range remote program when C RANGE switch is set to REM. C Range Gate is at L (low level) when either input goes L. This drives Open Collector Relay Driver to select a C range. Display Gate is enabled to display appropriate unit and decimal point when Function C is selected.

A3 & A6 Parts Locations under Fold

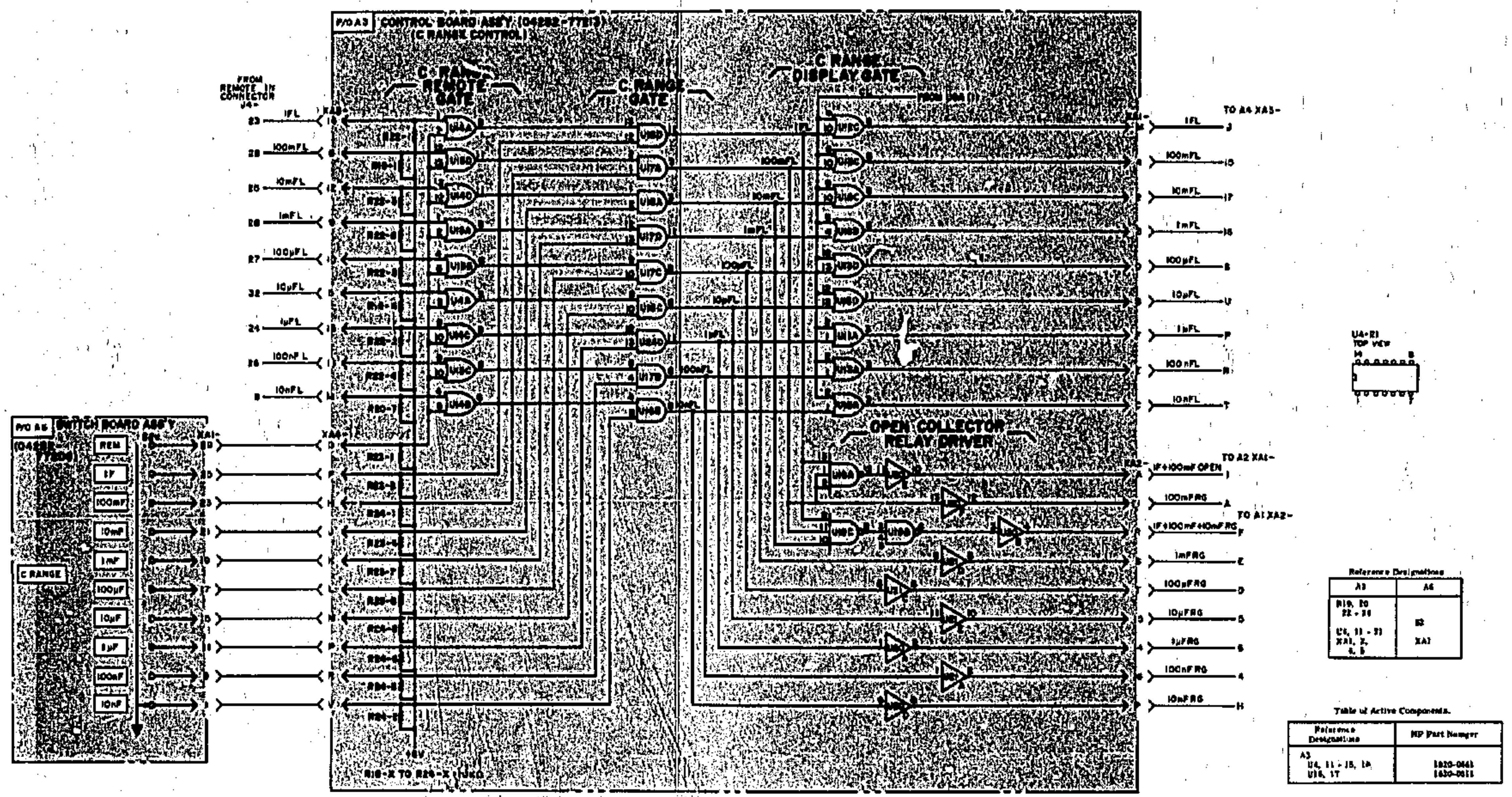
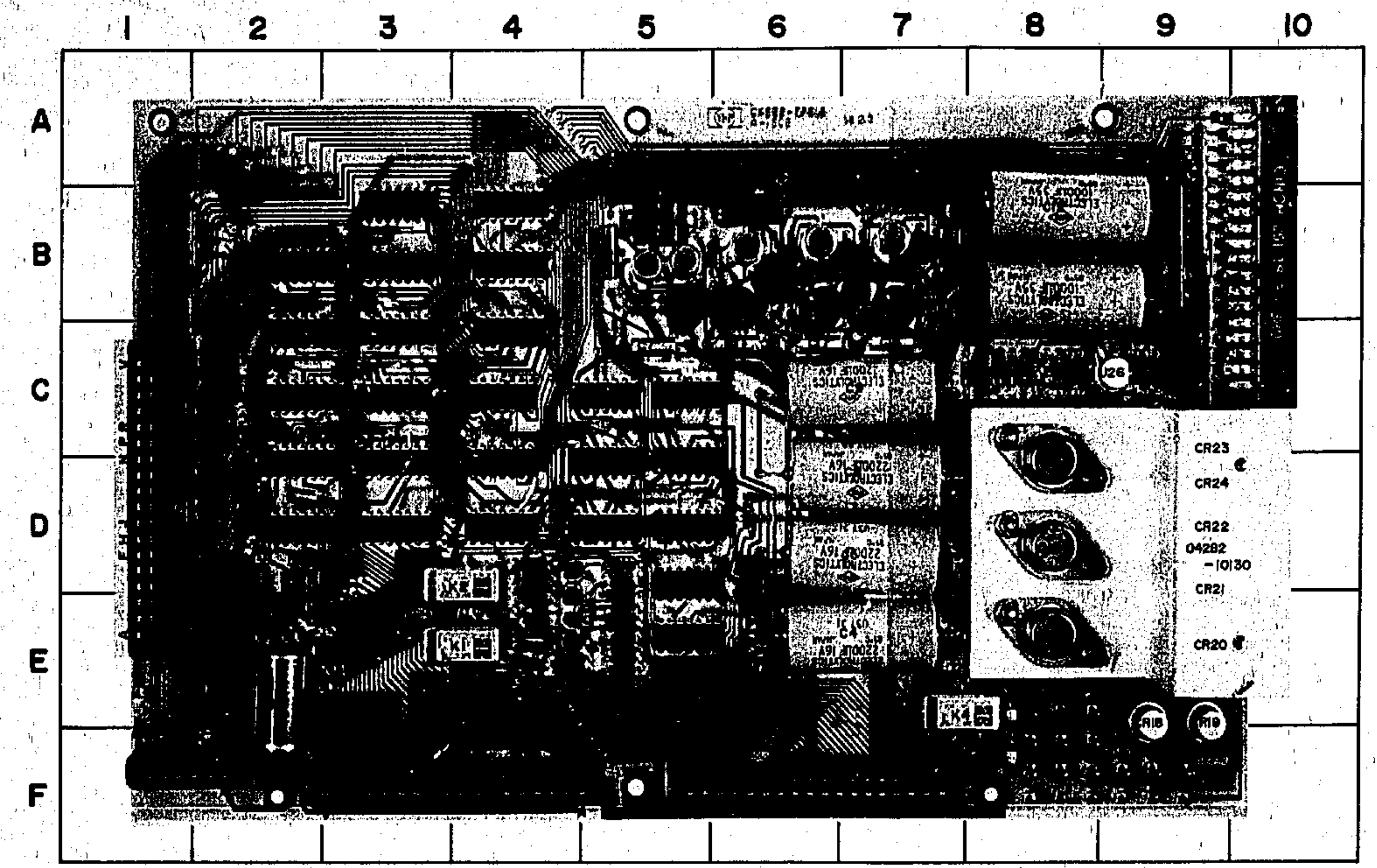
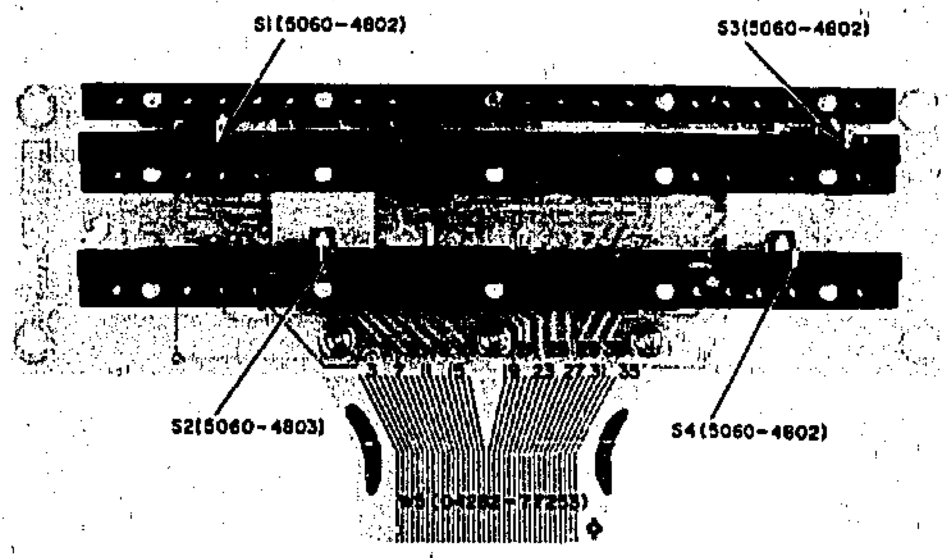


Figure 8-12. A3 Control Board Ass'y. (C Range Control)

A6 Switch Board Ass'y.





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Lod.	Ref. Desig.	Grid. Loc.
C1	B-7	R20	B-9	U11	C-2
C2	B-7	R23	C-1	U12	D-2
C3	C-8	R24	B-1	U22	C-3
		R25	E-2	U23	C-2
		R26	B-7	U24	C-3
CR10	C-8	R27	B-7	U25	D-2
CR11	C-8	R28	C-8	U26	C-9
CR12	C-8	R29	C-8		
CR13	C-8	R30	C-8	XA1	F-6
CR14	C-8	R31	C-8	XA2	F-3
CR15	C-8	R32	C-8	XA3	F-1
CR16	C-9			XA4	D-1
CR17	C-9			XA5	B-10

SEE INSIDE

Figure 8-12
A3 Control Board Ass'y
(C Range Control)
A6 Switch Board Ass'y

A3 CONTROL BOARD OPERATION

I_L Range Control Section.

This section contains I_L Range Remote Gate, I_L Range Gate and I_L Range Display Gate. Remote Gate is enabled to allow I_L Range remote programming when I_L RANGE switch set to REM. I_L Range Gate is at L (low level) when either input goes L. This is used for I_L Range selection in A7. Display Gate is enabled to display appropriate unit and decimal point when Function I_L is selected.

Check Fuse Sensor.

This circuit annunciates when measuring circuit fuse F2 is blown. When F2 blows, measuring signal is applied across R24. This signal is rectified by CR10, CR11 and fed to Comparator U26. U26 provides positive output and CR17 limits it to TTL high level.

A3 & A6 Parts Locations under Fold

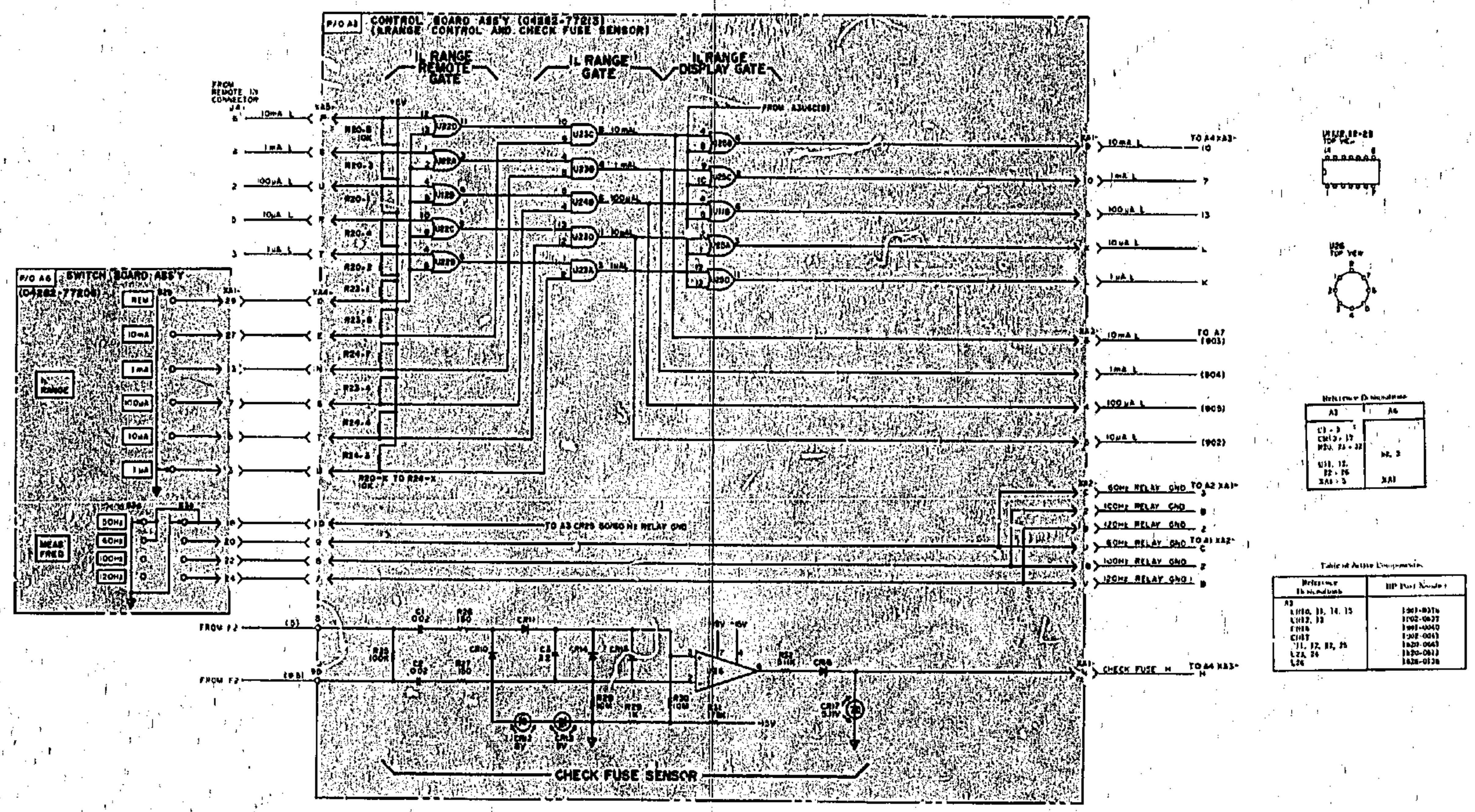
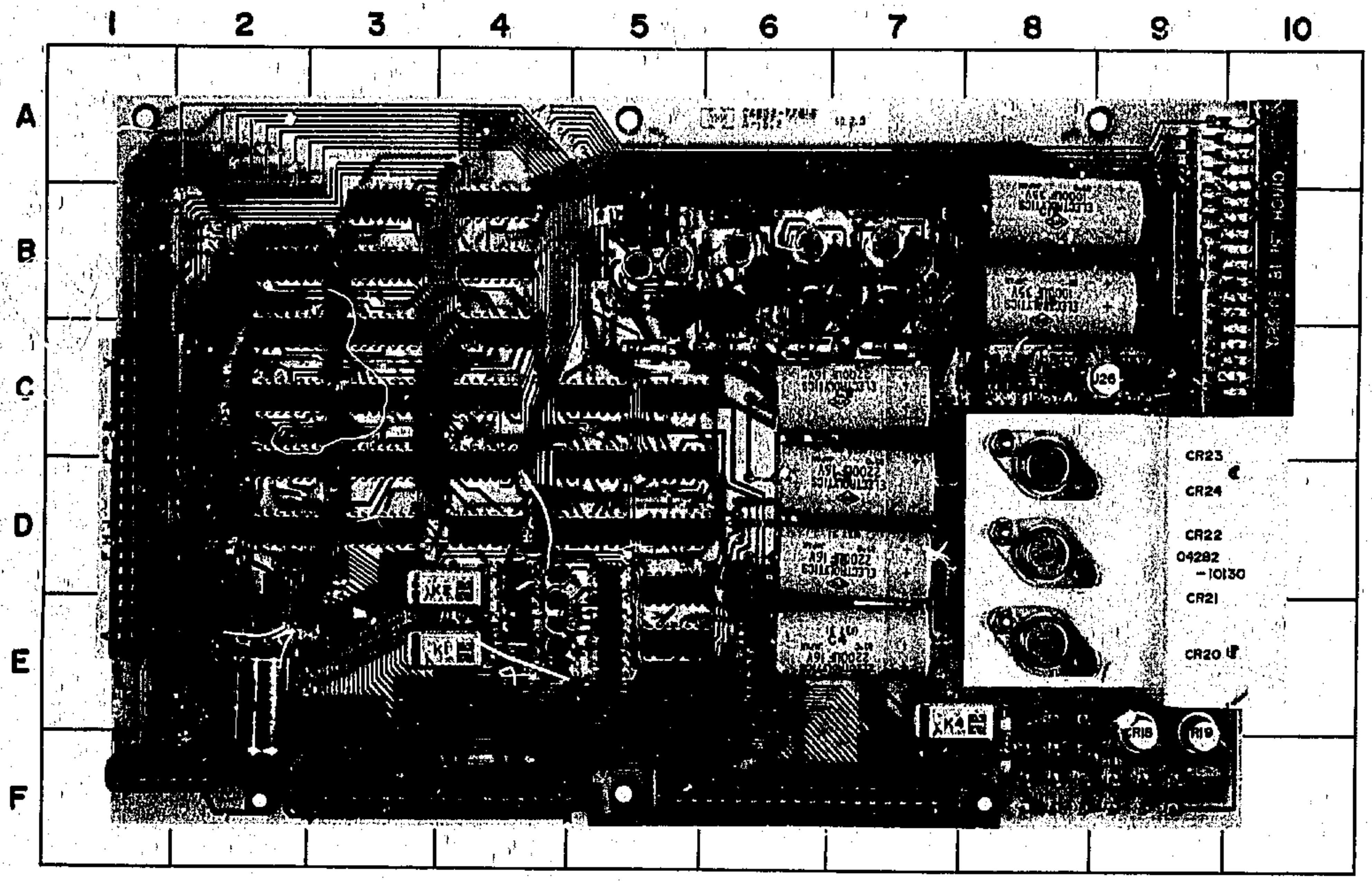


Figure 8-13. A3 Control Board Ass'y. (I_L Range Control and Check Fuse Sensor)
A6 Switch Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C4	E-7	CR22	D-10	R42	B-7
C5	D-7	CR23	C-10	R43	B-7
C6	B-5	CR24	D-10	R44	B-7
C7	C-5	CR25	E-7	R45	B-7
C8	D-7			R46	B-6
C9	C-7	K4	E-[illegible]	R47	B-7
C10	B-6			R48	B-6
C11	C-6	Q7	B-5	R49	B-7
C12	B-8	Q8	E-8	R50	E-8
C13	B-7	Q9	C-8	R51	E-7
C14	C-7	Q10	D-8		
C15	B-8			U27	B-5
C16	B-6	R33	B-5	U28	B-6
C17	C-6	R34	B-5	U29	B-7
C18	F-8	R35	B-5	U30	B-6
C19	F-8	R36	B-5		
		R37	B-5	XA1	F-6
CR18	E-9	R38	B-6	XA2	F-3
CR19	E-9	R39	B-6	XA3	F-1
CR20	E-9	R40	B-6	XA4	D-1
CR21	D-9	R41	B-6	XA5	B-10

Figure 8-13
A3 Control Board Ass'y
(I_L Range Control and Check Fuse Sensor)
A6 Switch Board Ass'y

SEE INSIDE

A3 CONTROL BOARD OPERATION

Power Supply Section.

This section contains four regulated dc sources, +5V, -5V, +15V and -15V and one non-regulated dc source, +26V. Also included is an ac 120V source sent to Leakage Current Board A7 (Option 001). The +15V regulator output is used in +5V regulator and the +5V output is used in -5V regulator. A3 also furnishes the Line Synchronous signal which is taken from Relay K4. The four dc regulators are very similar. Only +5V Regulator is described. Rectifier CR18 to CR21 is bridge type rectifier. Series Regulator Q1 is placed on main chassis to enhance radiation of heat. Voltage Controller U27 has a reference and current limiter in itself. Its equivalent circuit is shown as an inset on the schematic (Figure 8-14). Control signals appear at U27(6) and are fed to Q1 through Q7. Current limiting signal is taken from R36 and R37.

A3 Parts Locator under Fold

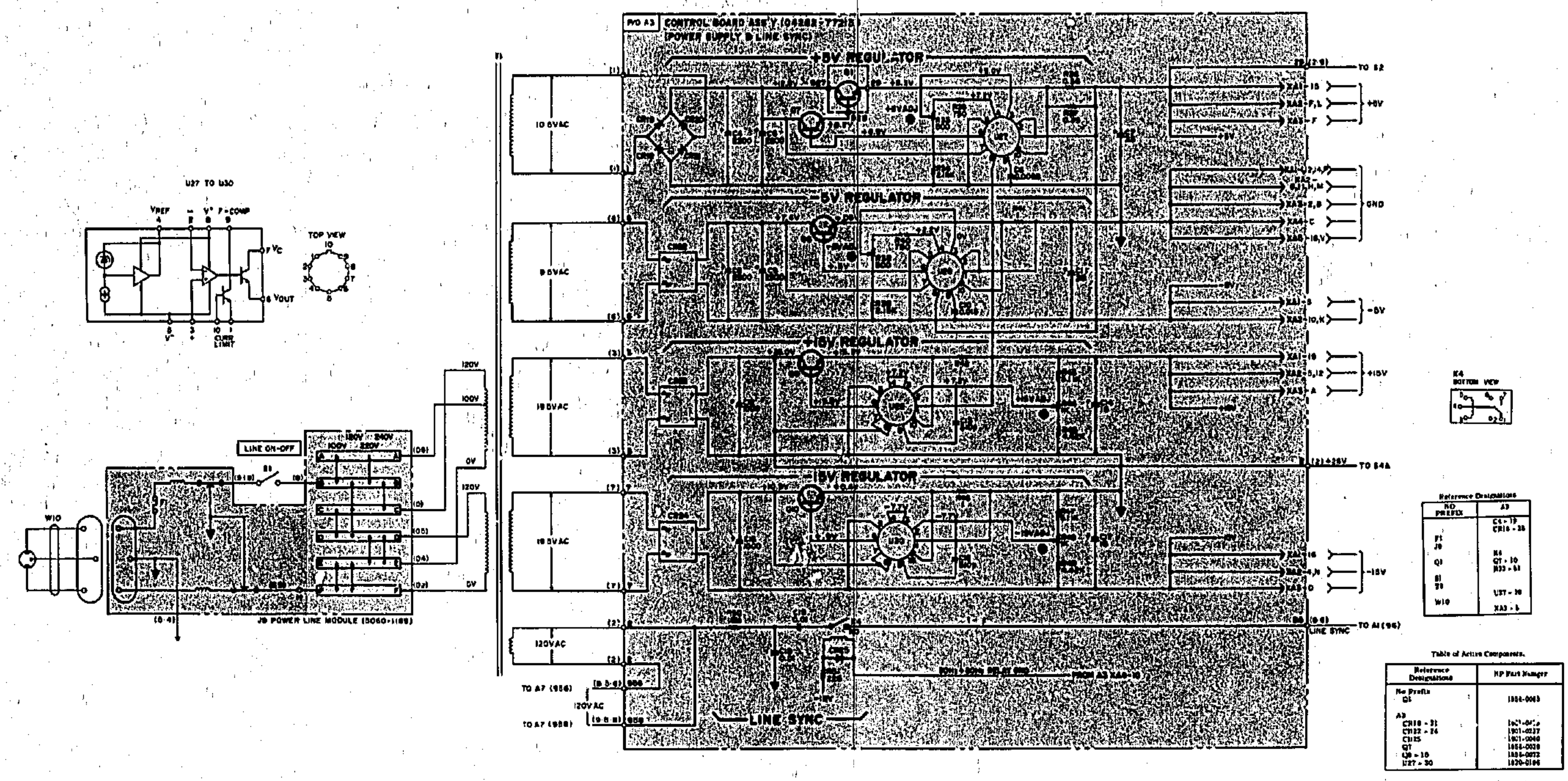
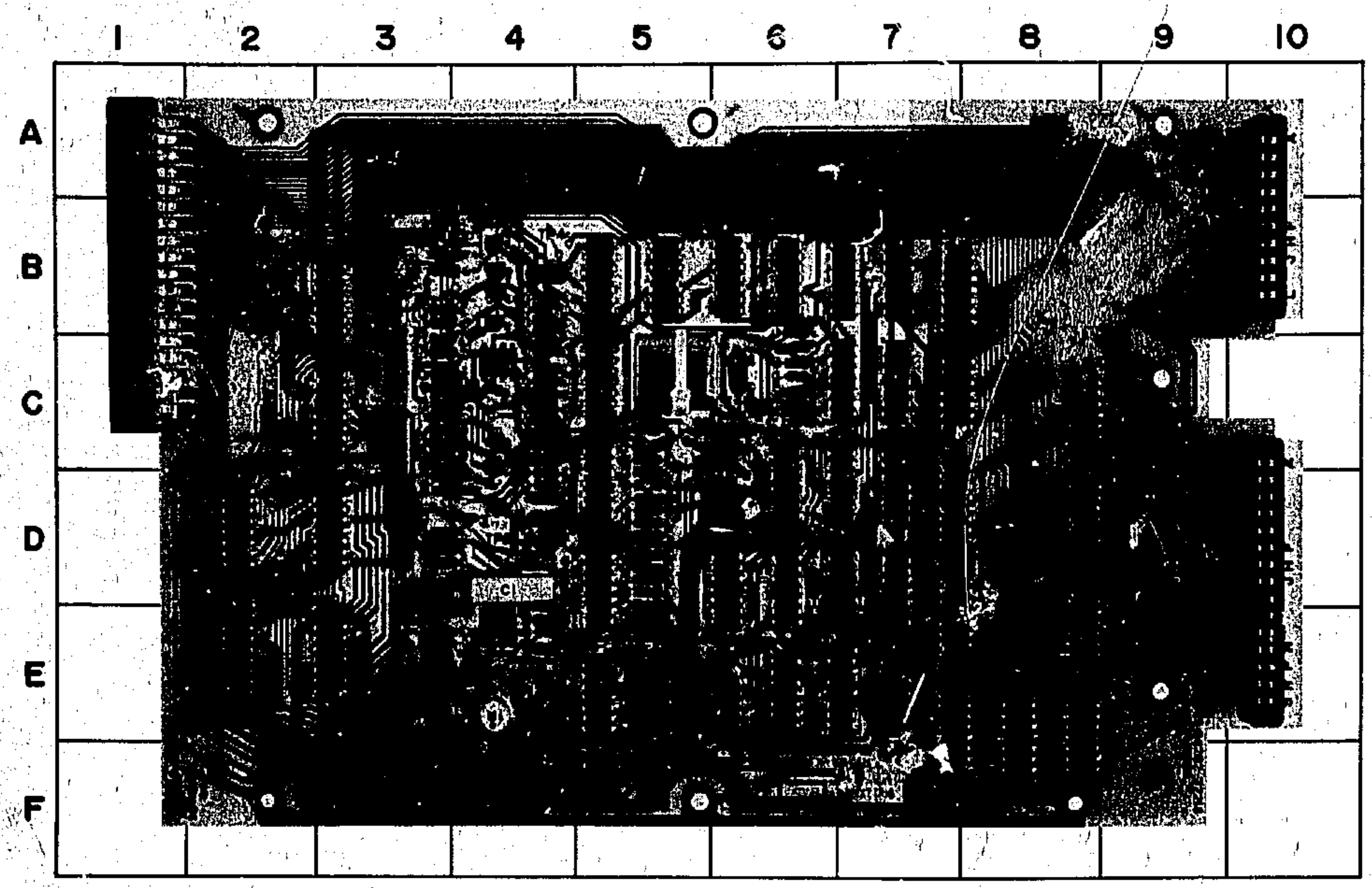


Figure 8-14. A3 Control Board Ass'y.
(Power Supply & Line Sync)
J9 Power Line Module.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	D-4	R1	E-4	R34	C-6
C2	D-4	R2	E-4	R35	C-6
C3	E-5	R3	E-4	R36	C-6
C4	E-5	R4	E-3	R37	C-6
C5	C-6	R5	E-4	R36	D-4
C6	C-6	R6	E-4	R39	E-4
C7	B-4	R7	D-4	R40	D-4
C8	D-4	R8	D-4	R41	D-3
C9	D-4	R9	D-5	R42	E-4
C10	C-4	R10	D-5	R43	D-4
C11	C-4	R11	D-5	R44	C-4
		R12	E-5	R45	C-4
CR1	E-4	R13	E-5	R46	C-4
CR2	E-4	R14	D-5	R47	C-4
CR3	E-4	R15	E-5	R48	C-4
CR4	E-4	R16	D-5	R49	C-4
CR5	D-4	R17	E-5	R50	C-4
CR6	B-4	R18	E-5	R51	C-4
CR7	B-4	R19	E-4	R52	D-4
CR8	C-4	R20	E-4	R53	D-4
CR9	C-4	R21	C-4		
CR10	D-4	R22	C-4	U1	E-4
CR11	E-4	R23	B-4	U2	E-4
		R24	C-4	U3	C-4
Q1	D-5	R25	D-4	U4	C-5
Q2	E-5	R26	C-4	U5	B-5
Q3	B-4	R27	C-4	U6	B-5
Q4	B-4	R28	C-4	U7	B-6
Q5	B-4	R29	C-4	U8	B-6
Q6	B-4	R31	C-4	U9	B-7
Q7	C-4	R32	B-4	U10	C-7
Q8	C-4	R33	B-4		
Q9	D-4			XA3	F-3
				Y1	C-5

SEE INSIDE

Figure 8-14
A3 Control Board Ass'y
(Power Supply & Line Sync)
J9 Power Line Module

A4 DVM BOARD OPERATION

Pulse Width Modulation (PWM) Section.

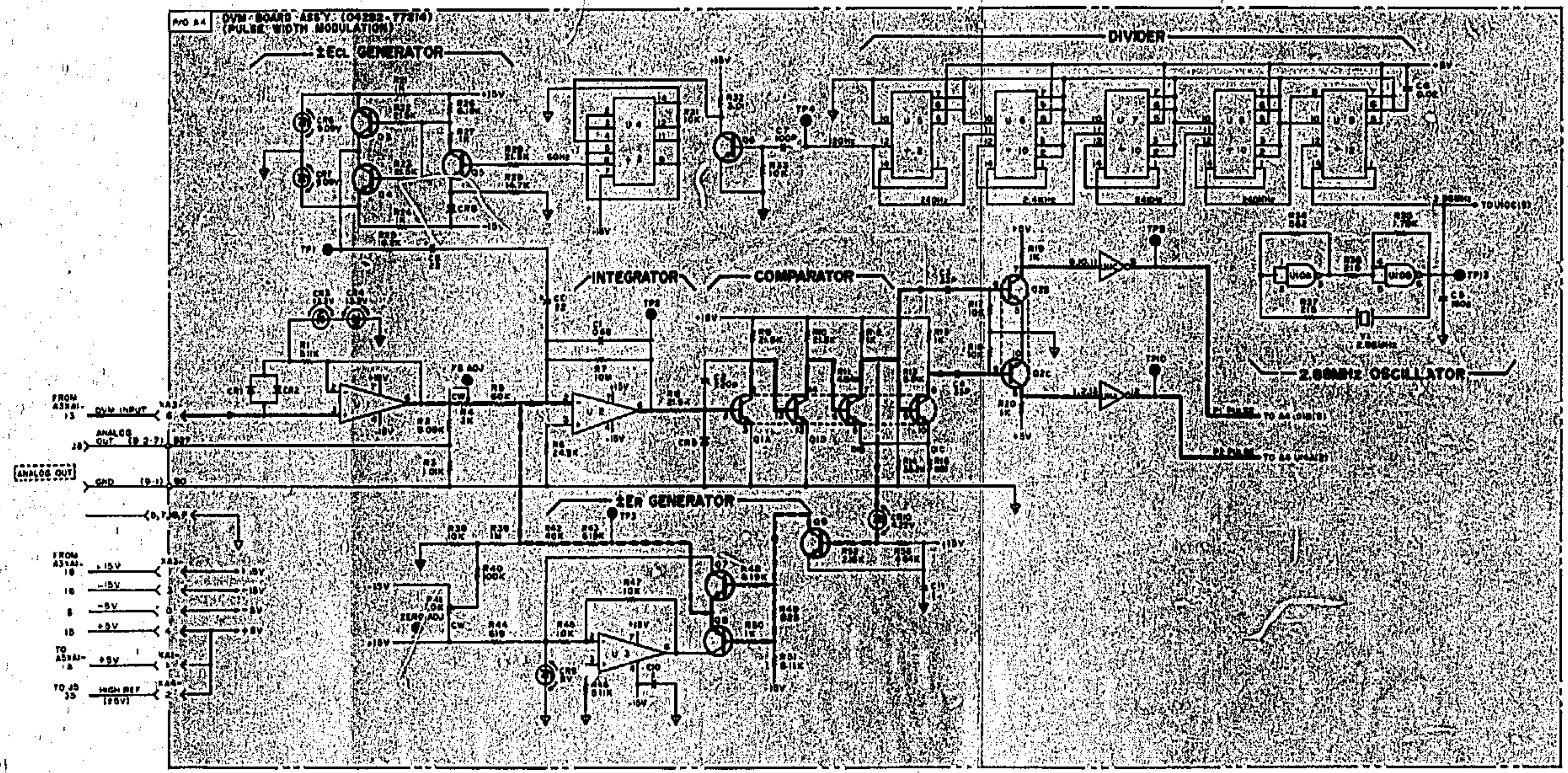
This section is employed to convert input voltage to time interval, which is accomplished by an $\pm E_{CL}$ Generator, an E_R Generator, an Integrator and a Comparator.

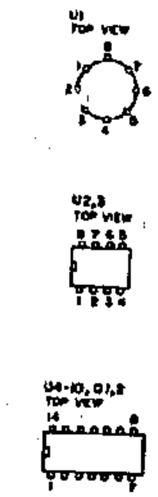
The $\pm E_{CL}$ Generator Q3 to Q5 and CR6/7 provide a 60Hz clock signal to determine the period of integration. The clock signal is obtained by dividing a 2.88MHz Crystal Oscillator output by 48,000 through Dividers U4 to U9. Q6 converts TTL level to negative level to fit Q5 drive requirements. Q3 and Q4 are switched alternately by Q5 and provide a symmetrical square wave whose frequency is 60Hz and whose amplitude is ±9.09V referred to CR6/7. The $\pm E_R$ Generator, whose duty cycle is determined by input voltage and whose frequency is 60Hz, provides ±9V referred to CR9 by alternately switching Q7 and Q8. Integrator U2 receives two inputs $\pm E_{CL}$ and $\pm E_R$ plus another input which is either E_C, E_L, V or E_{IL} (unknowns).

When E_{CL} and E_R are positive, the most rapid negative going ramp is produced at U2(6). When this ramp reaches zero, Comparator Q1A is turned off and a positive pulse (called P1) occurs at U11C(8). This also turns Q9 off to connect minus reference ($-E_R$) to U2(2) through Q8. Since the sum of three inputs is still positive, U2(6) continues to produce a slowed down negative going ramp until 60Hz clock changes to $-E_{CL}$. Then U(6) changes to the most rapid positive going ramp and, when crossing zero point, turns Q1A on. At this point a positive pulse (called P2) is produced at U11A(12). Q9 is also turned on to connect positive reference ($+E_R$) through Q7 to U2(2). The slowed down negative going ramp continues until 60Hz clock changes to $+E_{CL}$. This completes one cycle which has created P1 and P2 Pulses whose interval represents unknown input voltage.

Analog output is Impedance Converter U1 output divided by 10 and produces 1V output for a 10V input.

A4 Parts Locations under Fold





Reference Designations

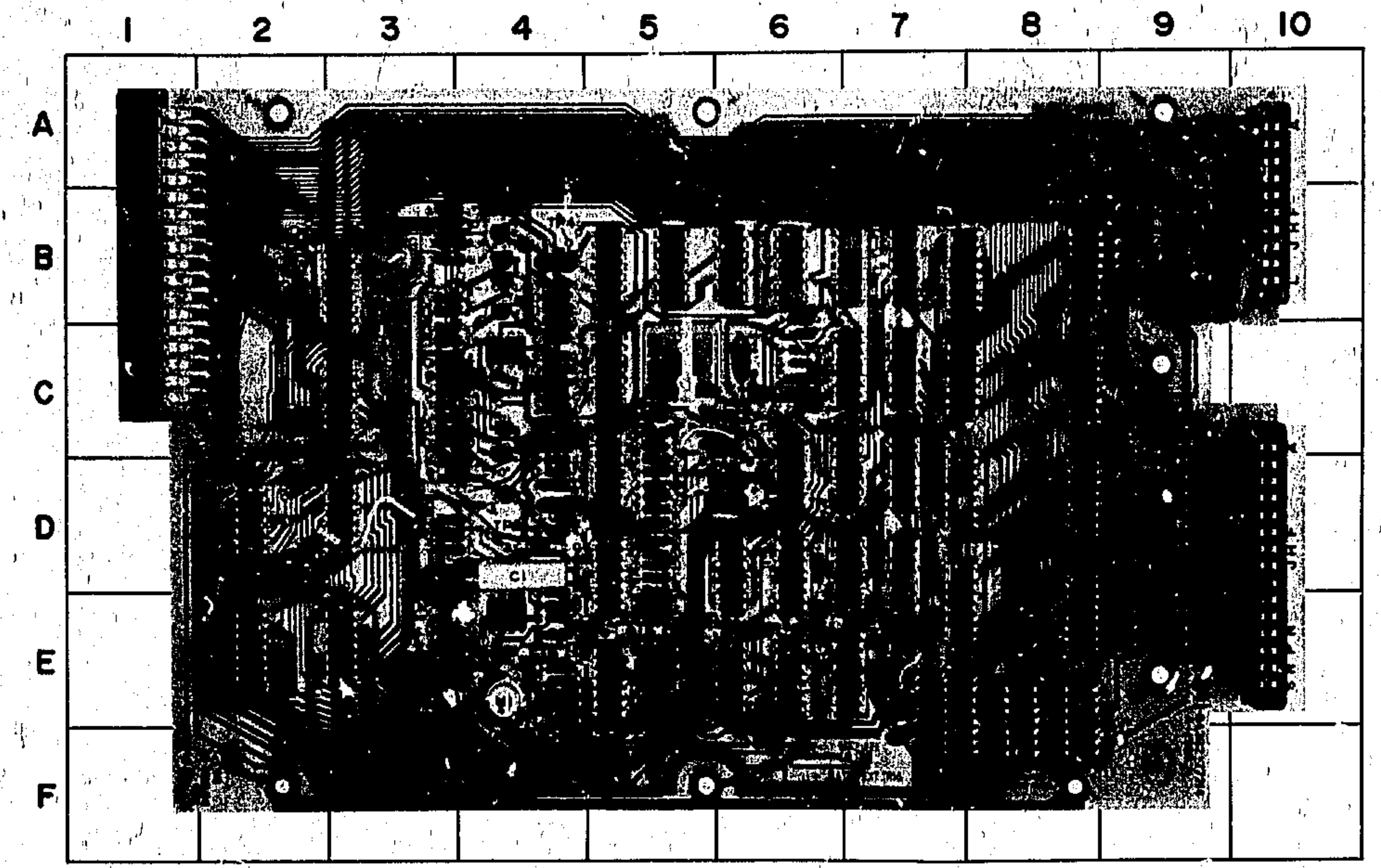
A4
C1 - 11
CR1 - 10
Q1 - 9
R1 - 53
U1 - 10
XA3
Y1

R30, not assigned.

Table of Active Components.

Reference Designations	HP Part Number
A4	
CR1, 2	1901-0376
CR3, 4	1902-3193
CR5, 6	1901-0040
CR6, 7, 8	1902-3150
CR10	1902-3070
Q1, 2	1858-0033
Q3, 5, 9	1853-0036
Q4, 6, 7	1854-0215
Q8	1853-0020
U1	5060-3621
U2, 3	1820-0493
U4	1820-1104
U5, 9	1820-0054
U6 - 8	1820-0600
U10	1820-0081
Y1	0410-0707

Figure 8-15. A4 DVM Board Ass'y.
(Pulse Width Modulation)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C12	C-6	R54	D-6	R74	B-9
C13	C-6	R55	C-6	R75	B-9
C14	C-6	R56	E-4	R104	F-6
C15	E-5	R57	E-4	R105	B-9
C16	E-4	R58	E-4	U10	C-7
C17	D-6	R59	E-4	U11	E-6
C18	D-6	R60	D-5	U12	D-6
C19	D-6	R61	C-5	U13	D-6
C20	E-7	R62	C-5	U14	E-7
C21	E-6	R63	D-5	U15	E-6
C22	D-7	R64	D-5	U16	D-6
		R65	C-5	U17	D-7
CR11	F-4	R66	D-5	U18	D-7
		R67	D-5	U19	E-8
Q2	E-5	R68	D-5	U20	E-8
Q12	D-5	R69	C-6	U21	B-3
Q13	A-9	R70	E-7		
Q14	B-9	R71	E-6	XA1	B-10
Q15	B-9	R72	B-4	XA2	D-
Q16	B-9	R73	E-9	XA3	F-
Q17	B-9			XA4	B-1

SEE INSIDE

Figure 8-17
A4 DVM Board Ass'y
(Pulse Width Modulation)

A4 DVM BOARD OPERATION

Control Logic Section.

This section includes Rate Generator, Timing Pulse Generator and various Gates. Rate Generator Q2A/D is astable MV whose period is variable from 0.3 to 2.0 seconds with RATE control.

The positive transition at U12(8) driven internally or externally causes positive transition at U13(6) or negative transition at U13(1) which holds H (high level) or L (low level) for about 80ms, respectively. They are Busy H or L and indicate busy period for one reading. Timing Pulse Generator Q12 provides negative Set Pulse at the beginning of busy period and positive Transfer Pulse and negative Print Command at the end of busy period.

When Set Pulse is issued, Dual F/F U15(13) and U17(13) are set to H and Counter U27 to U31 are set to zero. P1 Pulse Gate U11B enabled by U11B(3, 4) H allows acceptance of P1 Pulse. P2 Pulse Gate U14A is closed by U17 (12) L. P1 Pulse makes U15(9) H and opens Clock Gate U10C. At this point, the 2.88MHz Clock passes through U10C and goes into ÷2 Counter U18 whose output is applied to Counter U27. When Counters U27 to U31 count 8,000, U17(1) goes H and 12,000 counts of Counters returns U17(1) to L (Counter is reset to zero by itself). This negative transition makes U17(12) H and opens P2 Pulse Gate U14A. Then P2 Pulse appears at U14A(2) and makes U15(9) L to close U10C. Counters hold result which represents input voltage of PWM (Pulse Width Modulation) section. Negative transition of U15(9) also makes U15(13) L to close U11B. Above description is for positive input.

For negative input, since P2 Pulse occurs before the completion of half a period of 60Hz clock signal (before Counters count 12,000), P2 Pulse Gate U14A is closed but Gate U14D is opened. P2 Pulse passing through Gates U14D/C resets Counters. Counter again begin to count and is reset to zero by itself at 12,000 counts (after half period of 60Hz Clock from P2 Pulse). Under above conditions, next P1 Pulse is applied to U15(5). This makes U15(9) L and closes Clock Gate U10C and also P1 Pulse Gate U11B. Counters hold result which represents input voltage.

Bottom half of Dual F/F U17 provides polarity assignment. This is accomplished by checking which pulses (P1 or P2) are coincident with negative transition at U15(9) which is applied to U17(5). When P1 Pulse occurs, a negative transition at U17(5) transfers momentary H at U17(7) to U17(9) L. U17(9) L means positive input. Similarly, if a P2 Pulse occurs, it makes U17(9) H which means negative input.

U16 which forms F/F and Gates is Overload Detector. In an overload condition, P1 and P2 Pulses are not issued because of saturation of PWM section. Therefore, U15(13) remains H for one reading period after Set Pulse. When Busy L changes to H at the end of busy period, Gate U16(3) goes to L whose signal is Overload, F/F U16C/D stores this signal and U16D(11) provides Blanking L signal to blank display. This F/F is employed to keep display blanked until end of next busy period.

A4 Parts Locations under Fold

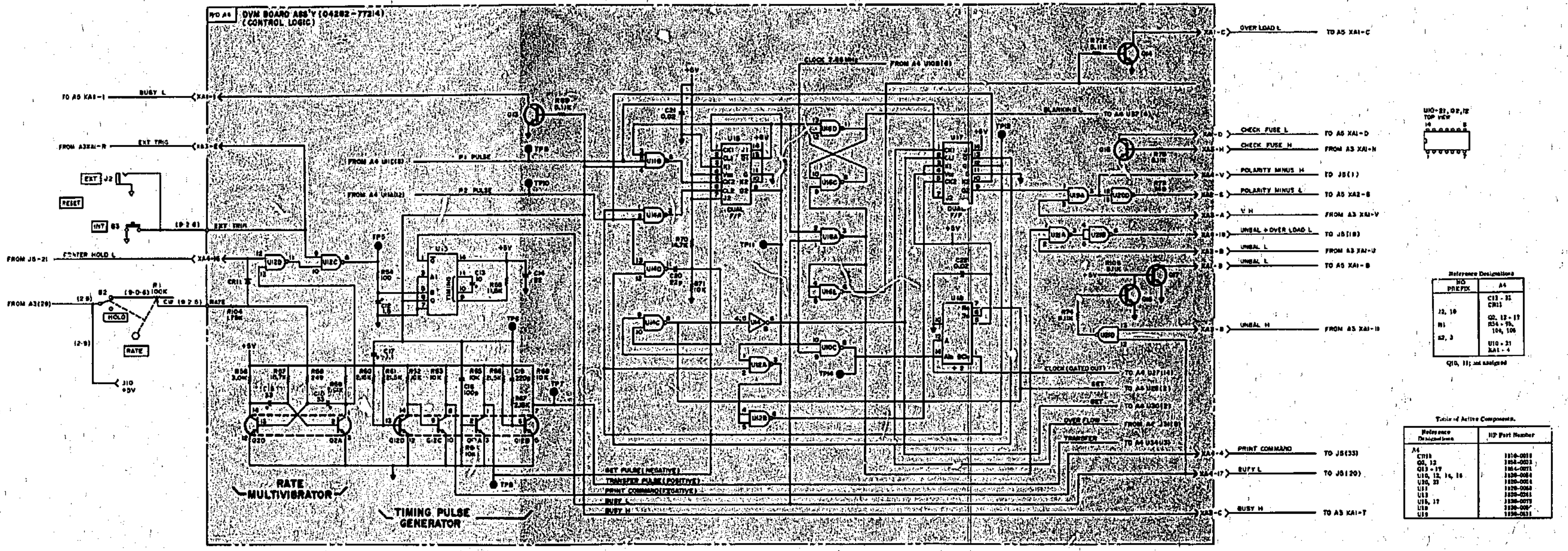
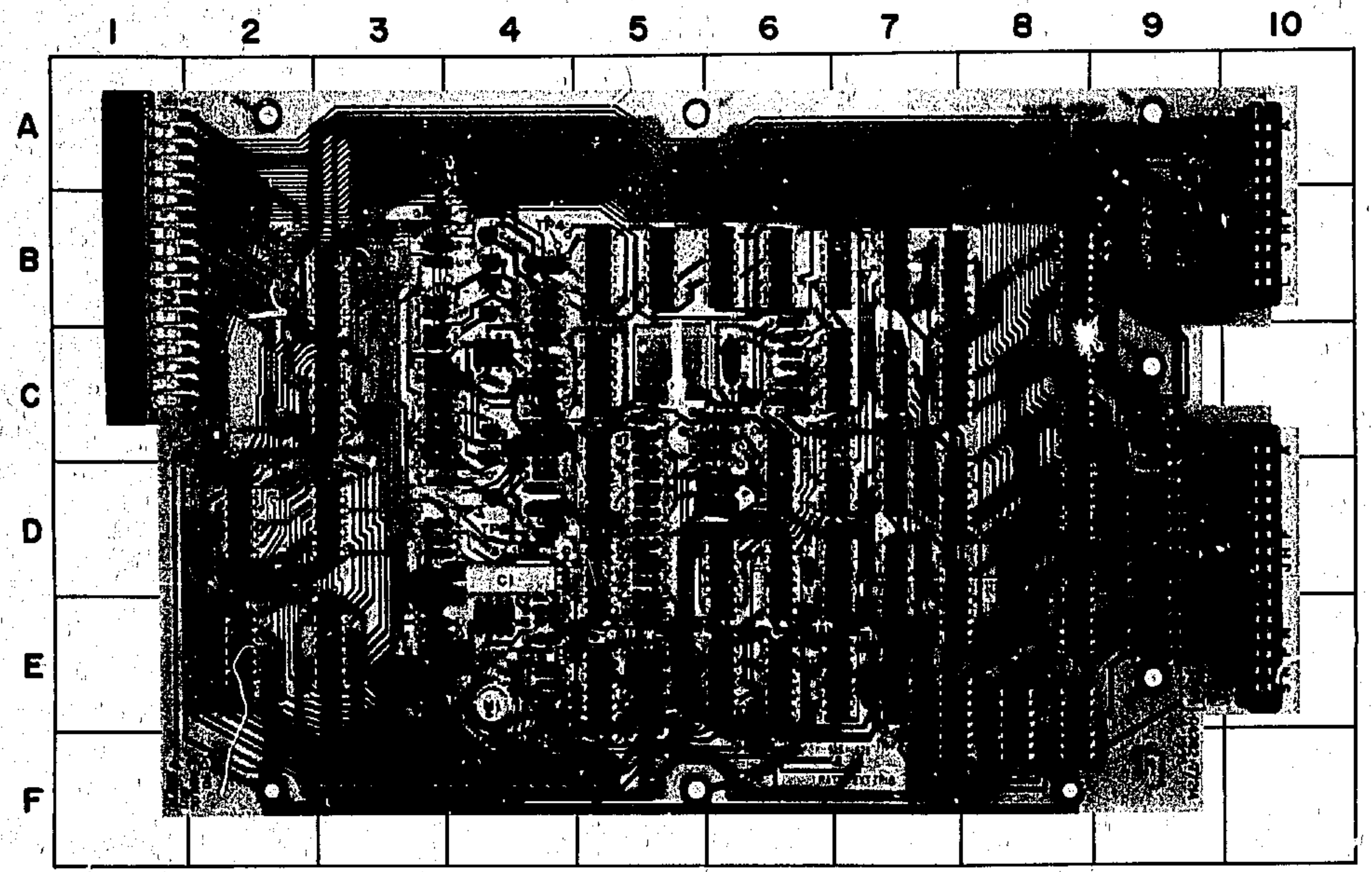


Figure 8-16. A4 DVM Board Ass'y. (Control Logic)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
U21	B-3	U24	C-3	XA1	B-10
U22	E-2	U25	D-2	XA3	F-3
U23	E-3	U26	D-3	XA4	B-1

SEE INSIDE

Figure 8-16
A4 DVM Board Ass'y
(Control Logic)

A4 DVM BOARD OPERATION

Unit and Decimal Point Logic Section.

This section converts unit and decimal point information obtained from combination of Function and Range settings to appropriate individual information. For example, when Function C and Range 1mF are selected, U26B(6) and U26 (6) go to H which means that unit is "mF" and decimal point is positioned at DP5. Same information is sent to DIGITAL OUT J5 connector.

A4 Parts Locations under Fold

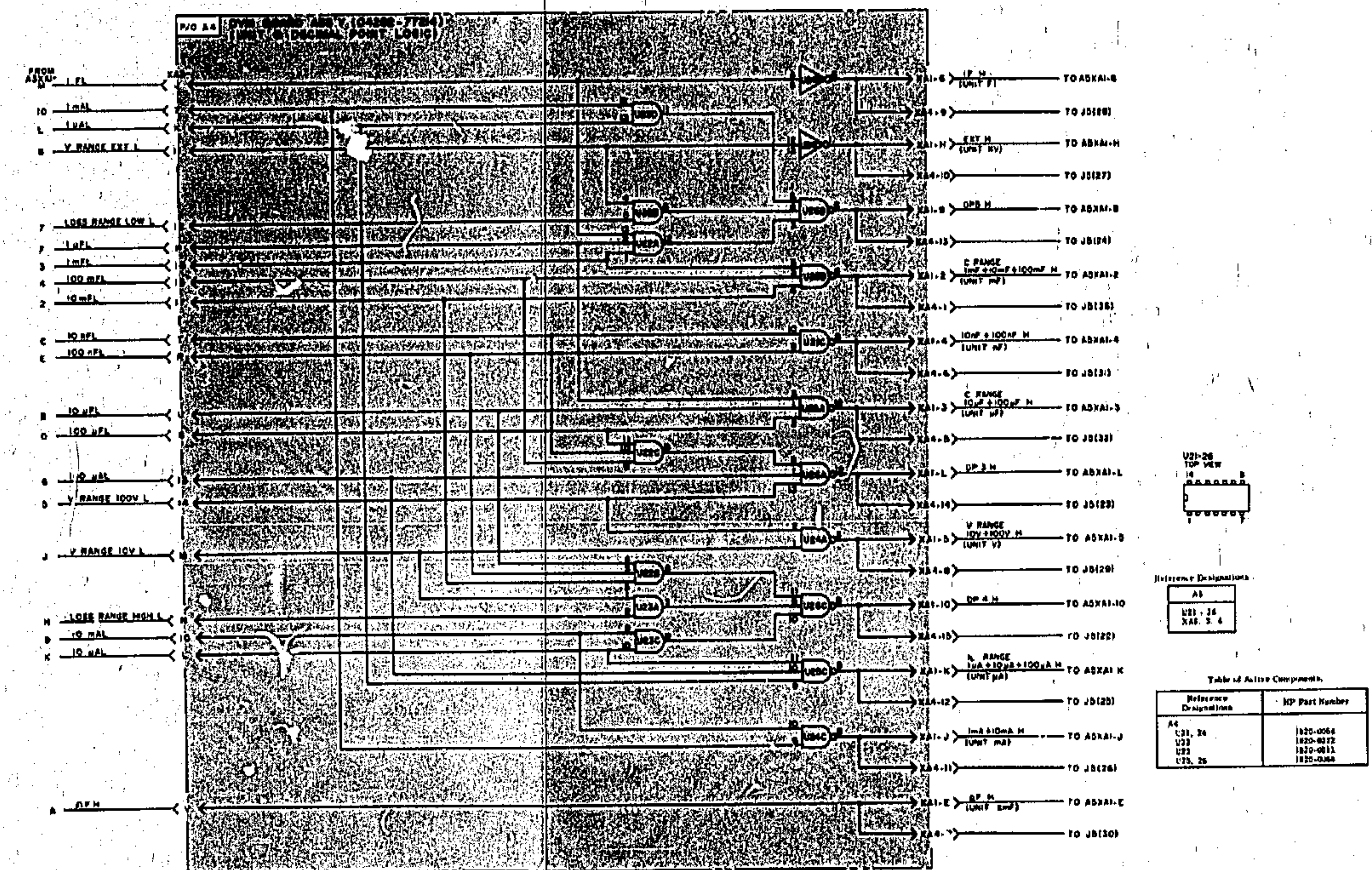
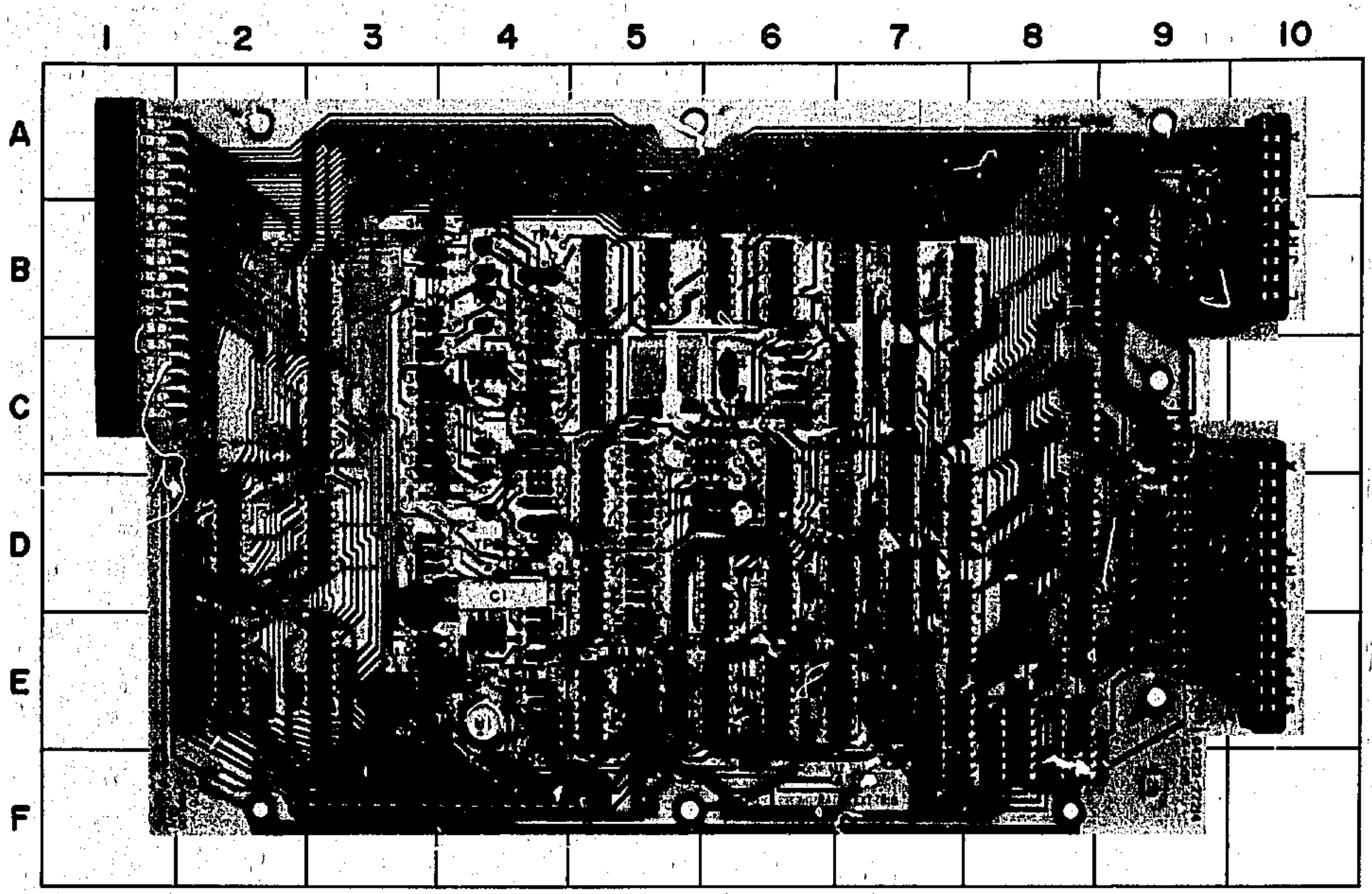
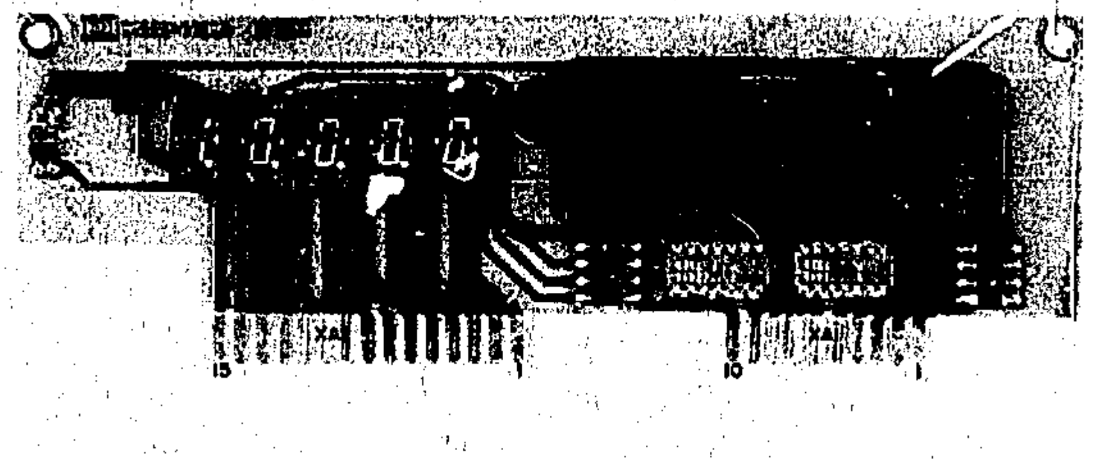


Figure 8-17. A4 DVM Board Ass'y. (Unit & Decimal Point Logic)





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C23	C-7	R90	D-9	U27	B-7
C24	F-7	R91	D-9	U28	C-7
		R92	D-9	U29	D-7
R76	C-9	R93	D-9	U30	D-7
R77	C-9	R94	D-9	U31	E-7
R78	D-9	R95	D-9	U32	B-8
R79	C-9	R96	D-9	U33	D-8
R80	C-9	R97	E-9	U34	D-8
R81	C-9	R98	D-9	U35	E-8
R82	D-9	R99	E-9	U36	C-8
R83	D-9	R100	E-9	U37	B-8
R84	D-9	R101	D-9	U38	C-8
R85	D-9	R102	E-9	U39	D-7
R86	D-9	R103	E-9	U40	E-7
R87	D-9				
R88	D-9	U19	E-8	XA2	D-10
R89	D-9	U20	E-8	XA3	F-3

SEE INSIDE

Figure 8-17
A4 DVM Board Ass'y
(Unit & Decimal Point Logic)

A4 DVM BOARD OPERATION

Counter, Buffer Storage and Decoder Circuits.

These circuits form three stages and are connected in cascade. Counter U27 to U31 consists of three different counters. U27 to U29 are decade counters, U30 is ÷4 counter and U31 is ÷3 counter, for a total maximum counting capacity of 11,999. Counter U27 to U31 is reset to zero by Set Pulse at beginning of busy period. Then Counter continues to count 2.88MHz Clock divided by two while Clock Gate U10C opens. During this period, Counter provides overflow signal at U31(9) which goes to H at 8,000 counts and returns to L at 12,000 counts. When Clock Gate U10C is closed, Counter holds result which is BCD and which represents input voltage.

Next stage is Buffer Storage U32 to U35 whose input is BCD output from Counter and whose output is previous data. The transfer between input and output is performed by Transfer Pulse issued at end of each busy period. Therefore, Buffer Storage holds data transferred for one reading period. Input for U32 to U34 is up to 9 decimal numbers and for U35 is up to 11 (to allow overranging). U19B/C and U20A/B are employed to take up this carry and enable display for overranging digit. U36, 1st Digit Enable, sends U32 output to Decoder when Function is C. In other functions, all four lines hold H to blank 1st digit.

Buffer Storage output is connected to Decoder and DIGITAL OUT J5 connector. Decoder U37 to U40 in last stage is BCD to seven segment decoder. Decoder enables to display appropriate number according to input BCD.

A5 DISPLAY BOARD OPERATION

This Assembly contains Seven Segment Numeric Display DS1 to DS4, Polarity and Overrange Display DS5, Annunciators DS6 to DS11, Rate Annunciator DS12, Unit Display DS13 to DS21 and Inverters U1 and U2. DS1 to DS5 are LED including decimal point each segment of which illuminates when corresponding pin is L (low level). Decimal point is valid only in DS3 to DS5. DS6 to DS11 light when the line is L and indicate that displayed data is invalid. DS12 is single LED which illuminates for busy period. DS13 to DS21 display measuring unit when the line is H (high level) because inputs are inverted by Inverters U1 and U2.

A4 & A5 Parts Locations under Fold

SECTION VII
MANUAL CHANGES AND OPTIONS

7-1. OPTIONS.

7-2. Options are standard modifications performed on -hp- instruments at the factory. Option 001 for Leakage Current Measurements is a currently available option. Operating instructions and other option 001 information are covered in manual corresponding to that for standard instrument.

7-3. SPECIAL INSTRUMENTS.

7-4. "Specials" are standard -hp- instruments that are modified according to customer specifications. A separate insert sheet is included with the manual for special instruments having electrical changes. Make the changes specified in addition to any other changes that are necessary.

7-5. MANUAL CHANGES.

7-6. This manual applies direcly to the Model 4282A with serials prefixed 1515. The following paragraphs explain how to adapt this manual to apply to later instruments with higher serial prefix, or earlier instruments with 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.

7-7. LATER INSTRUMENT: If the serial prefix of your Model 4282A is above 1515, refer to a separate "Manual Changes" sheet supplied with this manual. Locate the serial prefix of your instrument and make the indicated changes.

7-8. EARLIER INSTRUMENTS.
(Backdating Changes):
If the serial prefix of your Model 4282A is below 1515, refer to Table 7-1 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 7-1. Manual Backdating Changes.

Serial Prefix or Number	Make Changes
1319J00170 and below	1

CHANGE 1

Page 6-2, Table 6-2,
A1: Change to HP Part No. 04262-77201; BOARD ASSY:OSCILLATOR.

Pages 6-2 thru 6-4, Table 6-2,
Delete following parts,

A1C29 thru C33, R109 thru R120 and U13 thru U15.

Add following parts,

A1C24: HP Part No. 0180-01C6; CAPACITOR:FXD 60μF ±20% 6VDC TA-SOLID.
A1C25: HP Part No. 0180-0374; CAPACITOR:FXD 10μF ±10% 20VDC TA SOLID.
A1CR29 thru C32: HP Part No. 1901-0040; DIODE SWITCHING SI 30V MAX VRM 50MA.
A1K13 and K14: HP Part No. 0490-0226; RELAY REED.
A1Q11: HP Part No. 1853-0051; TRANSISTOR:PNP SI.
A1Q12 and Q13: HP Part No. 1854-0071; TRANSISTOR:NPN SI.
A1R64: HP Part No. 2100-2655; RESISTOR:VAR TRMR 100kΩ 10% C.
A1R73 and R74: HP Part No. 0686-2045; RESISTOR:FXD 200kΩ5% .5W CC TUBULAR.
A1R75: HP Part No. 0698-4406; RESISTOR:FXD 115Ω 1% .125W F.
A1R76: HP Part No. 0698-3454; RESISTOR:FXD 215kΩ 1% .125W F TUBULAR.
A1R77: HP Part No. 0698-3460; RESISTOR:FXD 422kΩ 1% .125W F TUBULAR.
A1R78 and R81: HP Part No. 0757-0453; RESISTOR:FXD 30.1kΩ 1% .125W F TUBULAR.
A1R79 and R82: HP Part No. 0757-0467; RESISTOR:FXD 121kΩ 1% .125W F TUBULAR.
A1R80: HP Part No. 0757-0444; RESISTOR:FXD 12.1kΩ 1% .125W F TUBULAR.
A1U10: HP Part No. 1826-0092; IC:LIN OP. AMPL DUAL.

Page 6-3, Table 6-2 and page 8-11, Figure 8-6,
Delete A1CR50 and CR51.

Page 6-3, Table 6-2,
A1K7: Change to HP Part No. 0490-0226; RELAY REED.

Page 6-4, Table 6-2,
A1R62: Change to HP Part No. 0698-2218; RESISTOR:FXD 33.5kΩ 1% .125W MET FLM.
A1R63: Change to HP Part No. 2100-2216; RESISTOR:VAR 5kΩ ±10% .5W CER.
A1R88: Change to HP Part No. 2100-2060; RESISTOR:VAR 50Ω 20% CER.

Page 8-13, Figure 8-7,
Change Figure 8-7 partially as shown in Figure 7-1.

Page 8-11, Figure 8-6 (in Table of Active Components),
Delete CR50 and 51; 1902-3059.
Change Q10 to 1854-0071

Page 8-13, Figure 8-7 (in Table of Active Components),
Add Q11; 1853-0051, Q12 and Q13; 1854-0071, U10; 1826-0092, CR29 thru 32; 1901-0040.

Page 6-5, Table 6-2,
A2: Change to HP Part No. 04262-77202; BOARD ASSY:MULTIPLIER.

Page 6-6, Table 6-2,
A2CR15: Change to HP Part No. 1902-0184; DIODE:VREG 16.2V VZ .4W MAX.

Page 6-8, Table 6-2,
A2R74: Change to HP Part No. 0757-0199; RESISTOR:FXD 21.5kΩ 1% .125W F TUBULAR.
A2R75: Change to HP Part No. 0698-3454; RESISTOR:FXD 215kΩ 1% .125W F TUBULAR.

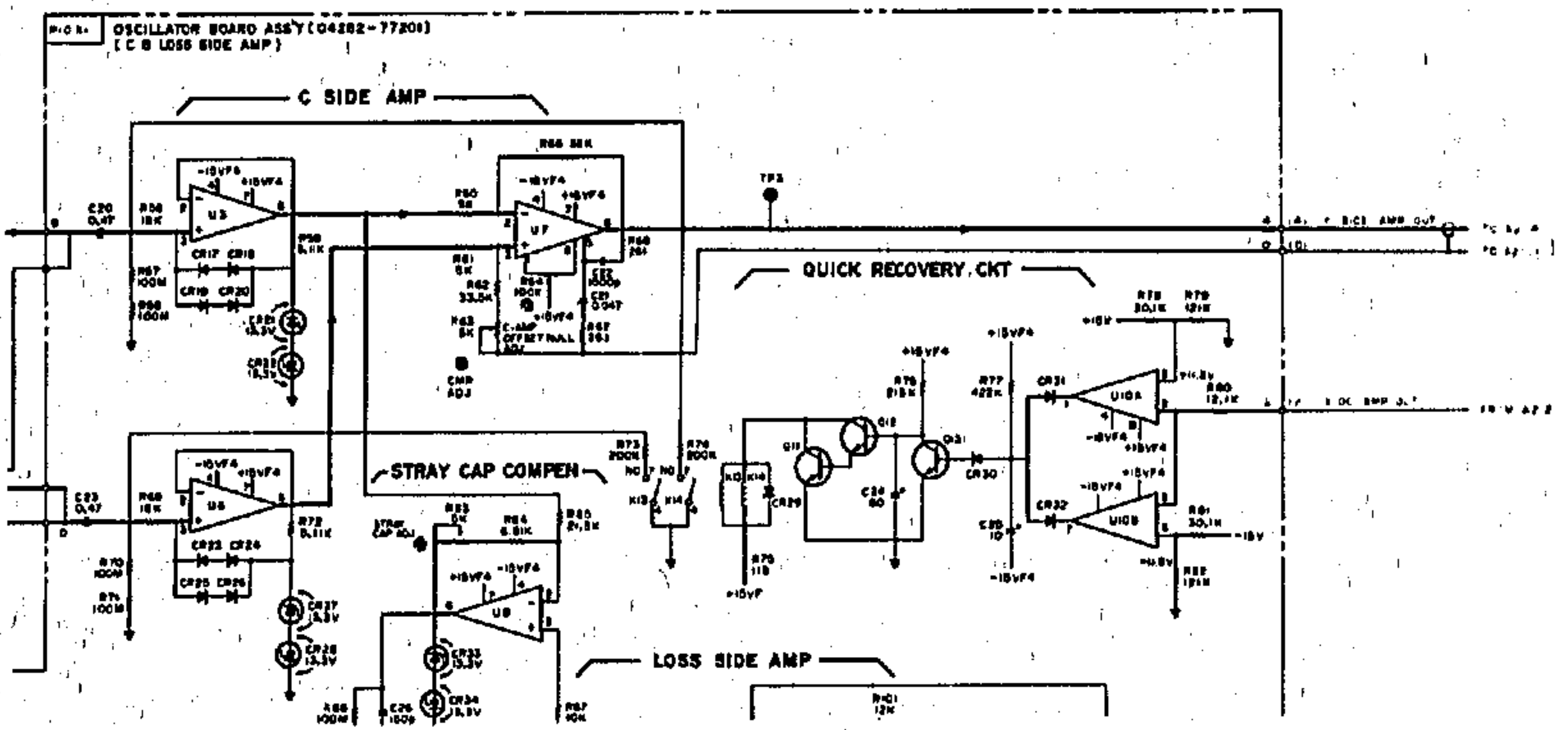

OSCILLATOR BOARD ASS'Y (04282-77201)
(C & LOSS SIDE AMP)
C SIDE AMP
QUICK RECOVERY CKT
STRAY CAP COMPEN
LOSS SIDE AMP
TP3
U3
U7
U6
U8
U10A
U10B
C-AMP OFFSET NULL ADJ
CMP ADJ
STRAY CAP ADJ

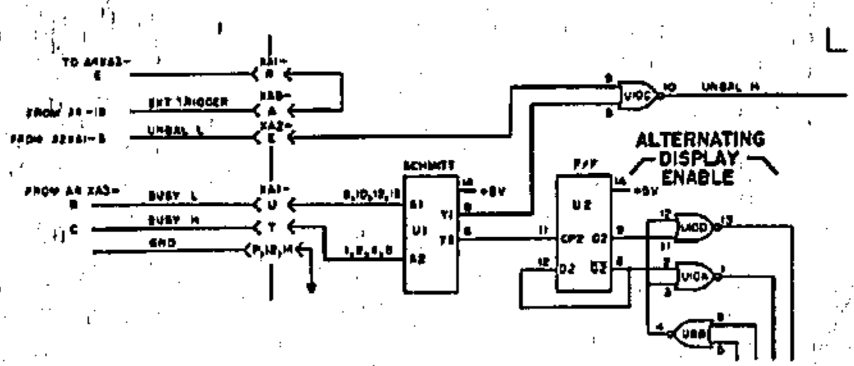
Figure 7-1.

Page 8-15, Figure 8-8,
Change Figure 8-8 partially as follows:

Page 8-15, Figure 8-8 (in Table of Active Components),
CR15: Change to 1902-0184.

Page 6-10, Table 6-2,
A3: Change to HP Part No. 04282-77203; BOARD ASSY:CONTROL.

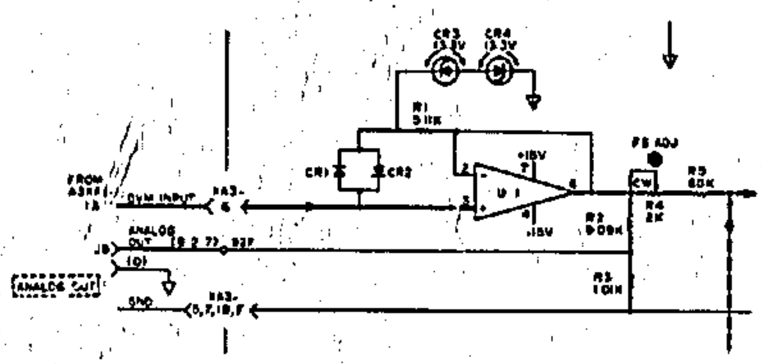
Page 8-21, Figure 8-11,
Change Figure 8-11 partially as follows:



Page 8-21, Figure 8-11 (in Table of Active Components),
Delete CR26.

Pages 6-12 through 6-14, Table 6-2,
A4: Change to HP Part No. 04282-77204; BOARD ASSY:DVM.
A4R58: Change to HP Part No. 0698-4431; RESISTOR:FXD 2.05kΩ 1% .125W F TUBULAR.
Delete following parts,
A4CR11, Q17, R104 and R105.

Page 8-29, Figure 8-15,
Change Figure 8-15 partially as follows:



Page 5-13, paragraph 5-54,
Replace with following paragraphs.

5-54. High Capacitance Ranges Adjustment (A1, A2).

5-55. This adjustment uses a standard capacitor (SOSHIN TM 520-C). Proceed as follows:

a. Set 4282A to same as paragraph 5-31 step a except set C RANGE to 10mF.

b. Set SOSHIN TM 520-C to 10mF.

c. Connect 16035A Test Leads to UNKNOWN connector.

d. Twist two current leads with each other (at lead five times) and also twist the two voltage lead together (see paragraph 3-34) and connect to SOSHIN TM-520-C.

e. Adjust 4282A display for certified 10mF capacitance value with A1R88 (10mF Range Adj.).

f. Set C RANGE and SOSHIN TM 520-C to 1F.

g. Adjust 4282A display for certified 1F capacitance value with A2R10 (1F Full-Scale Adj.).

Page 8-31, Figure 8-16,
Change Figure 8-16 partially as shown in Figure 7-2.

Page 8-31, Figure 8-16 (in Table of Active Components),
Delete CR11 and Q17.

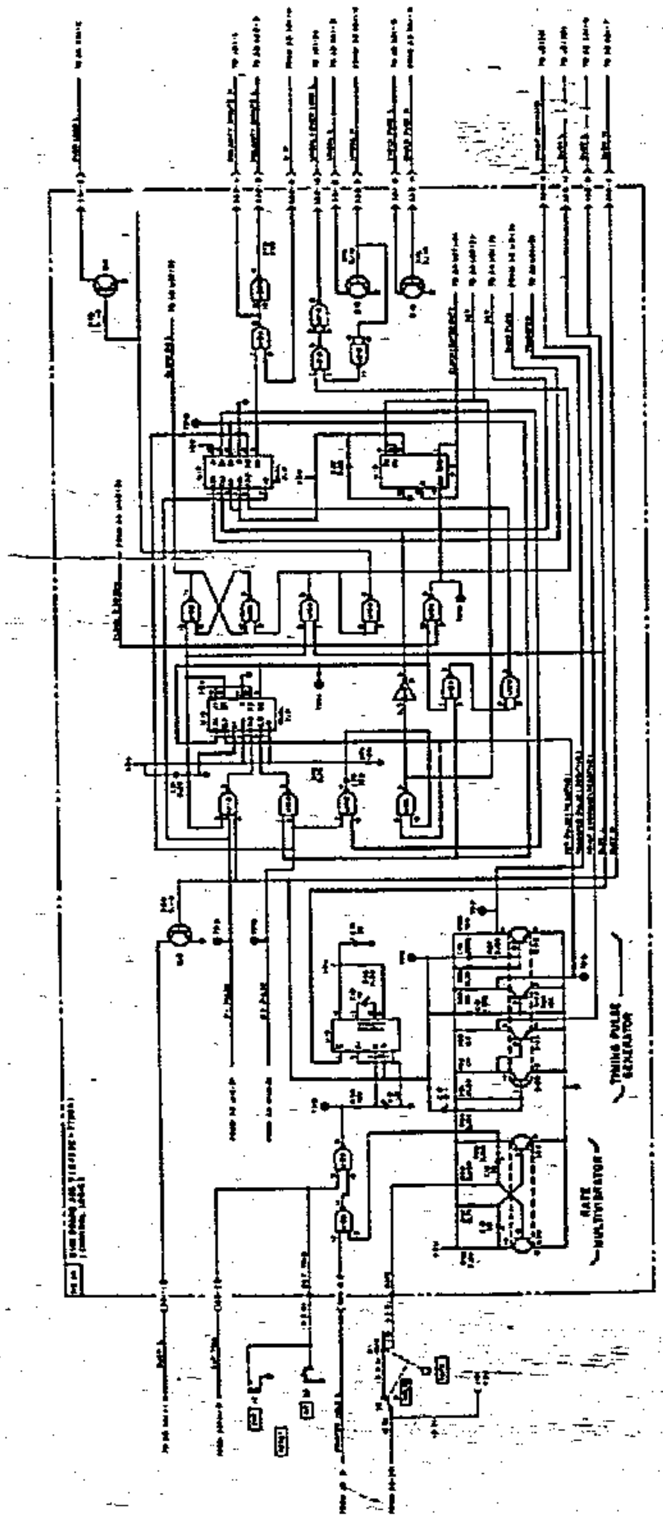


Figure 7-2.

SECTION VIII
CIRCUIT DIAGRAMS

8-1. INTRODUCTION.

8-2. This section includes the following:

a. General Notes for Schematic Diagrams.

b. Block Diagram.

c. Schematic Diagrams and part location illustrations.

d. Circuit Operations.

8-3. The Block Diagram or schematic diagrams can be unfolded and used with any other portion of the manual.

Resistance is in ohms, capacitance is in microfarads and inductance is in microhenries unless otherwise noted.

P/O = part of.

* Asterisk denotes a factory-selected value. Value shown is typical. Capacitors may be omitted or resistors jumpered.

L or H after signal name means the line goes to low or high level, respectively, when the signal is enabled.

R G (RELAY GROUND) or OPEN after signal name means the line is grounded or open, respectively, when the signal is enabled.

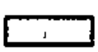
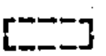
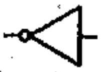
	Screwdriver adjustment.		Panel control.
	Encloses front panel designations.		Encloses rear panel designation.
	AND gate.		NAND gate.
	OR gate.		NOR gate.
	Exclusive OR gate.		Operational amplifier.
	Non-inverting.		Inverting.
	Assembly circuit common.		Floating circuit common.
	Chassis ground.		Protective ground.

Figure 8-1. Schematic Diagram Notes (sheet 1 of 2).

Circuit assembly borderline.

Other assembly borderline.

Heavy line with arrows indicates path and direction of main signal.

Heavy dashed line with arrows indicates path and direction of main feedback.

Wiper moves toward CW with clockwise rotation of control as viewed from shaft or knob.

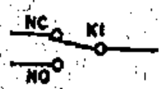
Shows location and number of test point.

(9-4-7)

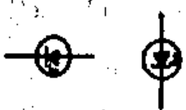
Encloses wire color code. Code used (MIL-STD-681) is the same as resistor color code. First number identifies the base color, second number the wider stripe, and third number identifies narrower stripe (e.g., 947 denotes white base, yellow wide stripe and violet narrow stripe).

A1 (5)

Shows square pin number used in circuit assembly [e.g., A1(5) denotes pin 5 in A1 assembly].



Indicates NC are normally closed contacts and NO are narmally open contacts when relay K1 is not energized.



Voltage regulator (breakdown diode).

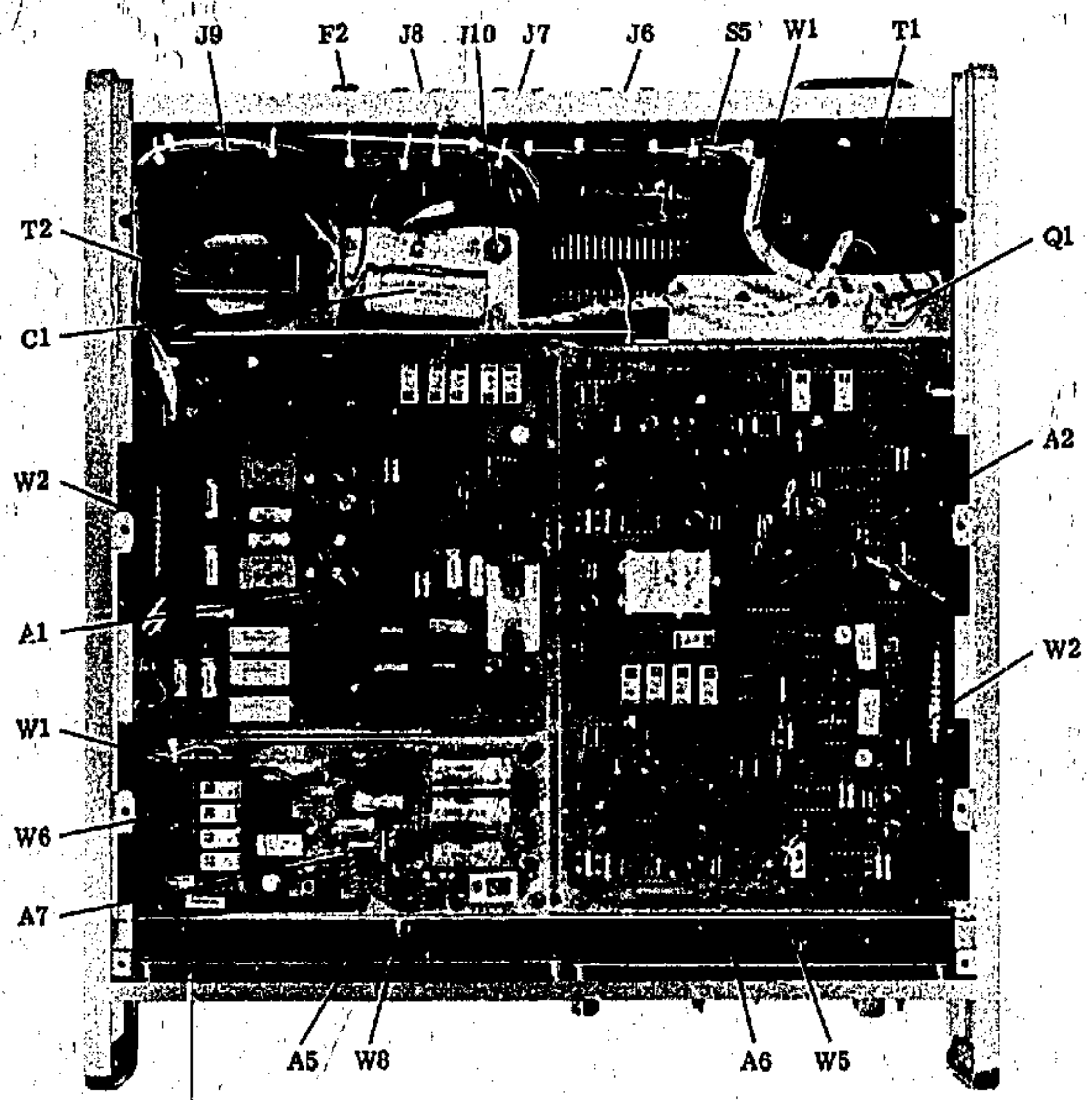
Field Effect transistor (FET) with N-type base.

FET with P-type base.

Tunnel diode.

Light emitting diode (LED).

Figure 8-1. Schematic Diagram Notes (sheet 2 of 2).



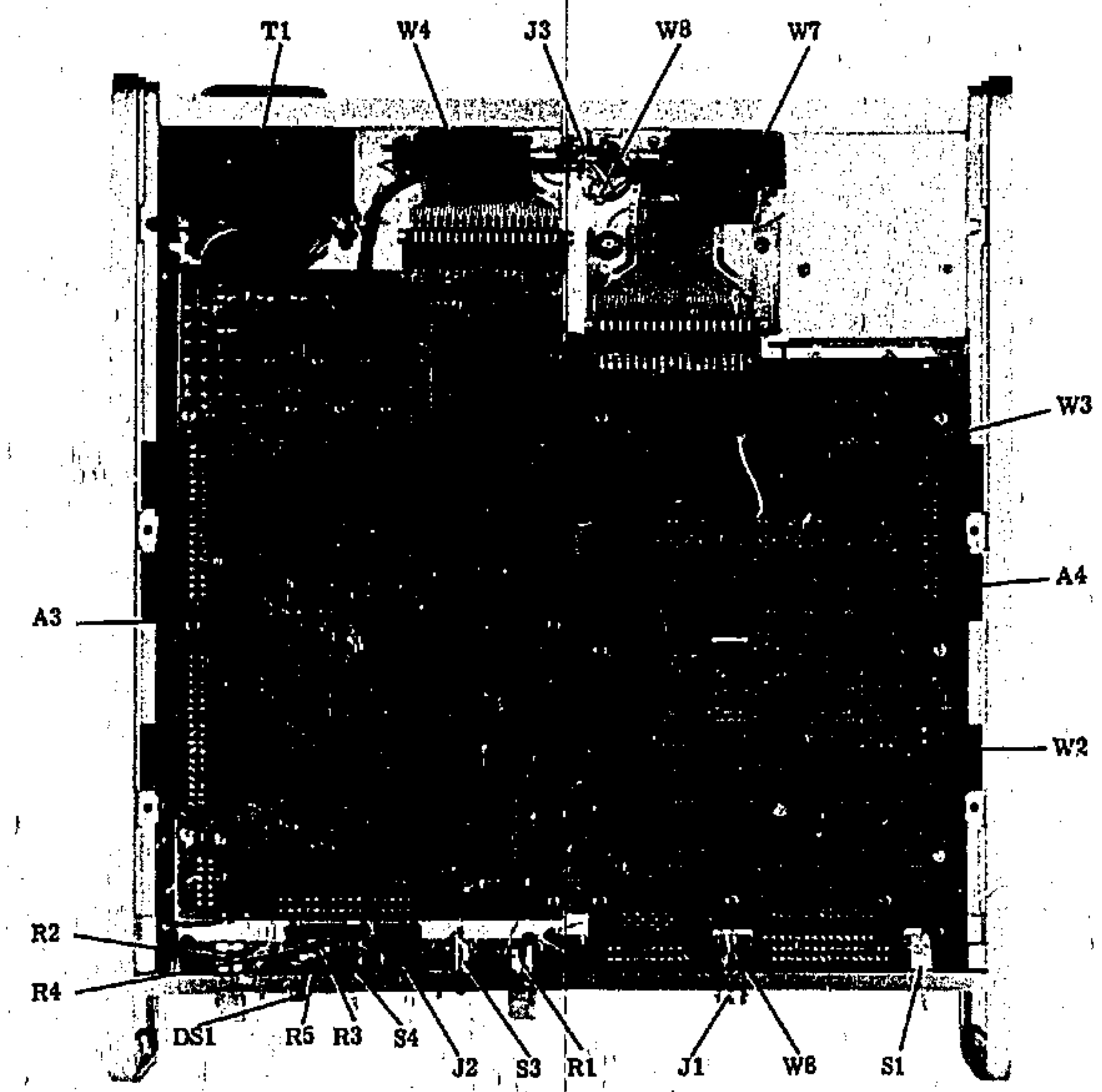


Figure 8-2. Assembly Location.

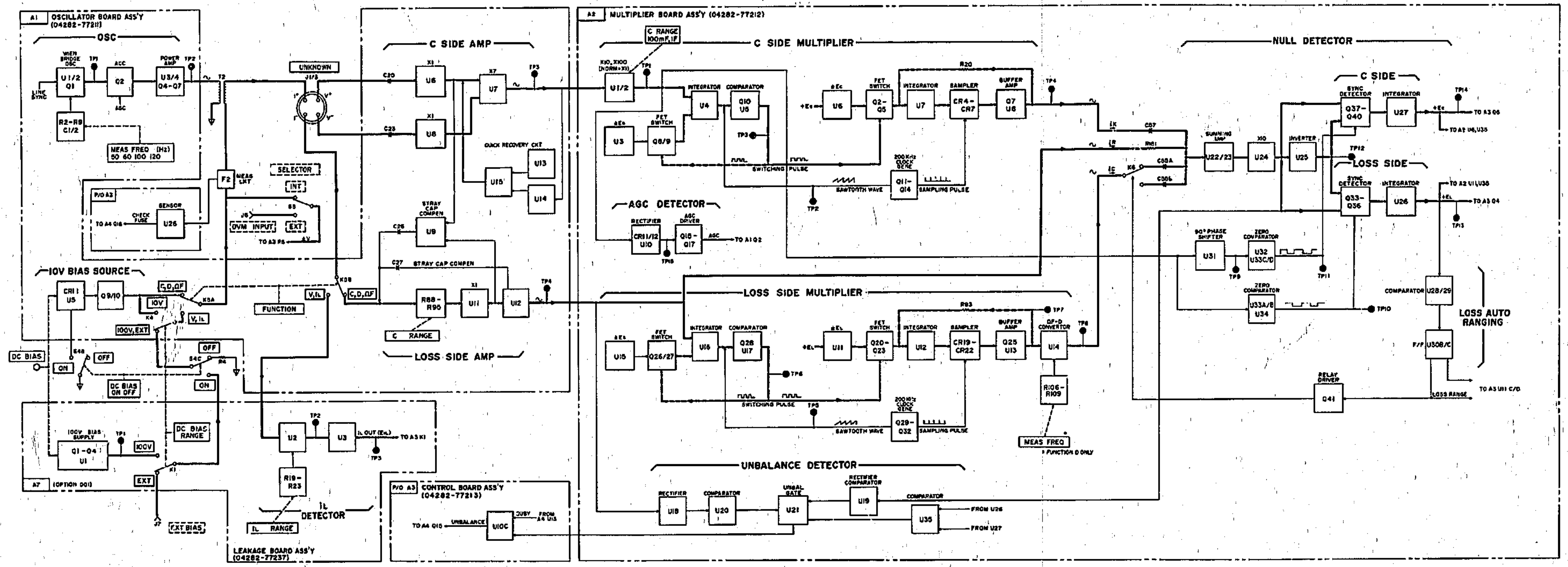


Figure 8-3. Block Diagram - Bridge Section.

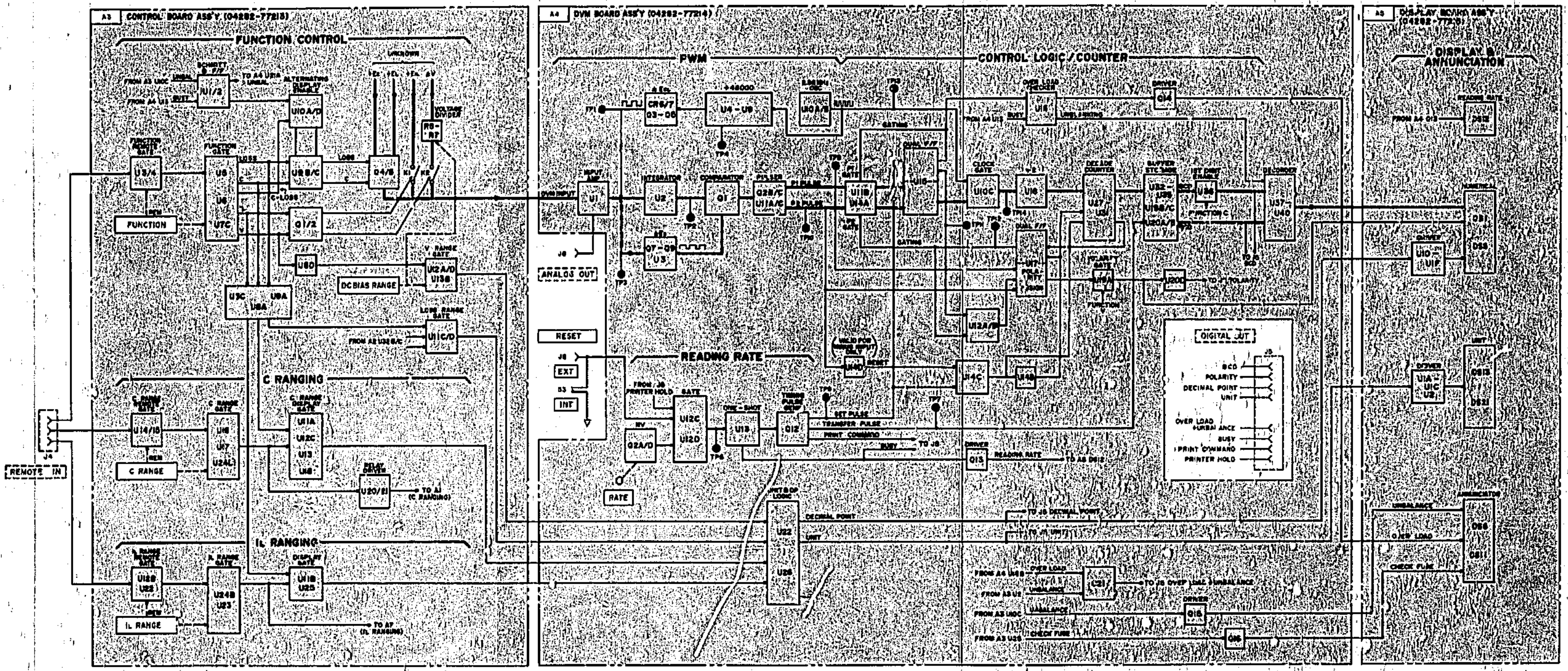


Figure 8-4. Block Diagram - Logic Section.

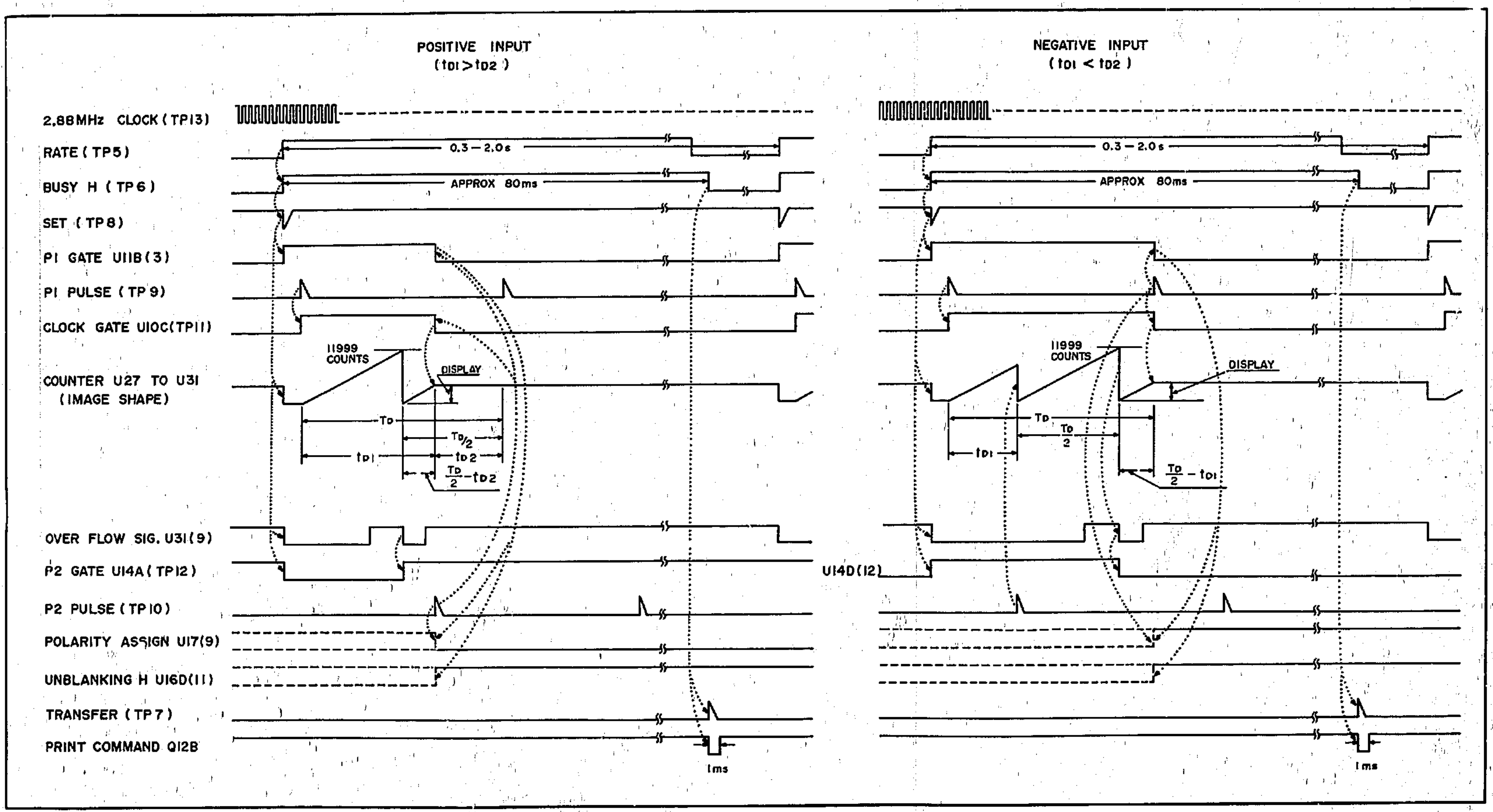
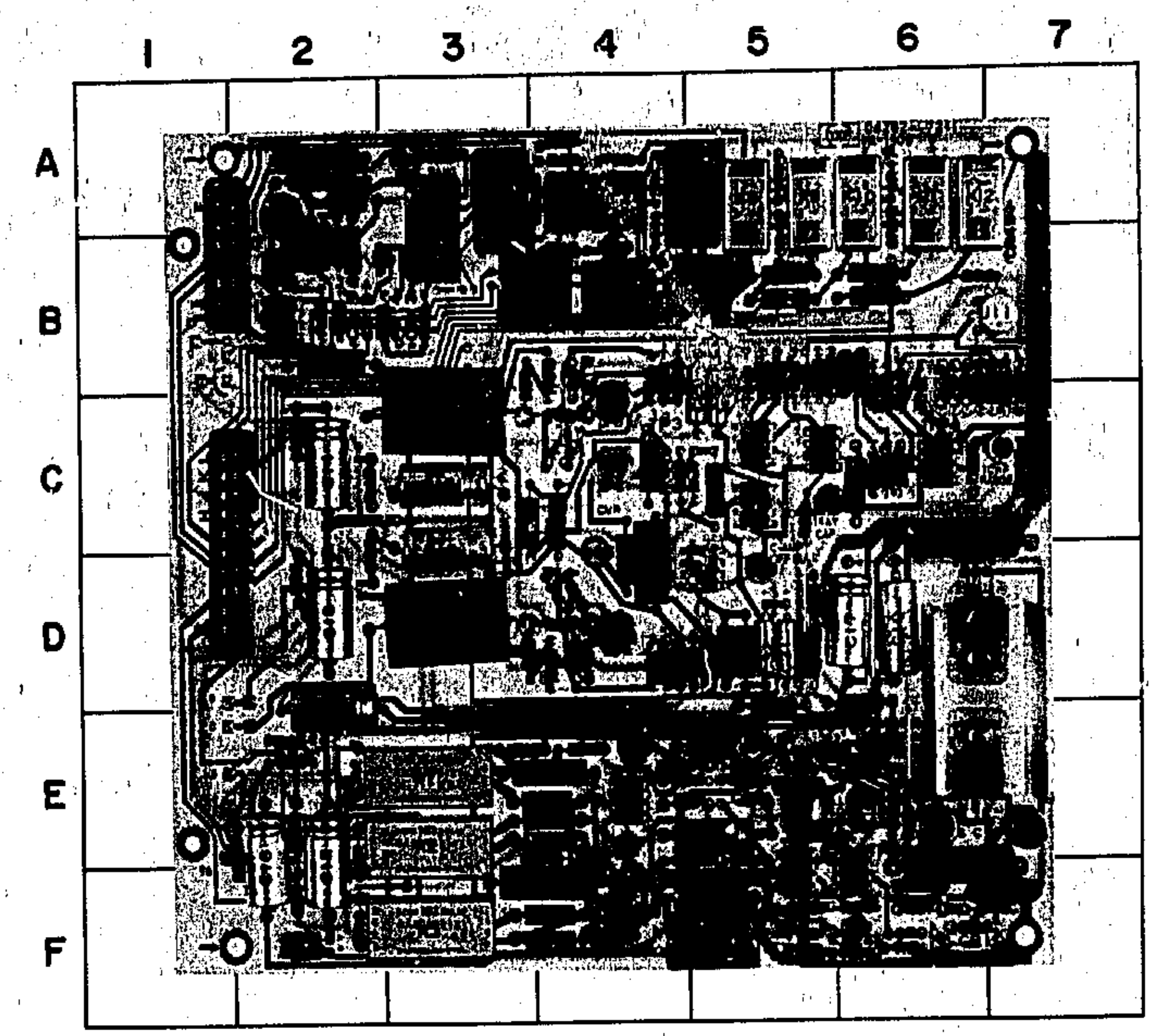


Figure 8-5. DVM Timing Diagram.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	F-5	C14	C-2	CR8	F-6	K3	F-3	Q10	A-2	R12	E-5	R25	E-6	R38	A-2	R51	E-2
C2	F-5	C15	C-3	CR9	F-6	K4	A-3			R13	F-4	R26	E-5	R39	B-2	R52	D-2
C3	E-5	C16	E-2	CR10	F-6	K5	A-3	R1	F-2	R14	E-4	R27	E-6	R40	B-2	R53	D-2
C4	E-5	C17	D-6	CR11	B-2			R2	E-4	R15	E-4	R28	F-6	R41	B-3		
C5	F-5	C18	D-2	CR12	A-2	Q1	E-4	R3	E-4	R16	E-4	R29	E-6	R42	B-2	U1	F-4
C6	E-5	C19	C-3	CR13	B-3	Q2	E-5	R4	F-4	R17	E-5	R30	E-6	R43	B-3	U2	E-4
C7	E-5			CR14	B-3	Q3	F-6	R5	F-5	R18	E-4	R31	F-6	R44	E-5	U3	F-5
C8	F-7	CR1	E-2	CR15	B-2	Q4	E-6	R6	E-4	R19	E-4	R32	F-6	R45	E-6	U4	F-6
C9	B-2	CR2	E-2	CR16	B-2	Q5	E-7	R7	E-4	R20	F-6	R33	F-6	R46	E-2	U5	B-2
C10	D-6	CR3	F-3	CR50	F-2	Q6	E-6	R8	F-4	R21	F-6	R34	D-6	R47	E-2		
C11	E-5	CR4	E-5	CR51	F-2	Q7	D-6	R9	F-4	R22	F-5	R35	B-2	R48	C-2	XA1	B-1
C12	E-2	CR5	E-3			Q8	B-2	R10	E-4	R23	F-5	R36	B-2	R49	C-2	XA2	C-1
C13	E-2	CR6	E-5	K1	E-3	Q9	B-2	R11	E-4	R24	F-6	R37	A-2	R50	E-1		
		CR7	F-6	K2	E-3												

SEE INSIDE

Figure 8-5
DVM Timing Diagram

A1 OSCILLATOR BOARD OPERATION

Measuring Signal Generator.

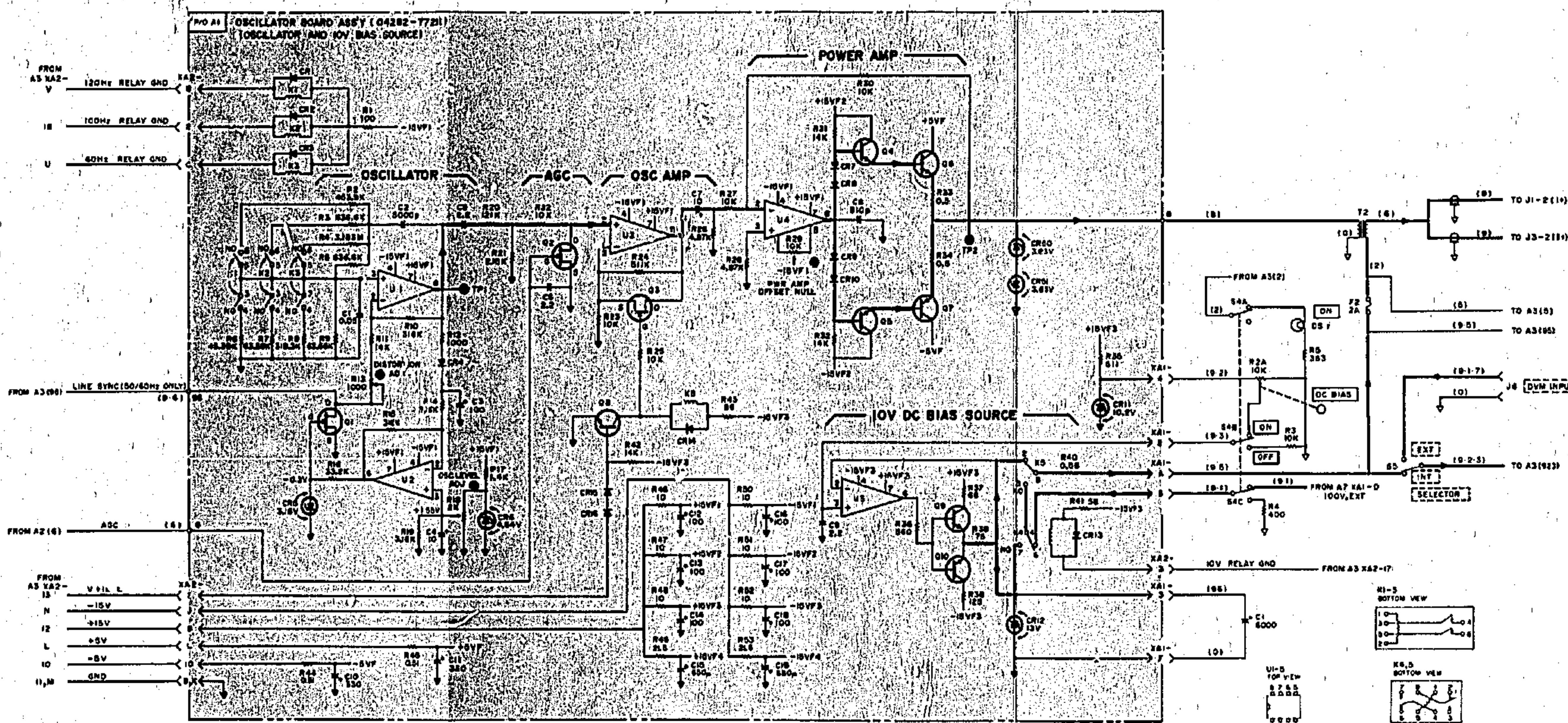
This section is the signal source of Bridge and consists of an oscillator, amplifier and power amplifier. The oscillator employs the Wien Bridge technique and provides four measuring frequencies of 50, 60, 100 and 120Hz. Selection and determination of frequency are done by relays K1, K2 and K3 which select R2 through R9 in combination with C1 and C2. FET Q1 is driven by U2 whose input is difference between Peak Detector CR4 output and reference voltage established by CR6. Q1 operates to maintain voltage ratio at U1(2) at one twenty first of voltage at U1(6) (because, for example, C1 is ten times of C2, R9 is one tenth of R5 at 50Hz setting, and so on). Output at U1(6) can be changed or maintained by potentiometer R18. When MEAS FREQ switch is set to 50 or 60Hz, line synchronous signal is applied to Q1 drain to synchronize frequency to line frequency.

AGC(Q2) only operates when C range is set to 100mF or 1F. On these two ranges, range is determined not by changing range resistances but by increasing amplifier A2U1, U2 gain from 1 to 10 or to 100. Amplifiers could be saturated depending upon unknown values. To prevent this, appropriate AGC signals reduce measuring signal level. Amplifier U3 amplifies oscillator signal to furnish sufficient drive to Power Amplifier. Both Q2 and Q3 turn on when function is set to V or I_L (option 001) which operate to extinguish oscillator signal. The Power Amplifier, which is comprised of U4 and Q4 through Q7, has unity gain and the capability to feed maximum signal current of about 660mA (equivalent to 1A) through transformer T2 which has a turns ratio of three to two. Q4, Q6 and Q5, A7 form a complementary push-pull circuit.

10V DC Bias Source.

A 10 volts DC Bias Source is provided by reference diode CR11, differential amplifier U5 and power amplifier Q9 and Q10. Bias voltage is controlled by DC BIAS control R2A. Maximum current is about 100mA.

A1 Parts Locations under Fold



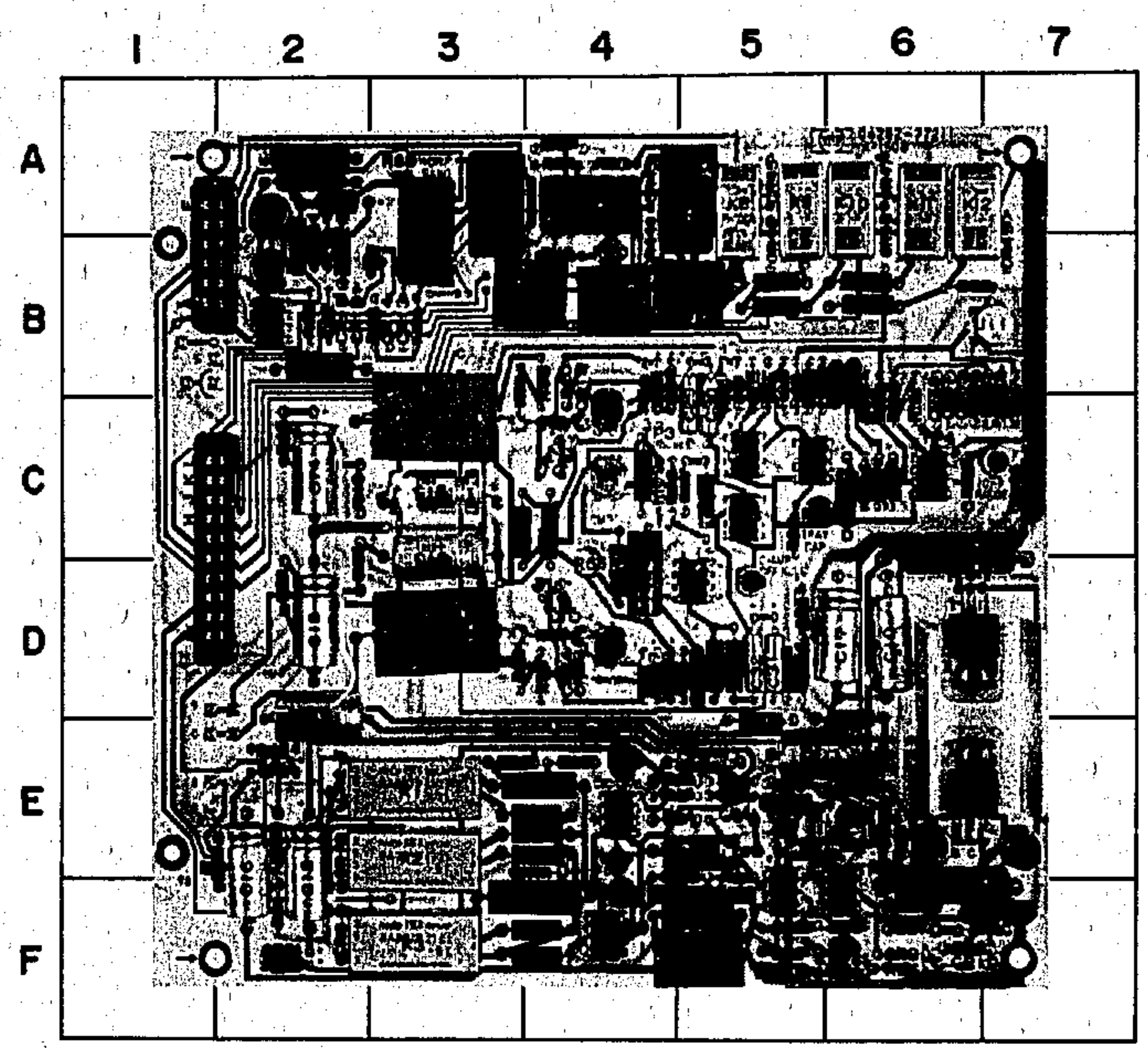
Reference Designations

NO PREFIX	A1
C1	C1 - 19
	CR1 - 16, 50, 51
DS1	
F2	
J6	
	K1 - 5
	Q1 - 10
R2 - 5	R1 - 53
S4, 5	
T2	
	U1 - 5
	XA1, 2

Table of Active Components

Reference Designations	HP Part Number
A1	
CR1 - 4, 7 - 10	1901-0040
CR13 - 16	1901-0040
CR5	1902-3036
CR50, 51	1902-3059
CR6	1902-3082
CR11	1902-3183
CR12	1902-0643
Q1	1855-0087
Q2, 3	1855-0081
Q4, 9	1854-0090
Q5	1853-0061
Q6	1854-0127
Q7	1853-0106
Q8	1853-0020
Q10	1853-0061
U1 - 5	1820-0216

Figure 8-6. A1 Oscillator Board Ass'y.
(Oscillator and 10V Bias Source)



PARTS LOCATOR

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C20	C-3	CR20	B-4	CR34	D-5	CR48	A-6	Q11	D-5	R63	D-5	R78	B-5	R92	B-5	R107	B-5
C21	D-5	CR21	C-4	CR35	B-6	CR49	B-7	Q12	D-5	R64	B-4	R79	B-5	R93	B-5	R108	A-3
C22	C-5	CR22	C-4	CR36	B-7			Q13	D-5	R66	C-4	R80	B-5	R94	B-6		
C23	D-3	CR23	D-4	CR37	B-6	K5	A-2			R67	D-5	R81	B-5	R95	B-6	U6	C-4
C24	D-5	CR24	D-4	CR38	B-6	K6	A-4	R43	B-3	R68	C-5	R82	B-5	R96	B-7	U7	C-5
C25	D-5	CR25	D-4	CR39	B-7	K7	A-5	R54	A-4	R69	D-4	R83	C-5	R97	B-7	U8	D-4
C26	B-6	CR26	D-4	CR40	B-7	K8	A-5	R55	A-4	R70	D-3	R84	C-5	R98	B-6	U9	C-5
C27	B-6	CR27	D-4	CR41	C-6	K9	A-5	R56	C-4	R71	D-4	R85	B-5	R99	B-6	U10	C-5
C28	C-6	CR28	D-4	CR42	C-6	K10	A-6	R57	C-3	R72	D-4	R86	B-5	R100	B-6	U11	B-7
		CR29	D-4	CR43	A-4	K11	A-6	R58	B-4	R73	D-3	R87	B-5	R101	B-6	U12	C-6
CR14	B-3	CR30	D-5	CR44	B-4	K12	A-7	R59	B-4	R74	C-3	R88	A-3	R103	C-6		
CR17	C-4	CR31	C-5	CR45	A-5	K13	C-4	R60	C-5	R75	D-4	R89	B-4	R104	C-7	XA1	B-1
CR18	C-4	CR32	C-5	CR46	A-5	K14	C-4	R61	D-5	R76	C-5	R90	B-4	R105	C-7		
CR19	B-4	CR33	D-5	CR47	A-6			R62	D-5	R77	C-5	R91	B-5	R106	C-6		

MEASURING CIRCUIT OPERATION

C, D, and ΩF Measurements.

Both UNKNOWN connectors J1 (front) and J3 (rear) each have the two current terminals and the two voltage terminals required for Four-Terminal operation. Measuring current from T2 appears at current terminal I^+ and flows through unknown to current terminal I^- into the range resistors in A1. Voltage terminals detect voltage across unknown and send it to C Side Amplifier in A1. When dc bias is superimposed, dc bias is fed from A1XA1-A and applied to unknown through T2. Quick action fuse F2 (2A) works to protect measuring circuit from excessive current. If fuse blows, measuring signal becomes input of Check Fuse Sensor in A3.

V (Voltage) Measurement.

When FUNCTION is set to V, voltage across unknown is connected to DVM Board (A4) through Control Board (A3). Both external input voltage and biasing voltages up to 600V are measureable. Selection is made with DVM INPUT SELECTOR switch S5.

I_L Measurement (Option 001).

When FUNCTION is set to I_L or V and DC BIAS ON-OFF switch S4 to ON, dc bias is fed from A1XA1-A and applied to unknown through current lead I^+. Leakage current through unknown is connected to A1XA1-6 and fed to Leakage Current Board (A7) through current lead I^-. A7 assembly converts this current to voltage. When S4 is set to OFF, discharge resistor R4 is connected to unknown.

SEE INSIDE

Figure 8-6
A1 Oscillator Board Ass'y
(Oscillator and 10V Bias Source)

A1 OSCILLATOR BOARD OPERATION
(C and Loss Side Amplifier Section).

C Side Amplifier.

The C side Amplifier contains two Impedance Converters U6 and U8 plus Amplifier U7. The impedance converters, whose inputs are connected to voltage terminals V^+ or V^-, provide high input impedance so as not to affect unknown. Amplifier U7 amplifies voltage across unknown seven times and sends an output opposite in phase to Multiplier Board A2. CR17 to CR22 and CR23 to CR28 form a protective circuit for large changes of dc bias. U13 to U15 provides negative feed back loop for stable dc offset nulling.

Loss Side Amplifier.

The Loss Side Amplifier includes C Range resistors R88 to R95, Impedance Converter U11 and Amplifier U12. Measuring signal goes to ground through current lead I^- and selected C Range Resistor. Impedance Converter U11 sends voltage across C Range resistor to Amplifier U12. U12 amplifies U11 output and provides an output in phase with measuring current which is sent to Multiplier Board A2.

Stray Capacitance Compensation Circuit.

Differential amplifier U9 and C26 compensate for stray capacitance between measuring leads and C27 compensates for stray capacitance of C Range Resistors.

A1 Part Locations under Fold

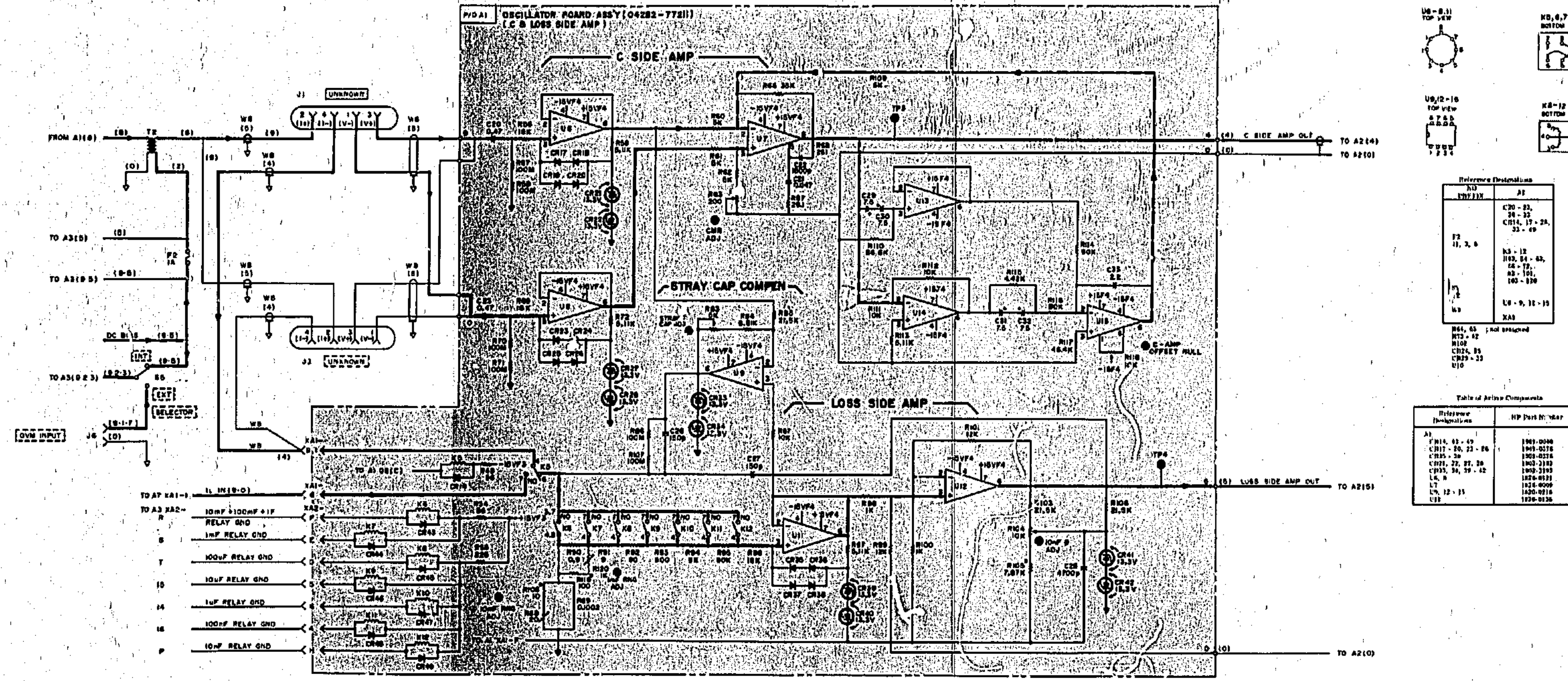
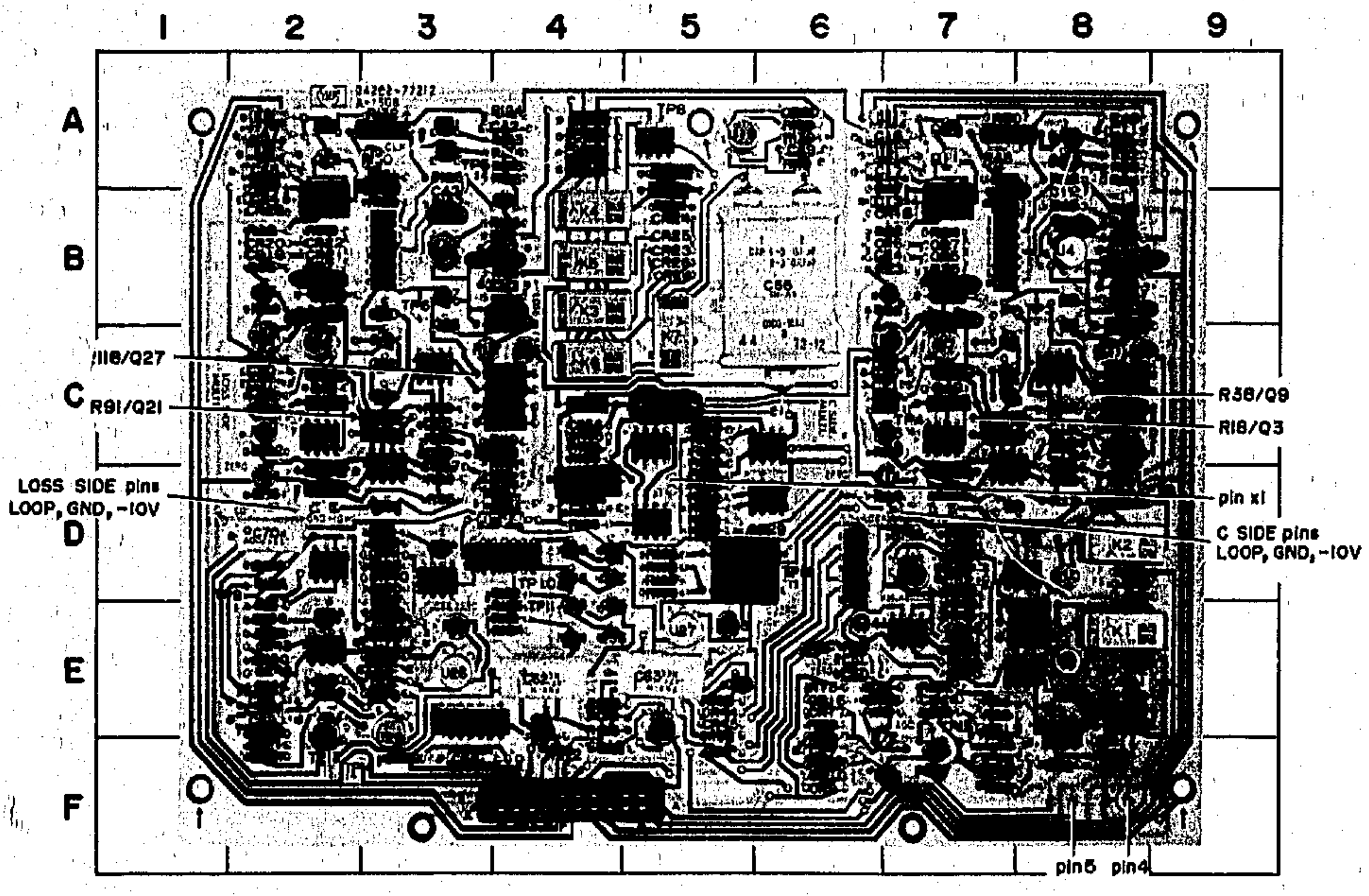


Figure 8-7. A1 Oscillator Board Ass'y. (C & Loss Side Amp)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	E-8	Q4	C-7	R39	C-8
C2	D-7	Q5	C-7	R40	B-8
C3	B-7	Q6	C-6	R41	B-8
C4	C-7	Q7	B-6	R42	B-8
C5	B-7	Q8	B-8	R43	A-8
C6	D-8	Q9	B-8	R44	B-8
C7	D-8	Q10	B-8	R45	B-8
C8	C-8	Q11	A-7	R46	B-7
C9	B-8	Q12	A-7	R47	B-6
C10	B-8	Q13	A-8	R48	A-7
C11	A-8	Q14	A-8	R49	B-7
C12	B-8	Q15	E-7	R50	A-7
C13	B-6	Q16	F-6	R51	A-8
C14	B-7	Q17	F-7	R52	A-8
C15	A-7			R53	A-8
C16	A-6	R1	E-8	R54	C-8
C17	A-6	R2	D-8	R55	C-6
C18	C-8	R3	E-8	R56	B-8
C19	C-8	R4	E-8	R57	C-8
C20	C-6	R5	E-8	R58	C-6
C21	C-6	R6	E-8	R59	B-8
C22	B-8	R7	D-8	R60	F-8
C23	B-8	R8	E-8	R61	E-8
C24	D-8	R9	D-7	R62	F-8
C25	E-7	R10	D-8	R63	F-8
C26	F-7	R11	D-6	R64	E-7
C27	E-6	R12	D-6	R65	E-7
		R13	D-7	R66	F-7
CR1	E-8	R14	D-7	R67	E-7
CR2	E-8	R15	D-8	R68	F-7
CR3	D-8	R16	D-8	R69	E-7
CR4	B-6	R17	C-7	R70	E-6
CR5	B-7	R18	C-7	R71	E-6
CR6	B-6	R19	C-7	R72	E-6
CR7	B-7	R20	C-7	R73	E-6
CR8	C-8	R21	B-7	R74	E-6
CR9	F-6	R22	B-6	R75	E-6
CR10	F-6	R23	B-6	R76	F-6
CR11	E-8	R24	B-6		
CR12	E-8	R25	B-7	T1	B-7
CR13	E-7	R26	B-6		
CR14	E-7	R27	C-6	U1	E-7
CR15	E-6	R28	C-6	U2	D-7
CR16	E-6	R29	C-6	U3	C-8
CR17	E-6	R30	C-8	U4	B-8
CR18	B-6	R31	C-8	U5	B-7
		R32	C-8	U6	C-7
K1	E-8	R33	D-8	U7	C-7
K2	D-8	R34	C-8	U8	C-7
		R35	D-8	U10	E-8
Q1	D-7	R36	C-8		
Q2	B-7	R37	C-8	XA1	F-4
Q3	C-7	R38	C-8		

SEE INSIDE

Figure 8-7
A1 Oscillator Board Ass'y
(C & Loss Side Amp)

A2 MULTIPLIER BOARD OPERATION
(C Side Multiplier and AGC Detector Section).

C Side Multiplier.

The C Side Multiplier, shown in top section of schematic Figure 8-8, produces the product of C Side Amplifier output in A1 and C Side Integrator output (E_C) in A2. Amplifiers U1 and U2 (x10 and x100) have a gains of 1 below a C Range 10mF and increase their gains to 10 on 100mF range and to 100 on 1F range. U2 output is applied to integrator U4. The $\pm E_S$ Generator CR8 and U3 provide plus and minus references through R38 and R37, respectively. The $+E_S$ is switched by FET Switch Q8 and Q9 as U4 input goes to zero during one period of 200kHz clock. U4 output produces both positive and negative going ramps during one clock period. Changing of ramp polarity occurs at the same level of U4 output and sawtooth waveform of Q14 in 200kHz Clock Generator. This is sensed by Comparator Q10, which changes state of U5C and U5B whose output is connected to FET Switch Q8 and Q9 (to complete negative feedback loop) and also to FET switch Q2 to Q5. U5 is driven in negative domain to match action of FET Switches and provides a waveform modulated to pulse width by U2 output.

The $\pm E_C$ Generator U6 accepts C Side Integrator output ($+E_C$) and develops $-E_C$. Q1 is temperature compensator for U6. The $+E_C$ is connected to Integrator U7 through R17 and the $-E_C$ is connected to U7 through R18 and FET Switch Q2 to Q5 which is switched by timing from U5. U7 integrates the sum of these two inputs. U7 output through Q6 is sampled by applying sampling pulse issued at each end of sawtooth from T1 in 200kHz Clock Generator to Sampler (CR4 to CR7) and is stored in C5. Charge stored in C5 maintains input to Buffer Amplifier Q7 and U8. Therefore, U8 output forms staircase which is similar to and in phase with C Side Amp output in A1. Negative feedback loop through R20 operates to cancel result of previous integration. The heart of 200kHz Clock Generator is the Blocking Oscillator (Q11, T1 and CR18). This provides two outputs, one is sampling pulse of 10V peak at T1 (1-2) and the other is sawtooth at Q14 emitter.

AGC Detector.

AGC Detector, shown on bottom section of schematic Figure 8-8, provides a valid signal only when C Range is 100mF or 1F to reduce Oscillator signal level in A1 according to conditions of U1 and U2. On the other ranges, U2 output never exceeds about 7Vrms but on two ranges the 7Vrms may be exceeded which saturates U1 and U2 due to increased gain. Rectifier CR11 and CR12 and U10 rectifies U2 output and sends it to Smoothing Circuit and again to AGC Driver Q16. Q16 emitter level is normally negative and goes towards positive when U2 output increases. Q17 is on when Function is V or I_L to break out Oscillator signal in A1.

A2 Parts Locations under Fold

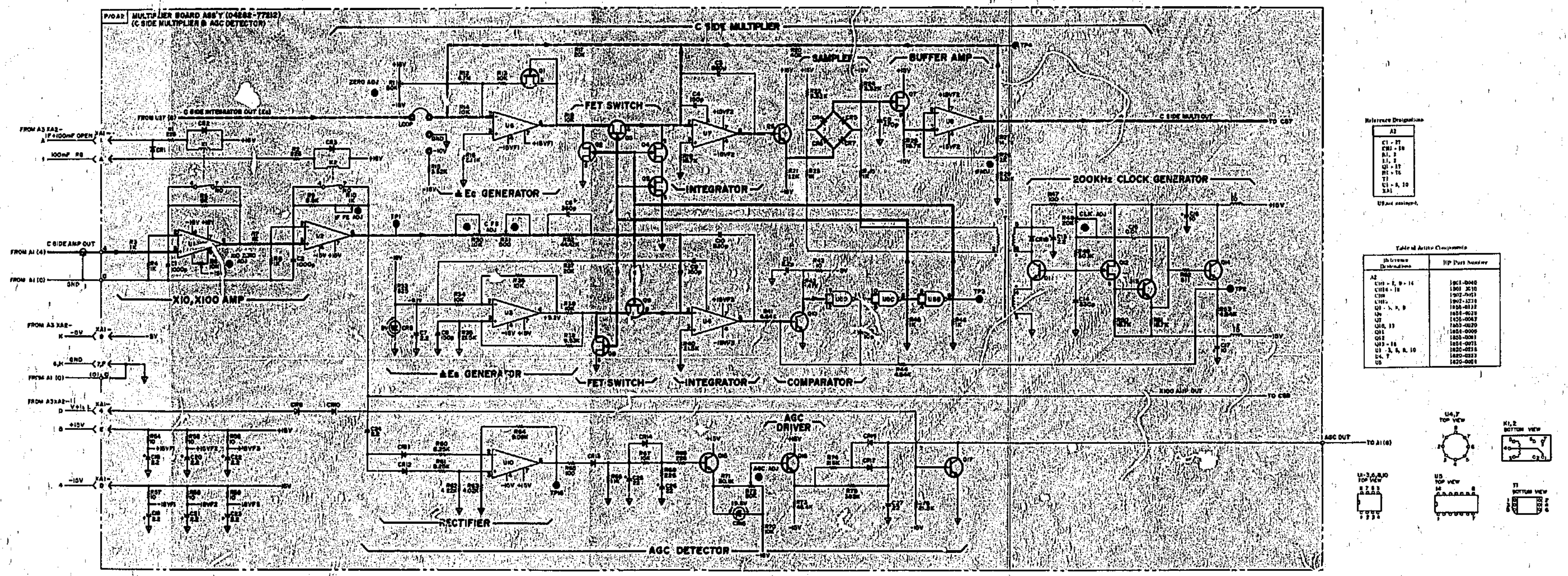
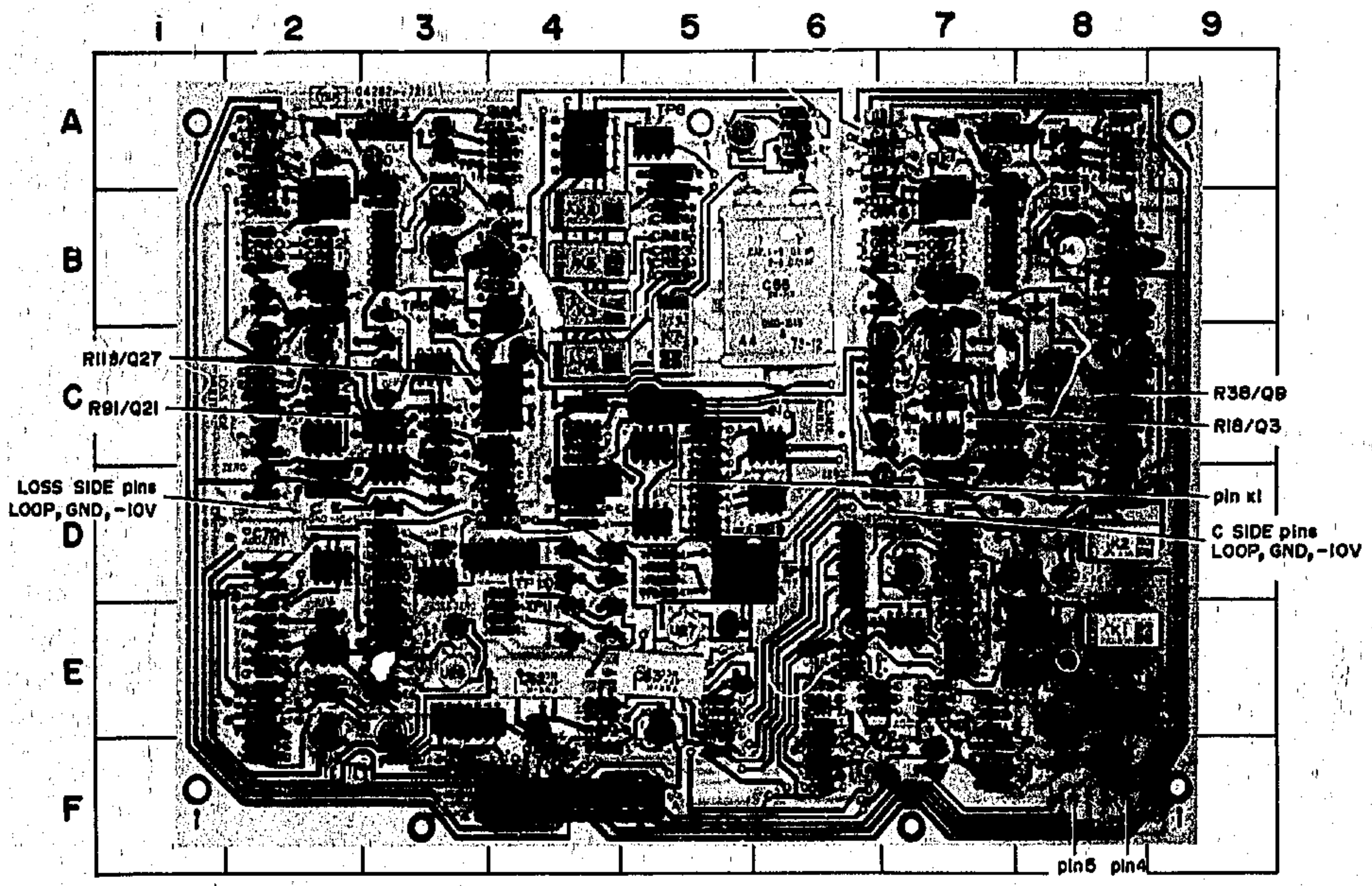


Figure 8-8. A2 Multiplier Board Ass'y.
(C Side Multiplier & AGC Detector)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C28	C-3	Q19	D-3	R115	C-4
C29	C-3	Q20	B-3	R116	C-4
C30	C-2	Q21	C-3	R117	C-3
C31	C-2	Q22	C-3	R118	C-4
C32	B-4	Q23	C-3	R119	C-4
C33	B-4	Q24	C-2	R120	B-4
C34	C-2	Q25	B-2	R121	C-4
C35	B-2	Q26	B-3	R122	B-4
C36	B-2	Q27	B-3	R123	D-4
C37	D-4	Q28	B-4	R124	A-4
C38	C-4	Q29	A-2	R125	A-3
C39	B-4	Q30	A-2	R126	A-4
C40	B-3	Q31	A-3	R127	B-3
C41	B-4	Q32	A-3	R128	B-3
C42	A-4			R129	B-2
C43	B-3	R77	E-5	R130	A-3
C44	B-2	R78	C-3	R131	A-3
C45	B-3	R79	C-3	R132	A-3
C46	A-3	R80	C-2	R133	A-4
C47	A-2	R81	C-2	R134	A-4
C48	A-2	R82	B-4	R135	A-4
C49	A-6	R83	B-4	R136	D-5
C50	E-6	R84	D-2	R137	D-5
C51	E-6	R85	D-3	R138	A-6
C52	D-7	R86	D-2	R139	A-6
C53	D-7	R87	D-2	R140	E-7
C54	E-6	R88	C-2	R141	E-6
		R89	D-3	R142	E-7
CR19	B-2	R90	C-3	R143	E-7
CR20	B-2	R91	C-3	R144	E-6
CR21	B-2	R92	C-2	R145	E-7
CR22	B-2	R93	C-2	R146	D-7
CR23	B-5	R94	B-2	R147	D-7
CR24	B-5	R95	B-2	R148	D-7
CR25	B-5	R96	B-2	R149	D-7
CR26	B-5	R97	B-2	R150	D-7
CR27	C-3	R98	B-2		
CR28	B-2	R99	B-2	T2	B-2
CR29	D-5	R100	C-2		
CR30	A-6	R101	C-2	U11	C-3
CR31	E-7	R102	C-2	U12	C-2
CR32	E-7	R103	E-5	U13	C-2
CR33	D-7	R104	B-5	U14	A-5
		R105	A-4	U15	C-3
K3	B-4	R106	A-4	U16	B-3
K4	B-4	R107	A-4	U17	B-3
K5	B-4	R108	A-4	U18	E-7
K6	C-4	R109	B-5	U19	A-5
		R110	A-6	U20	D-7
L3	A-2	R111	A-5	U21	D-6
L4	A-2	R112	C-4		
		R113	C-4	XA1	F-4
Q18	E-5	R114	C-4		

SEE INSIDE

Figure 8-8
A2 Multiplier Board Ass'y
(C Side Multiplier & AGC Detector)

A2 MULTIPLIER BOARD OPERATION
(Loss Side Multiplier and Unbalance Detector Section).

Loss Side Multiplier.

Loss Side Multiplier produces the product of Loss Side Integrator output (E_L) in A2 and Loss Side Amplifier output in A1. This operation is very similar to C Side Multiplier. Loss Side Amplifier output is sent to Integrator U16 and reference resistor R151. The $\pm E_S$ Generator CR27 and U15 provides plus and minus references through R118 and R121, respectively. The $+E_S$ is switched by FET Switch Q26 and Q27 as U16 input goes to zero during one period of 200kHz Clock. U16 output produces positive and negative going ramps in one clock period. Changing of ramp polarity occurs at the same level of U16 output and sawtooth waveform of Q32 in 200kHz Clock Generator. This is sensed by Comparator Q28, which changes state of U17C and U17B whose output is connected to FET Switch Q26 and Q27 to complete negative feedback loop and also to FET switch Q20 to Q23. U17 is driven in negative domain to match operation of FET Switches and provides waveform modulated to pulse width by Loss Side Amp output in A1.

The $\pm E_L$ Generator U11 accepts Loss Side Integrator output ($+E_L$) and provides $-E_L$. Q19 is temperature compensator for U11. The $+E_L$ is connected to Integrator U12 through R90 and $-E_L$ is connected to U12 through R91 and FET Switch Q20 to Q23 which is switched by timing from U17. U12 integrates the sum of these two inputs. U12 output through Q24 is sampled by applying sampling pulse, issued at each end of sawtooth from T2 in 200kHz Clock Generator, to Sampler (CR19 to CR22) and is stored in C36. Charge stored in C36 maintains input of Buffer Amplifier Q25 and U13. Therefore, U13 output forms staircase which is similar to and 180° out of phase with Loss Side Amp output in A1. Negative feedback loop through R93 operates to cancel result of previous integration. Following stage, U14, is ΩF-D Converter. The gain is one for Function ΩF and is $1000/2\pi f$ for Function D (f is measuring frequency in Hz). The heart of 200kHz Clock Generator is the Blocking Oscillator (Q29, T2 and CR28). This provides two outputs, one is a sampling pulse of 10V peak at T2(1-2) and the other is sawtooth at Q32 emitter.

Unbalance Detector.

Unbalance Detector judges unbalance condition from three sources of information. The first is sensed by U18 and U20 when unknown capacitance is too low compared to C Range setting. The second is by U19 when an error signal always exists on Null Detector. The third is by A2U35 when E_C or E_L exceeds +12V. U18 and CR31 plus CR32 form a Rectifier and the smoothed output is applied to Comparator U20. U20 output goes to L (low level) when the level at U20(3) goes lower than at U20(2), which means that Loss Side Amp output is too small. If an error signal exists, it is rectified by CR29 and fed to Comparator U19. U19(6) goes L when the level at U19(2) exceeds that at U19(3). Either one, when conditioned, drives Gate U21D(11) to H (high level) and also U21B(6) L. Finally, A2U35 output goes to L when E_C or E_L exceed +12V and similarly makes U21A(3) H, and U21B (6) L. Gate U21B is disabled when Function is V or I_L.

A2 Parts Locations under Fold

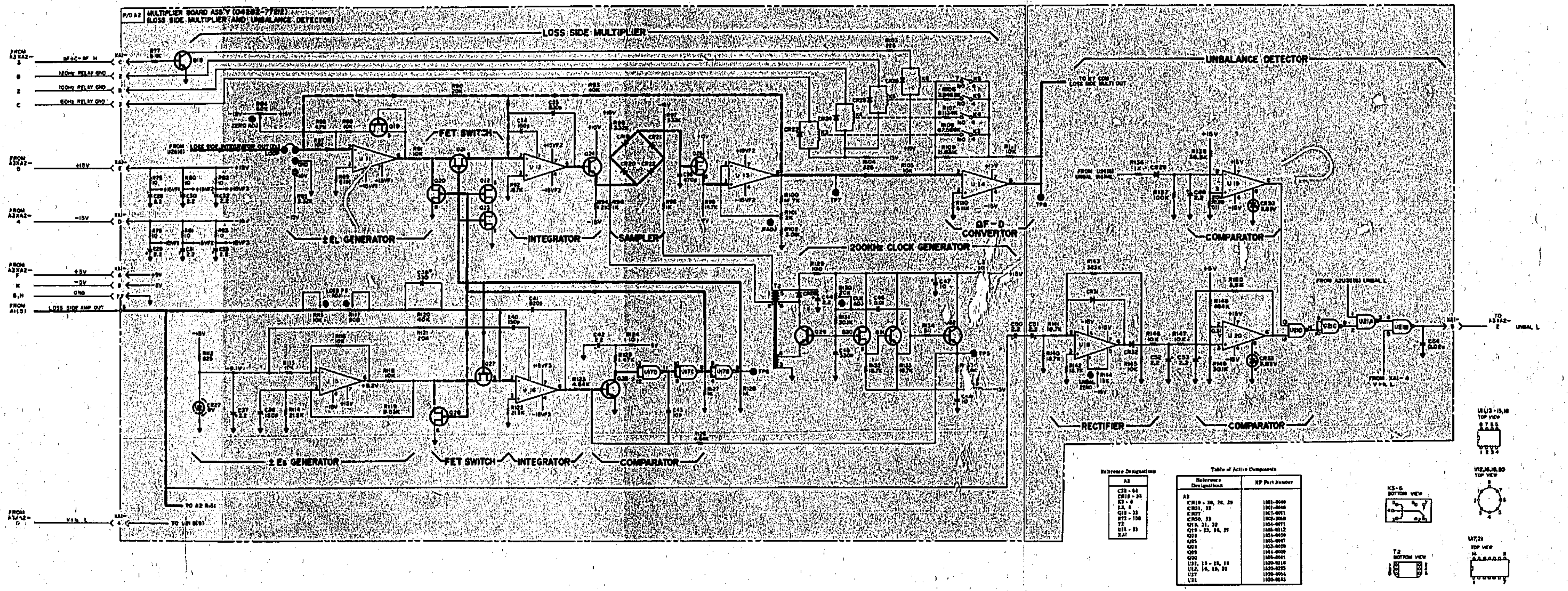
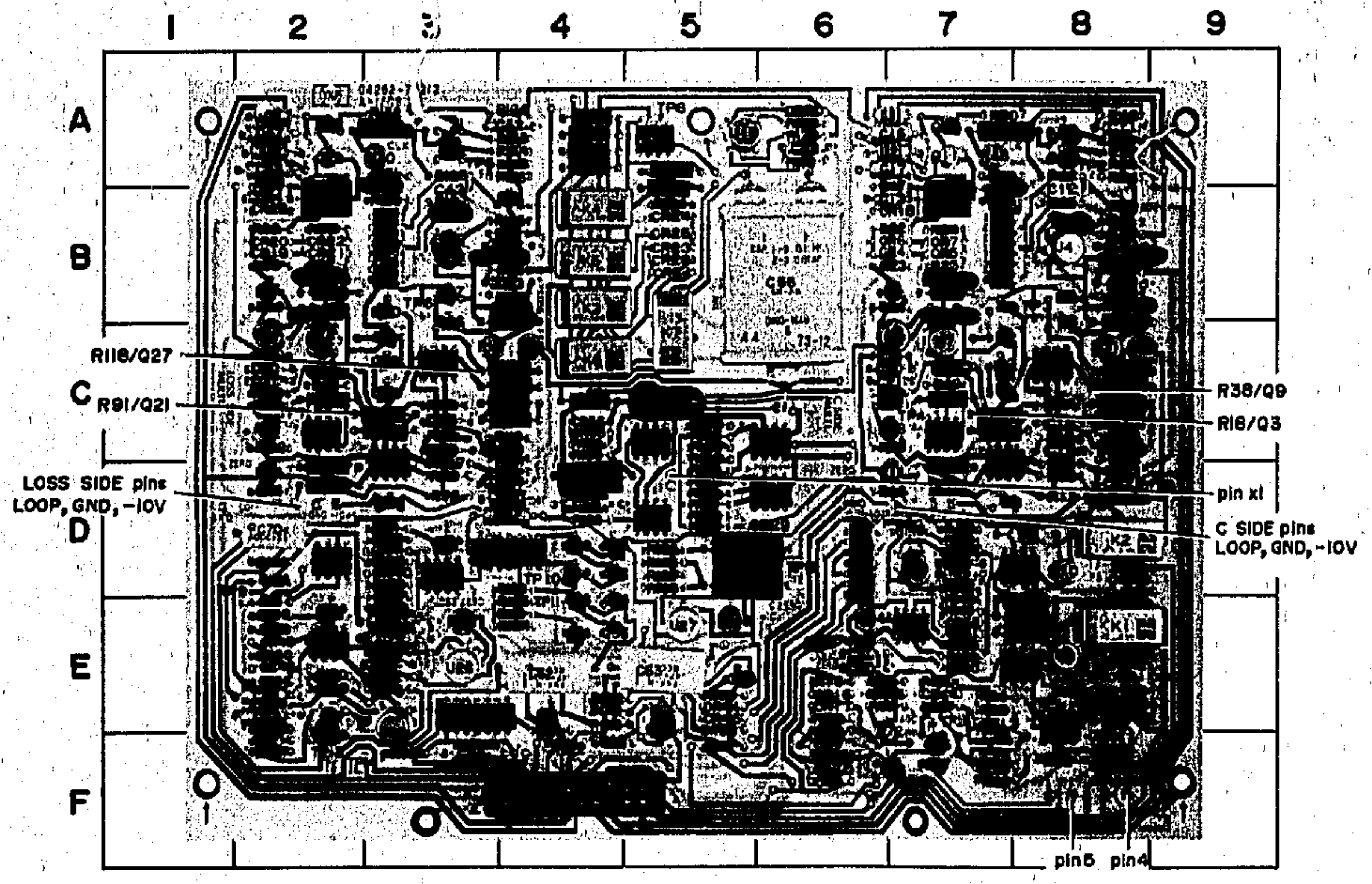


Figure 8-9. A2 Multiplier Board Ass'y.
(Loss Side Multiplier and Unbalance Detector)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C55	B-6	Q35	D-4	R179	E-3
C57	C-5	Q36	D-4	R180	D-3
C58	D-4	Q37	D-4	R181	D-3
C59	D-4	Q38	D-4	R182	D-3
C60	D-5	Q39	D-4	R183	D-3
C61	D-5	Q40	D-4	R184	E-4
C62	E-4	Q41	E-4	R185	D-4
C63	E-5	Q42	D-3	R186	E-2
C64	E-3	Q43	E-2	R187	D-3
C65	E-3			R188	E-2
C66	E-3	R151	C-4	R189	E-2
C67	D-4	R152	C-4	R190	E-2
C68	E-2	R153	C-4	R191	E-4
C69	E-2	R154	C-5	R192	D-4
C70	D-2	R155	D-4	R193	E-5
C71	D-3	R156	C-5	R194	E-4
C72	D-3	R157	C-5	R195	E-4
		R158	C-5	R196	E-4
CR34	B-5	R159	D-5		
CR35	C-4	R160	D-5	U22	C-5
CR36	C-4	R161	D-5	U23	D-5
CR37	E-2	R162	D-5	U24	C-6
CR38	E-2	R163	D-5	U25	D-6
CR39	E-3	R164	D-5	U26	E-3
CR40	D-3	R165	D-5	U27	E-5
CR41	D-3	R166	D-5	U28	E-2
CR42	E-2	R167	E-3	U29	E-3
CR43	E-2	R168	E-5	U30	E-3
CR44	E-5	R169	E-2	U31	D-2
CR45	E-5	R170	E-2	U32	D-3
CR46	E-4	R171	E-2	U33	D-4
		R172	E-4	U34	E-2
K7	C-5	R173	E-4	U35	E-5
		R174	E-3		
L5	D-4	R175	E-3	XA1	F-4
		R176	D-2		
Q33	E-4	R177	D-2		
Q34	E-4	R178	D-2		

SEE INSIDE

Figure 8-9
A2 Multiplier Board Ass'y
(Loss Side Multiplier and Unbalance Detector)

A2 MULTIPLIER BOARD OPERATION

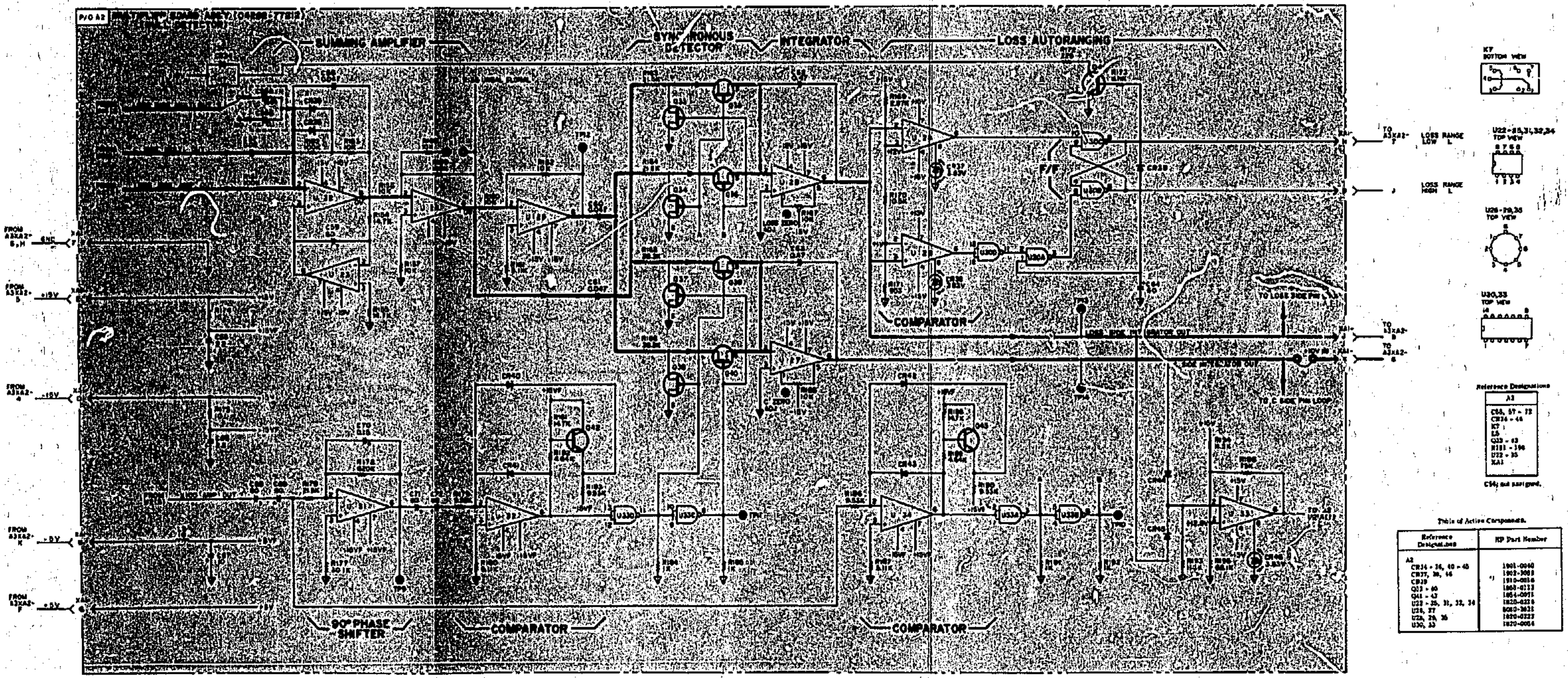
Null Detector Section.

This section contains Summing Amplifier U22 to U24, Synchronous Detectors Q33 to Q40 and Integrators U26 and U27. Also included are Loss Auto Ranging Circuit U28 to U30 and Synchronous Detector Driver U31 to U34.

The three outputs, C Side Multiplier, Loss Side Multiplier and Loss Side Amplifier, are fed to Standard Capacitors C57 and C55 and Standard Resistor R151, respectively. They are summed at summing node of U22(2). U22 detects the summed difference as error and feeds it to U24. CR35 and CR36 work to reduce gain of U22 to prevent saturation during balancing process. U23 is employed to verify zero of dc level at U22(6). U24, which has a gain of 10, amplifies error signal and feeds it to Sync Detectors. One input is fed directly and the other is fed through Inverter U25. The two Sync Detector (FET Switches) are driven by pulses having a 90° phase difference with each other. Therefore, the two Detectors detect in phase and 90° phase different components and feed them to Integrators U26 (Loss Side) and U27 (C Side), respectively. U26 and U27 integrate error signals detected and provide outputs as E_L and E_C.

Loss Auto ranging Circuit selects proper Loss Range from two available ranges. This information is received from Comparators U28 and U29. U28(6) is L when U28(2) is above about +12V. Since U29(6) is H, F/F U30B/C is H at U30(8) and L at U30(6). This means up-ranging is required so Q41 is turned on to energize K7 to connect Standard Capacitor C55B. This operates to reduce U26 output E_L to one-tenth. Additionally, CR39 is turned off and U28A(1) is maintained L which prevents frequent range changing until charge of C64 reaches H. On the other hand, when E_L is below about +1V, U29(3) goes to L. This makes U30B(5) L. Since U30C(10) is H, F/F changes state as U30C(8) is L and U30B(6) is H. This means down-ranging is required so Q41 is turned off to connect C55A. Synchronous Detector Driver circuitry includes 90° Phase Shifter U31 and two comparators U32 and U34. U31 provides a sine wave 90° out of phase with input. U32 produces a square wave output in phase with U31 output. U33D/C is driven in negative domain to match operation of FET Switches. U34 also produces square wave in phase with input. U33A/B are similar to U33C/D.

A2 Parts Locations under Fold



Reference Designations

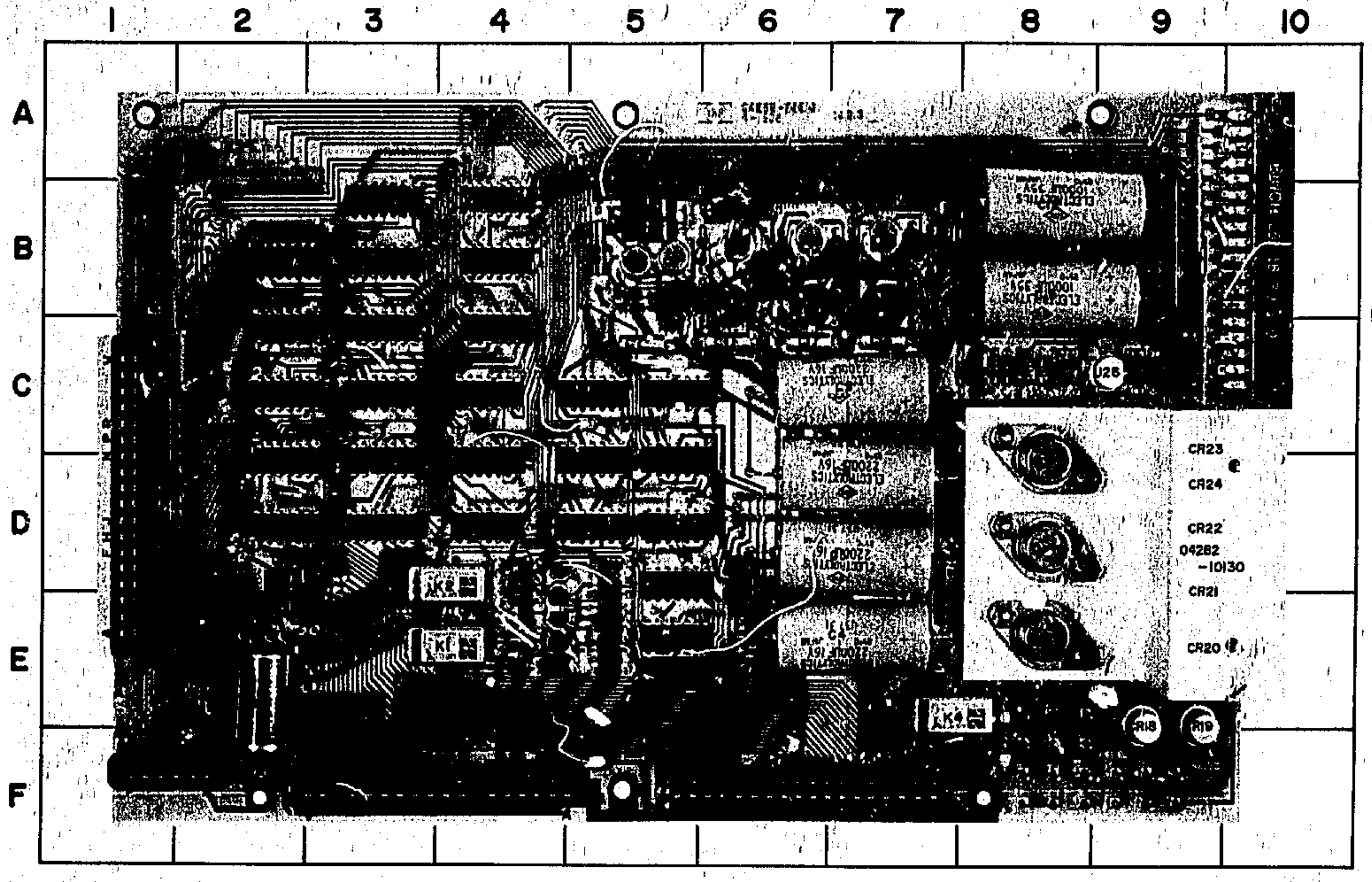
A2
C56, 57 – 72
CR34 – 46
K7
L5
Q33 – 43
R151 – 196
U22 – 35
XA1

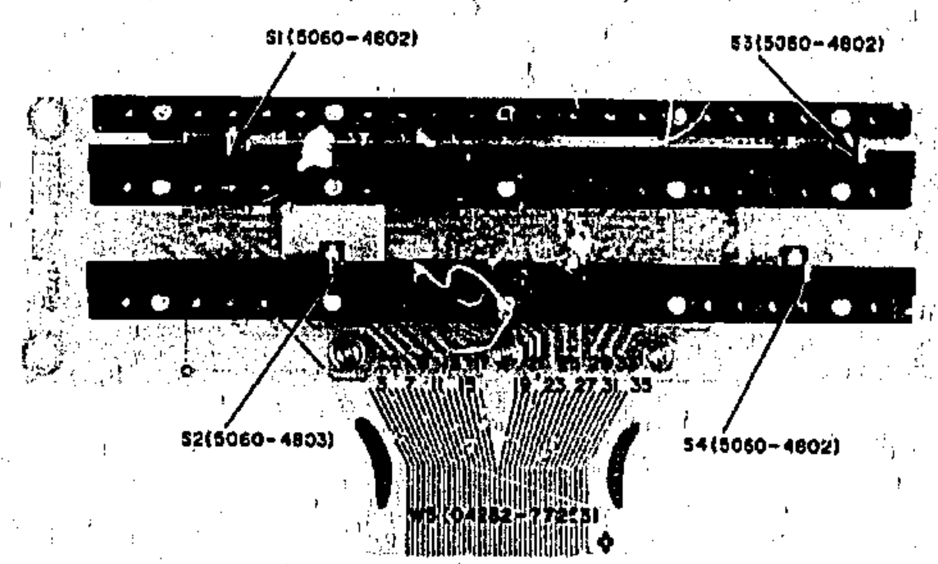
C56 not assigned.

Table of Active Components.

Reference Designation	HP Part Number
A2	
CR34 – 36, 40 – 45	1901-0040
CR37, 38, 46	1902-3001
CR39	1910-0016
Q33 – 40	1855-0233
Q41 – 43	1854-0071
U22 – 25, 31, 32, 34	1820-0224
U26, 27	5080-3021
U28, 29, 35	1820-0223
U30, 33	1820-0054

Figure 8-10. A2 Multiplier Board Ass'y. (Null Detector)





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C20	D-5	R1	E-4	U1	E-5
		R2	E-4	U2	D-5
CR1	E-4	R3	D-4	U3	C-5
CR2	E-3	R4	E-4	U4	D-4
CR3	E-2	R5	D-2	U5	D-5
CR4	D-4	R6	D-2	U6	D-4
CR5	D-5	R7	D-2	U7	C-5
CR6	E-5	R8	E-3	U8	D-5
CR7	D-5	R9	D-4	U9	D-5
CR8	E-5	R10	D-4	U10	D-5
CR9	E-4	R11	D-5	U11	C-2
CR26	D-5	R12	D-5	U12	D-2
		R13	E-5	U13	D-3
K1	E-4	R14	E-5		
K2	D-4	R15	E-5	XA1	F-6
K3	E-2	R16	E-6	XA2	F-3
		R17	E-5	XA3	F-1
Q1	E-4	R18	E-4	XA4	D-1
Q2	E-4	R19	C-9	XA5	B-10
Q3	D-4	R20	B-9		
Q4	D-4	R21	B-2		
Q5	E-4	R52	E-5		
Q6	E-4	R53	D-6		

SEE INSIDE

Figure 8-10
A2 Multiplier Board Ass'y
(Null Detector)

A3 CONTROL BOARD OPERATION

Function Control Section.

This section contains the various logic circuits. For explanatory purposes (in text and in diagrams), H or L after function letter abbreviation shows TTL logic level when that function is enabled, e.g., C H shows that C signal line is at TTL high level when Function C is selected.

Function Remote Gate is enabled to allow Function to be remotely programmed when FUNCTION switch is set to REM. Function Gate provides H (high level) when either one input goes L (low level). When C Function is selected, U5B(4) or U5B(5) go to L and U5B(6) is H. This makes U9C (8) L and C Enable Switch Q6 turns on. Q6 on means that C Side Integrator A2U27 output E_C is connected to DVM input in A4. U5B(6) H also makes U6A(1) L to enable transfer of C Range information.

Similarly, when D or ΩF Function is selected, Q4 is turned on to Loss Side Integrator A2U26 whose output E_L is connected to DVM input. Then U9A(12) becomes L to enable transfer of Loss (D or ΩF) range and units information.

When Functions C-D or C-ΩF are selected, U6B(4) goes to L to enable U10A/D. On the other hand, each negative transition of Busy H signal which comes from A4U13 causes a positive transition is Schmitt U1(6). This positive transition, which occurs at the same time as data transfer pulse, alternately changes F/F U2 state. Assuming U10D(13) is H (U2(9) = L) is equivalent to assuming an independent selection of Function C. The difference is that U10D(13)H makes U9A(12) L. This is required to enable transmission of information of range and unit of Loss (D or ΩF) because the display is Loss while DVM is measuring E_C (capacitance value) and vice versa.

When Function is V, U6A(3) H turns relay driver Q2 on which turns K2 on to connect voltage (V) to DVM input and makes U10B(4) L which completes voltage measurement circuit and also U6D(11) L which enables V Range Gate. Input voltage is attenuated by Voltage Divider R5 to R7 determined by DC BIAS RANGE switch A6S4 setting.

When Function is I_L, U6B(6) H turns relay driver Q1 on which turns K1 on to connect I_L Detector output (E_{IL}) to DVM input and makes U10B(4) L which completed I_L measurement circuit and also U6C(8) L which enables transfer of I_L Range and unit information.

A3 & A6 Parts Locations under Fold

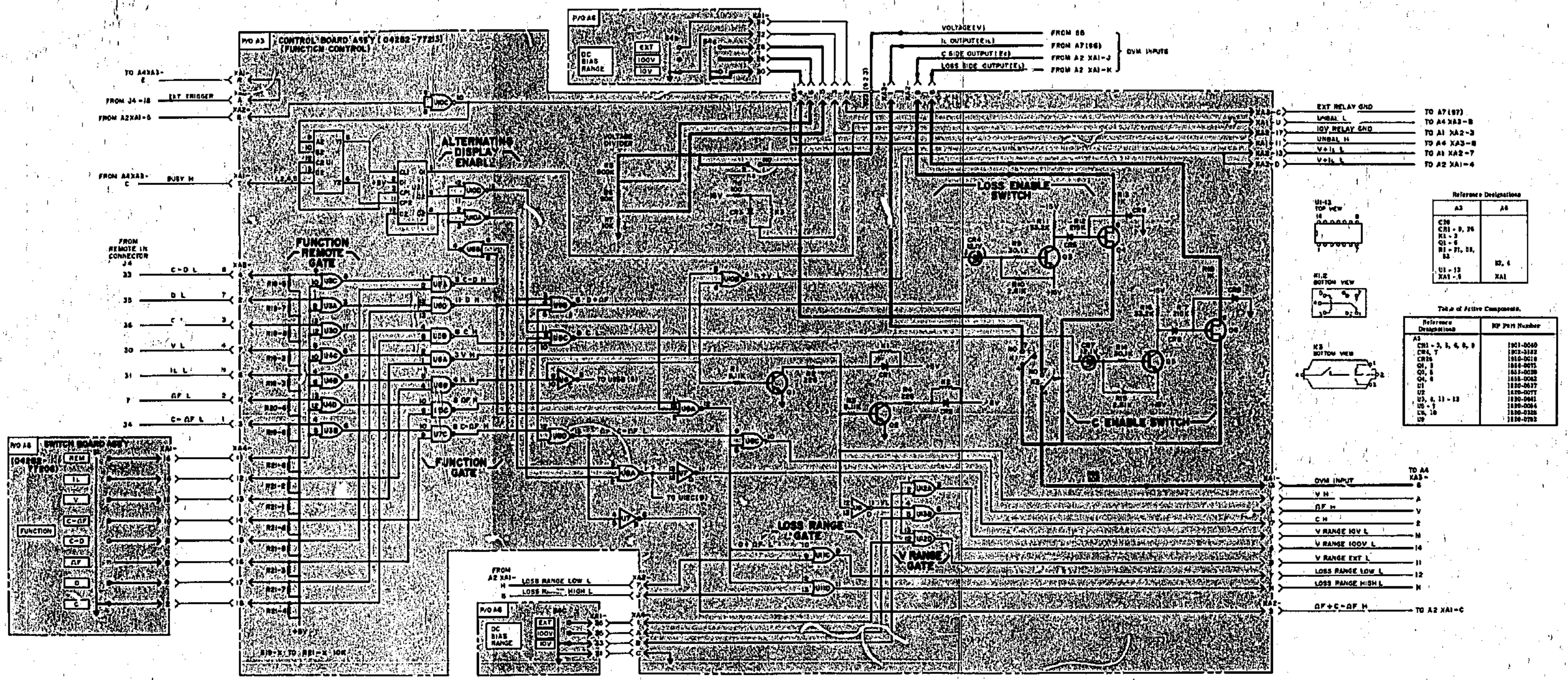
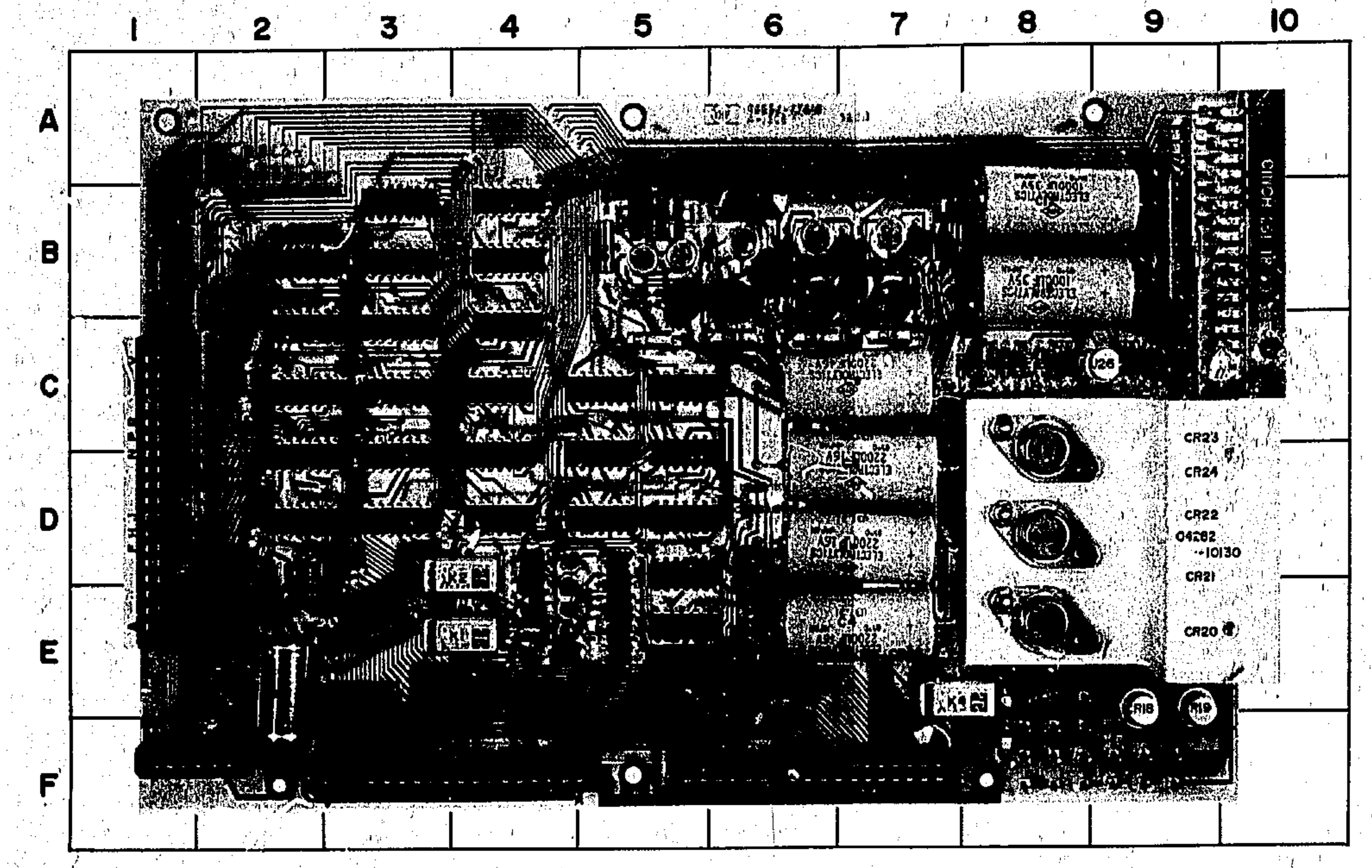
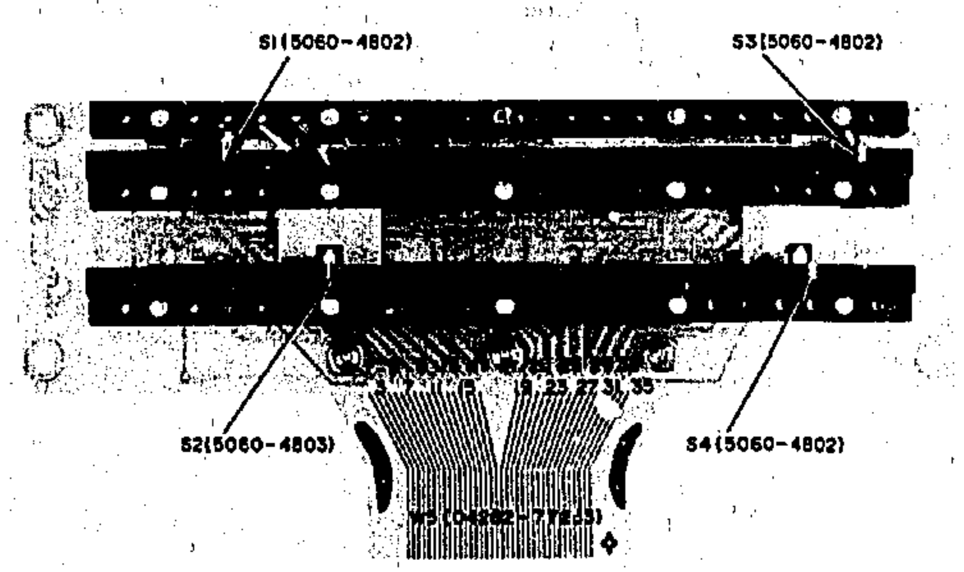


Figure 8-11. A3 Control Board Ass'y. (Function Control)
A6 Switch Board Ass'y.





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
R19	C-9	U12	D-2	U20	B-2
R20	B-9	U13	D-3	U21	B-3
R22	B-9	U14	B-4		
R23	C-1	U15	B-4	XA1	F-6
R24	B-1	U16	C-4	XA2	F-3
		U17	C-4	XA4	D-1
U4	D-4	U18	D-3	XA5	B-10
U11	C-2	U19	B-3		

SEE INSIDE

Figure 8-11
A3 Control Board Ass'y
(Function Control)
A6 Switch Board Ass'y

A3 CONTROL BOARD OPERATION

C Range Control Section.

This section contains C Range Remote Gate, C Range Gate, C Range Display Gate and Open Collector Relay Driver. The Remote Gate is enabled to allow C Range remote program when C RANGE switch is set to REM. C Range Gate is at L (low level) when either input goes L. This drives Open Collector Relay Driver to select a C range. Display Gate is enabled to display appropriate unit and decimal point when Function C is selected.

A3 & A6 Parts Locations under Fold

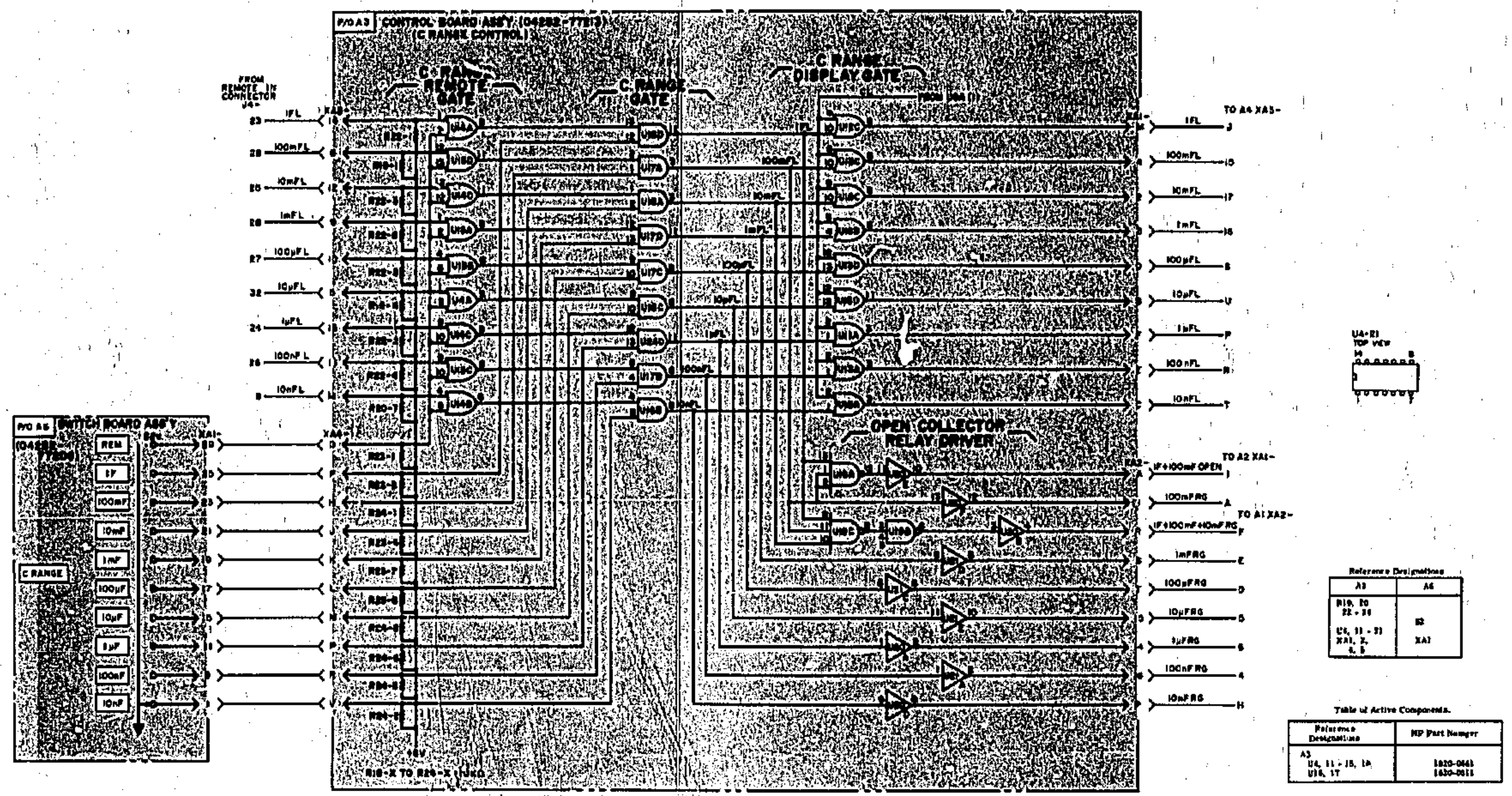
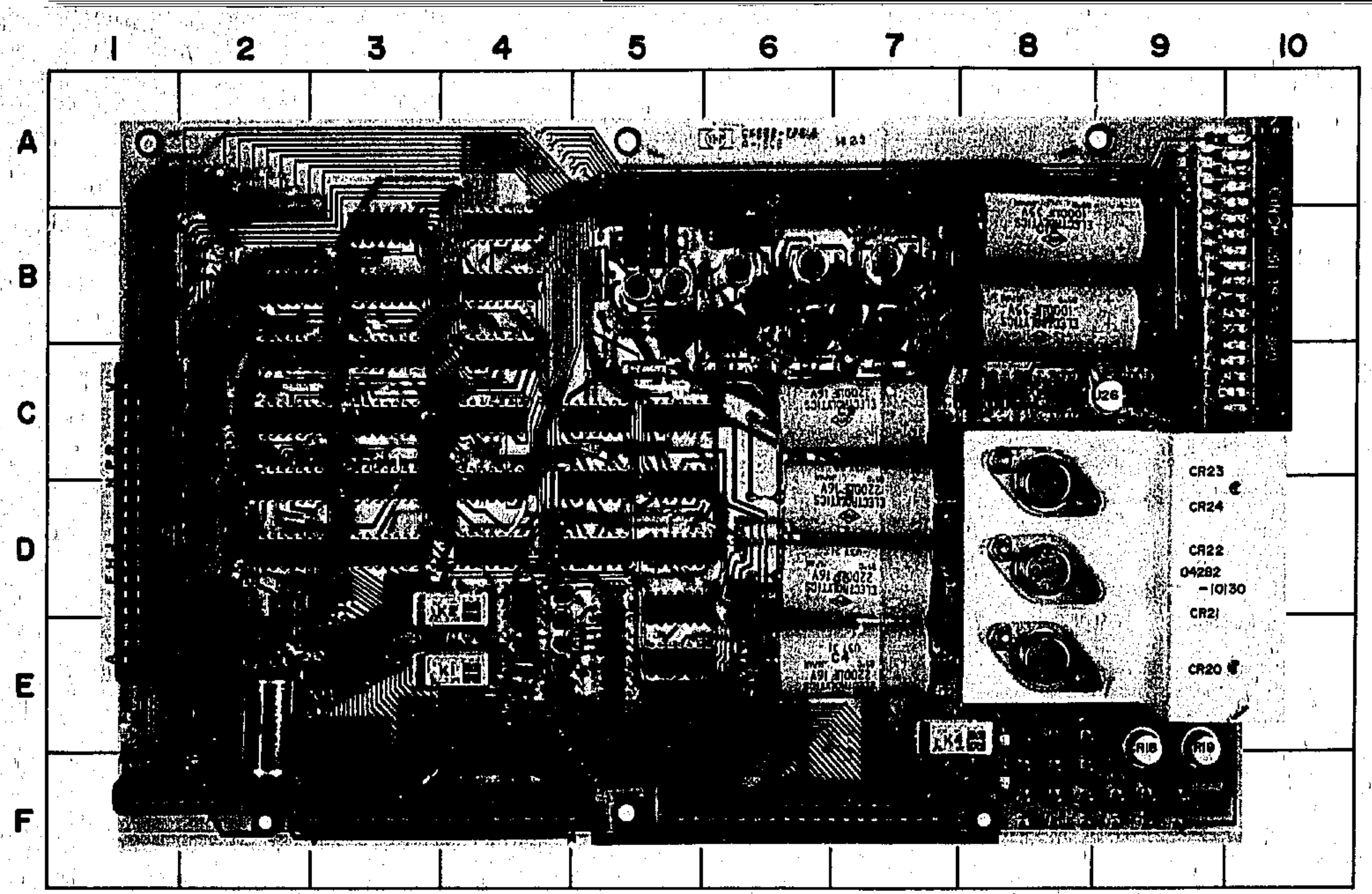
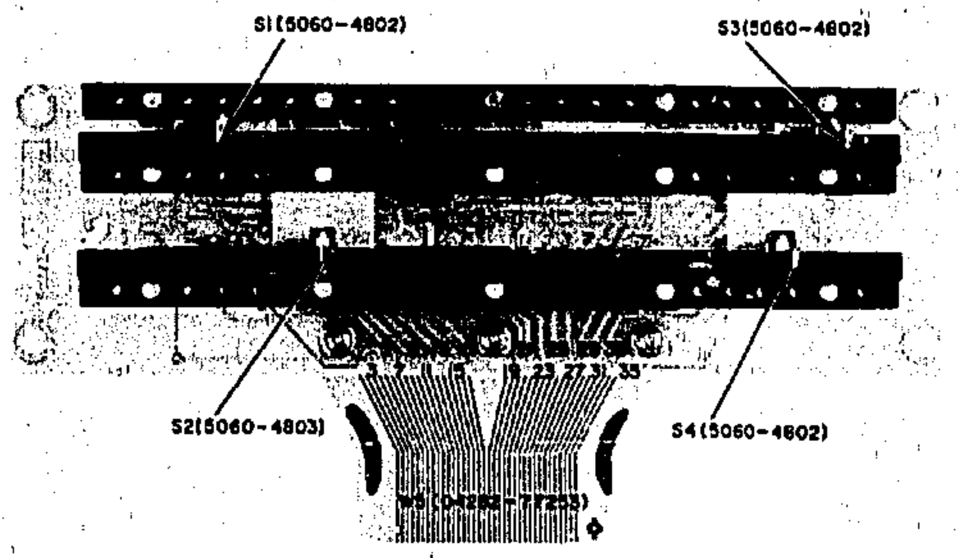


Figure 8-12. A3 Control Board Ass'y. (C Range Control)
A6 Switch Board Ass'y.





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Lod.	Ref. Desig.	Grid. Loc.
C1	B-7	R20	B-9	U11	C-2
C2	B-7	R23	C-1	U12	D-2
C3	C-8	R24	B-1	U22	C-3
		R25	E-2	U23	C-2
		R26	B-7	U24	C-3
CR10	C-8	R27	B-7	U25	D-2
CR11	C-8	R28	C-8	U26	C-9
CR12	C-8	R29	C-8		
CR13	C-8	R30	C-8	XA1	F-6
CR14	C-8	R31	C-8	XA2	F-3
CR15	C-8	R32	C-8	XA3	F-1
CR16	C-9			XA4	D-1
CR17	C-9			XA5	B-10

SEE INSIDE

Figure 8-12
A3 Control Board Ass'y
(C Range Control)
A6 Switch Board Ass'y

A3 CONTROL BOARD OPERATION

I_L Range Control Section.

This section contains I_L Range Remote Gate, I_L Range Gate and I_L Range Display Gate. Remote Gate is enabled to allow I_L Range remote programming when I_L RANGE switch set to REM. I_L Range Gate is at L (low level) when either input goes L. This is used for I_L Range selection in A7. Display Gate is enabled to display appropriate unit and decimal point when Function I_L is selected.

Check Fuse Sensor.

This circuit annunciates when measuring circuit fuse F2 is blown. When F2 blows, measuring signal is applied across R24. This signal is rectified by CR10, CR11 and fed to Comparator U26. U26 provides positive output and CR17 limits it to TTL high level.

A3 & A6 Parts Locations under Fold

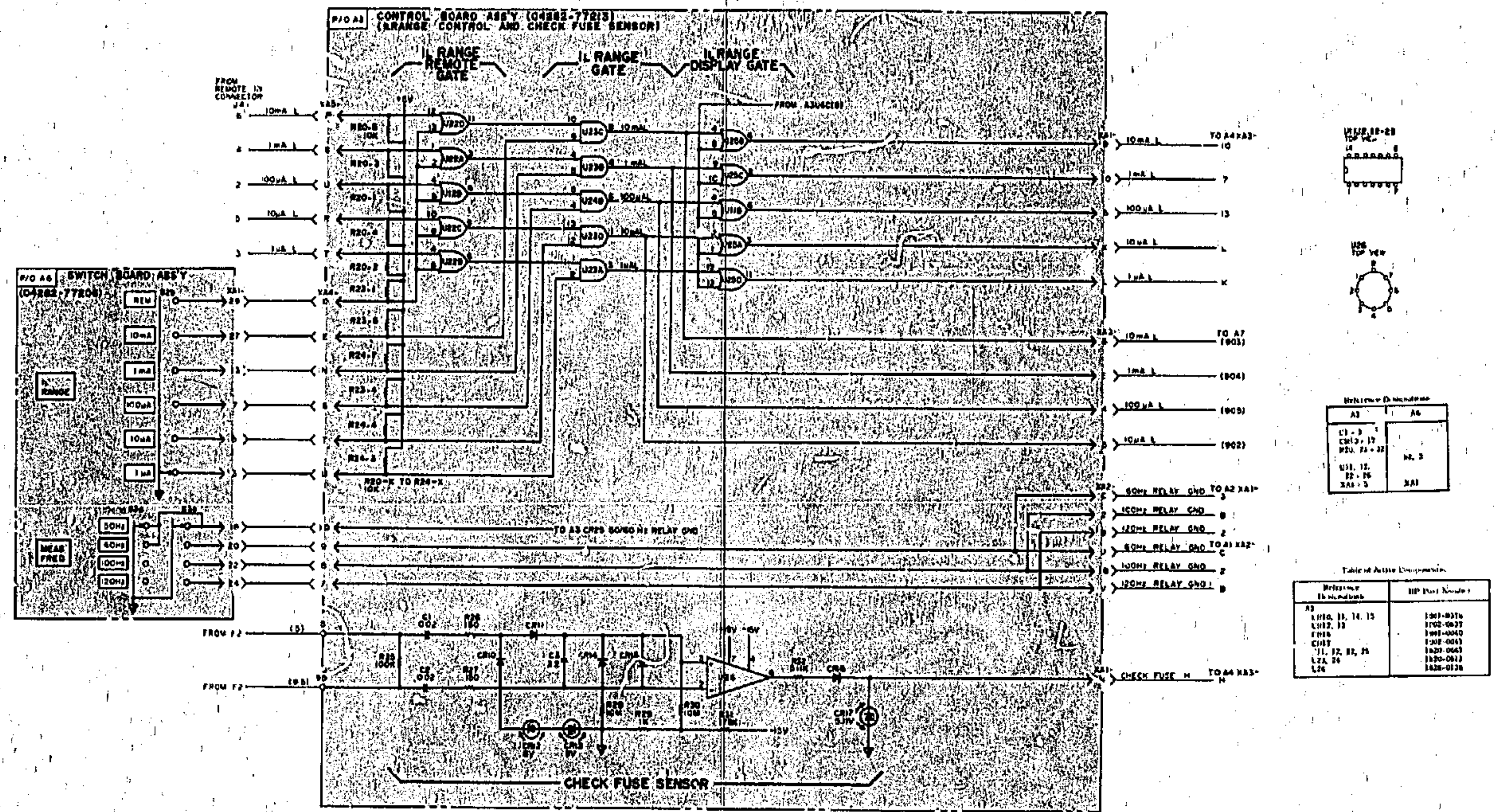
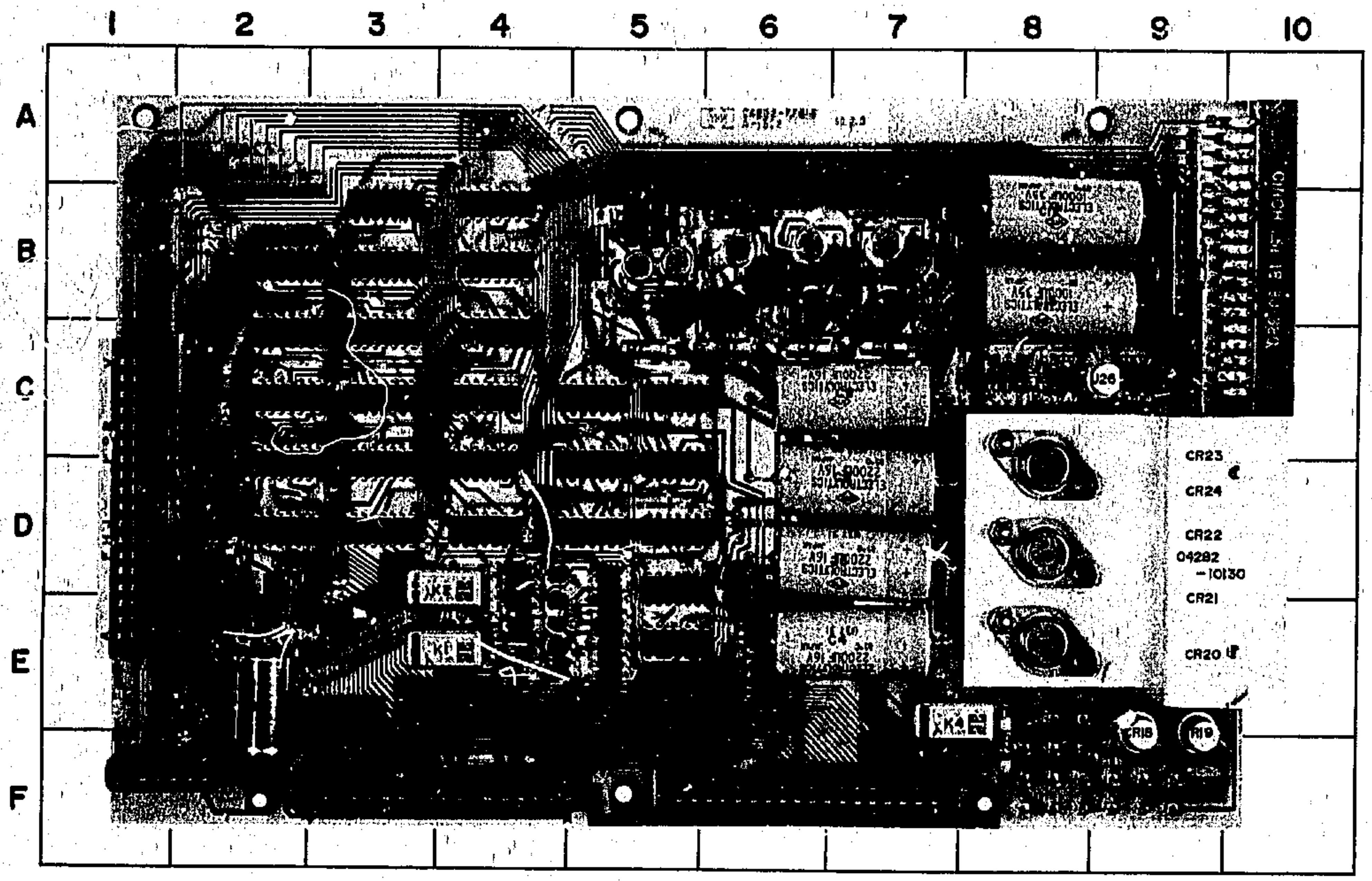


Figure 8-13. A3 Control Board Ass'y. (I_L Range Control and Check Fuse Sensor)

A6 Switch Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C4	E-7	CR22	D-10	R42	B-7
C5	D-7	CR23	C-10	R43	B-7
C6	B-5	CR24	D-10	R44	B-7
C7	C-5	CR25	E-7	R45	B-7
C8	D-7			R46	B-6
C9	C-7	K4	E-[illegible]	R47	B-7
C10	B-6			R48	B-6
C11	C-6	Q7	B-5	R49	B-7
C12	B-8	Q8	E-8	R50	E-8
C13	B-7	Q9	C-8	R51	E-7
C14	C-7	Q10	D-8		
C15	B-8			U27	B-5
C16	B-6	R33	B-5	U28	B-6
C17	C-6	R34	B-5	U29	B-7
C18	F-8	R35	B-5	U30	B-6
C19	F-8	R36	B-5		
		R37	B-5	XA1	F-6
CR18	E-9	R38	B-6	XA2	F-3
CR19	E-9	R39	B-6	XA3	F-1
CR20	E-9	R40	B-6	XA4	D-1
CR21	D-9	R41	B-6	XA5	B-10

Figure 8-13
A3 Control Board Ass'y
(I_L Range Control and Check Fuse Sensor)
A6 Switch Board Ass'y

SEE INSIDE

A3 CONTROL BOARD OPERATION

Power Supply Section.

This section contains four regulated dc sources, +5V, -5V, +15V and -15V and one non-regulated dc source, +26V. Also included is an ac 120V source sent to Leakage Current Board A7 (Option 001). The +15V regulator output is used in +5V regulator and the +5V output is used in -5V regulator. A3 also furnishes the Line Synchronous signal which is taken from Relay K4. The four dc regulators are very similar. Only +5V Regulator is described. Rectifier CR18 to CR21 is bridge type rectifier. Series Regulator Q1 is placed on main chassis to enhance radiation of heat. Voltage Controller U27 has a reference and current limiter in itself. Its equivalent circuit is shown as an inset on the schematic (Figure 8-14). Control signals appear at U27(6) and are fed to Q1 through Q7. Current limiting signal is taken from R36 and R37.

A3 Parts Locator under Fold

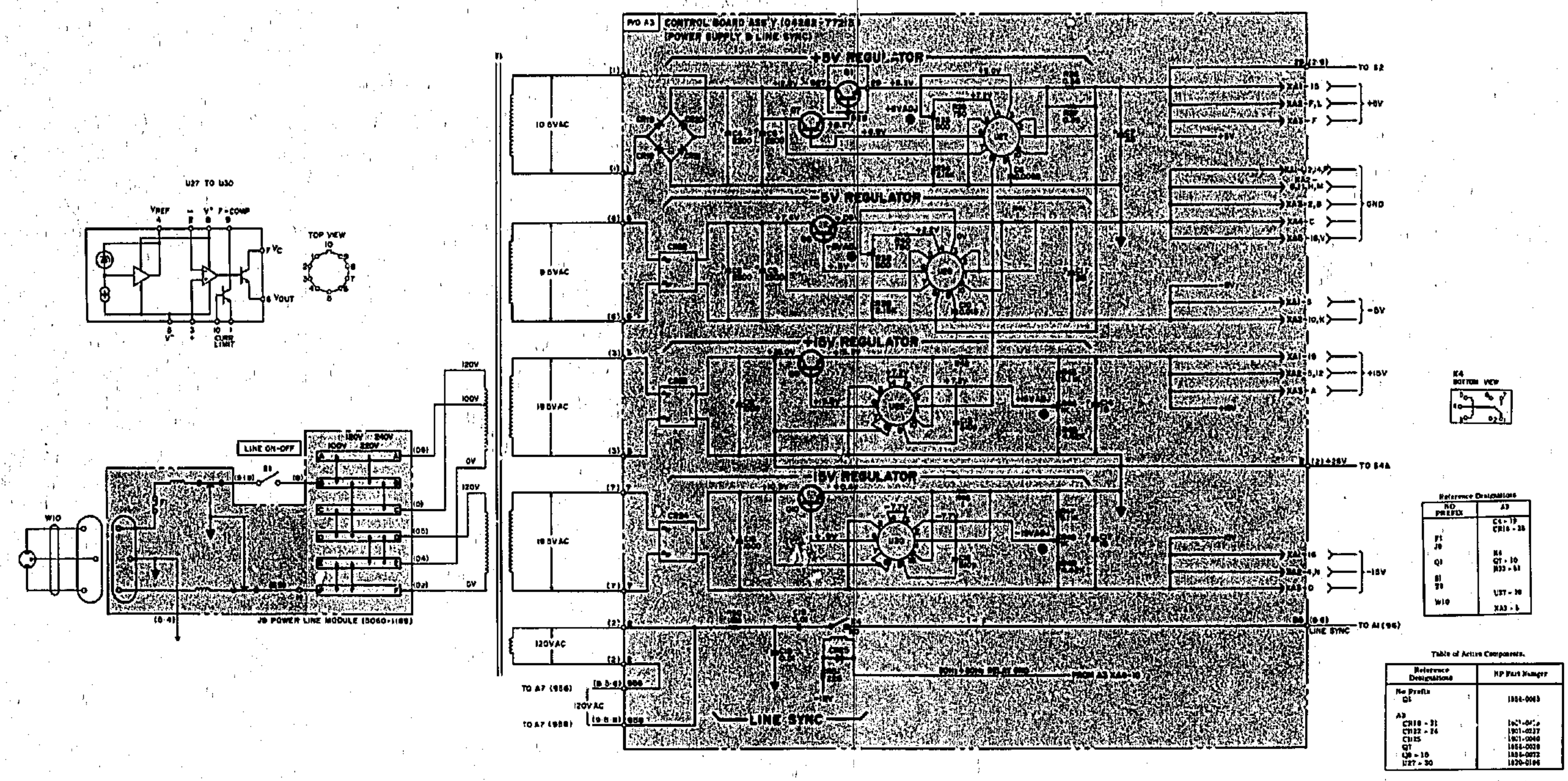
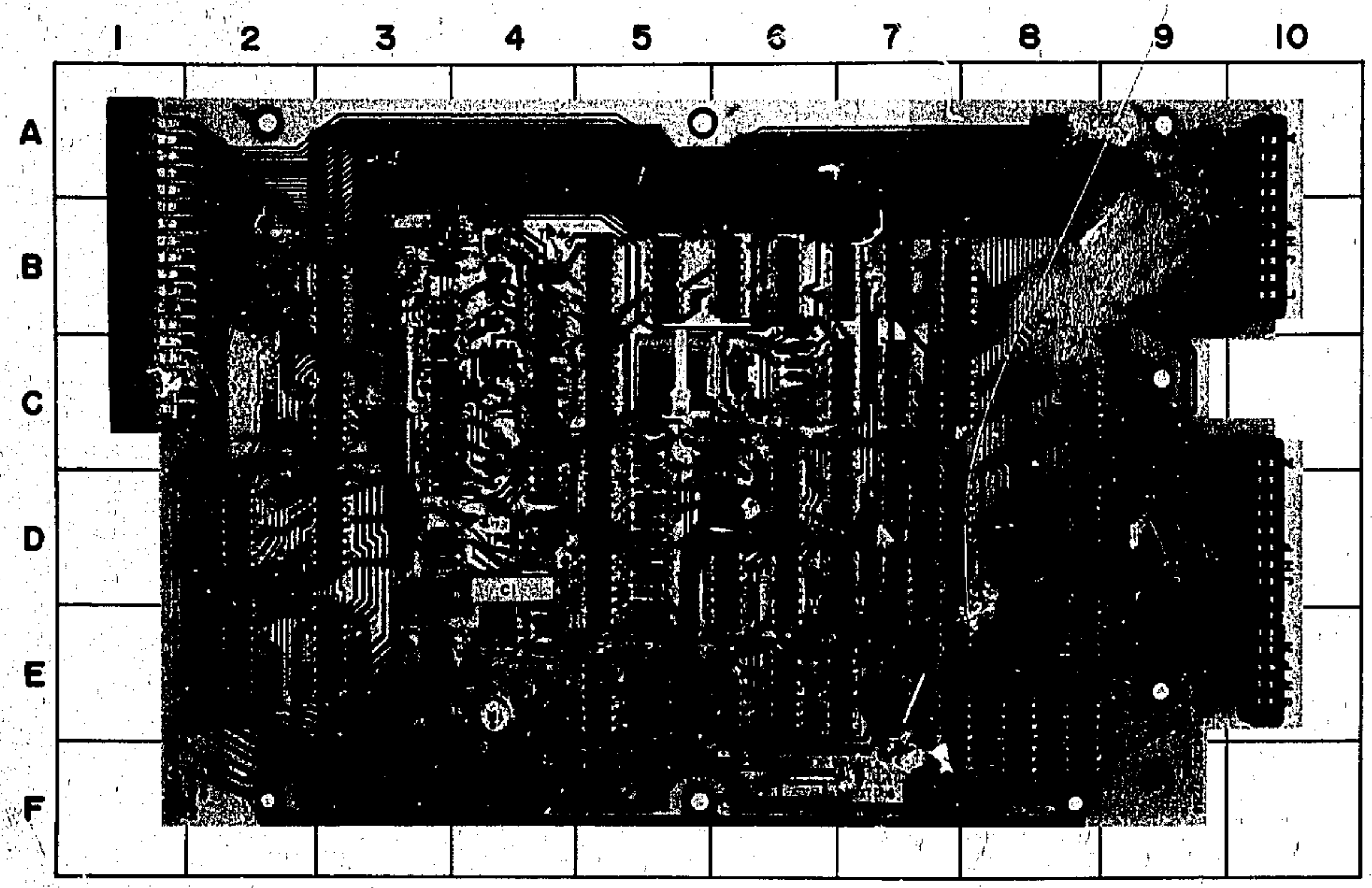


Figure 8-14. A3 Control Board Ass'y. (Power Supply & Line Sync)
J9 Power Line Module.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	D-4	R1	E-4	R34	C-6
C2	D-4	R2	E-4	R35	C-6
C3	E-5	R3	E-4	R36	C-6
C4	E-5	R4	E-3	R37	C-6
C5	C-6	R5	E-4	R36	D-4
C6	C-6	R6	E-4	R39	E-4
C7	B-4	R7	D-4	R40	D-4
C8	D-4	R8	D-4	R41	D-3
C9	D-4	R9	D-5	R42	E-4
C10	C-4	R10	D-5	R43	D-4
C11	C-4	R11	D-5	R44	C-4
		R12	E-5	R45	C-4
CR1	E-4	R13	E-5	R46	C-4
CR2	E-4	R14	D-5	R47	C-4
CR3	E-4	R15	E-5	R48	C-4
CR4	E-4	R16	D-5	R49	C-4
CR5	D-4	R17	E-5	R50	C-4
CR6	B-4	R18	E-5	R51	C-4
CR7	B-4	R19	E-4	R52	D-4
CR8	C-4	R20	E-4	R53	D-4
CR9	C-4	R21	C-4		
CR10	D-4	R22	C-4	U1	E-4
CR11	E-4	R23	B-4	U2	E-4
		R24	C-4	U3	C-4
Q1	D-5	R25	D-4	U4	C-5
Q2	E-5	R26	C-4	U5	B-5
Q3	B-4	R27	C-4	U6	B-5
Q4	B-4	R28	C-4	U7	B-6
Q5	B-4	R29	C-4	U8	B-6
Q6	B-4	R31	C-4	U9	B-7
Q7	C-4	R32	B-4	U10	C-7
Q8	C-4	R33	B-4		
Q9	D-4			XA3	F-3
				Y1	C-5

SEE INSIDE

Figure 8-14
A3 Control Board Ass'y
(Power Supply & Line Sync)
J9 Power Line Module

A4 DVM BOARD OPERATION

Pulse Width Modulation (PWM) Section.

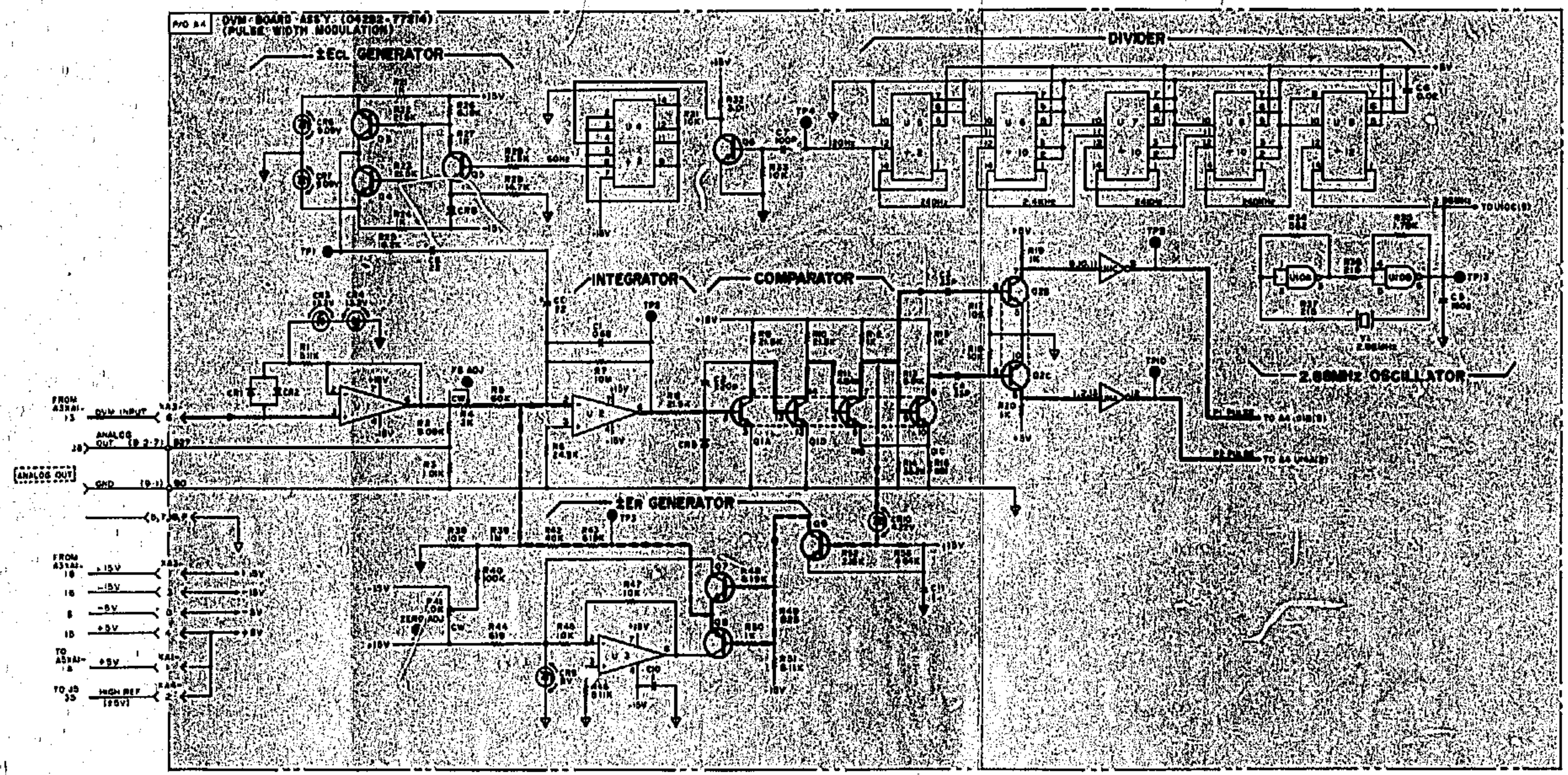
This section is employed to convert input voltage to time interval, which is accomplished by an $\pm E_{CL}$ Generator, an E_R Generator, an Integrator and a Comparator.

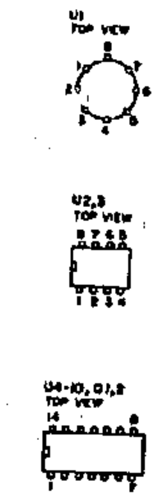
The $\pm E_{CL}$ Generator Q3 to Q5 and CR6/7 provide a 60Hz clock signal to determine the period of integration. The clock signal is obtained by dividing a 2.88MHz Crystal Oscillator output by 48,000 through Dividers U4 to U9. Q6 converts TTL level to negative level to fit Q5 drive requirements. Q3 and Q4 are switched alternately by Q5 and provide a symmetrical square wave whose frequency is 60Hz and whose amplitude is ±9.09V referred to CR6/7. The $\pm E_R$ Generator, whose duty cycle is determined by input voltage and whose frequency is 60Hz, provides ±9V referred to CR9 by alternately switching Q7 and Q8. Integrator U2 receives two inputs $\pm E_{CL}$ and $\pm E_R$ plus another input which is either E_C, E_L, V or E_{IL} (unknowns).

When E_{CL} and E_R are positive, the most rapid negative going ramp is produced at U2(6). When this ramp reaches zero, Comparator Q1A is turned off and a positive pulse (called P1) occurs at U11C(8). This also turns Q9 off to connect minus reference ($-E_R$) to U2(2) through Q8. Since the sum of three inputs is still positive, U2(6) continues to produce a slowed down negative going ramp until 60Hz clock changes to $-E_{CL}$. Then U(6) changes to the most rapid positive going ramp and, when crossing zero point, turns Q1A on. At this point a positive pulse (called P2) is produced at U11A(12). Q9 is also turned on to connect positive reference ($+E_R$) through Q7 to U2(2). The slowed down negative going ramp continues until 60Hz clock changes to $+E_{CL}$. This completes one cycle which has created P1 and P2 Pulses whose interval represents unknown input voltage.

Analog output is Impedance Converter U1 output divided by 10 and produces 1V output for a 10V input.

A4 Parts Locations under Fold





Reference Designations

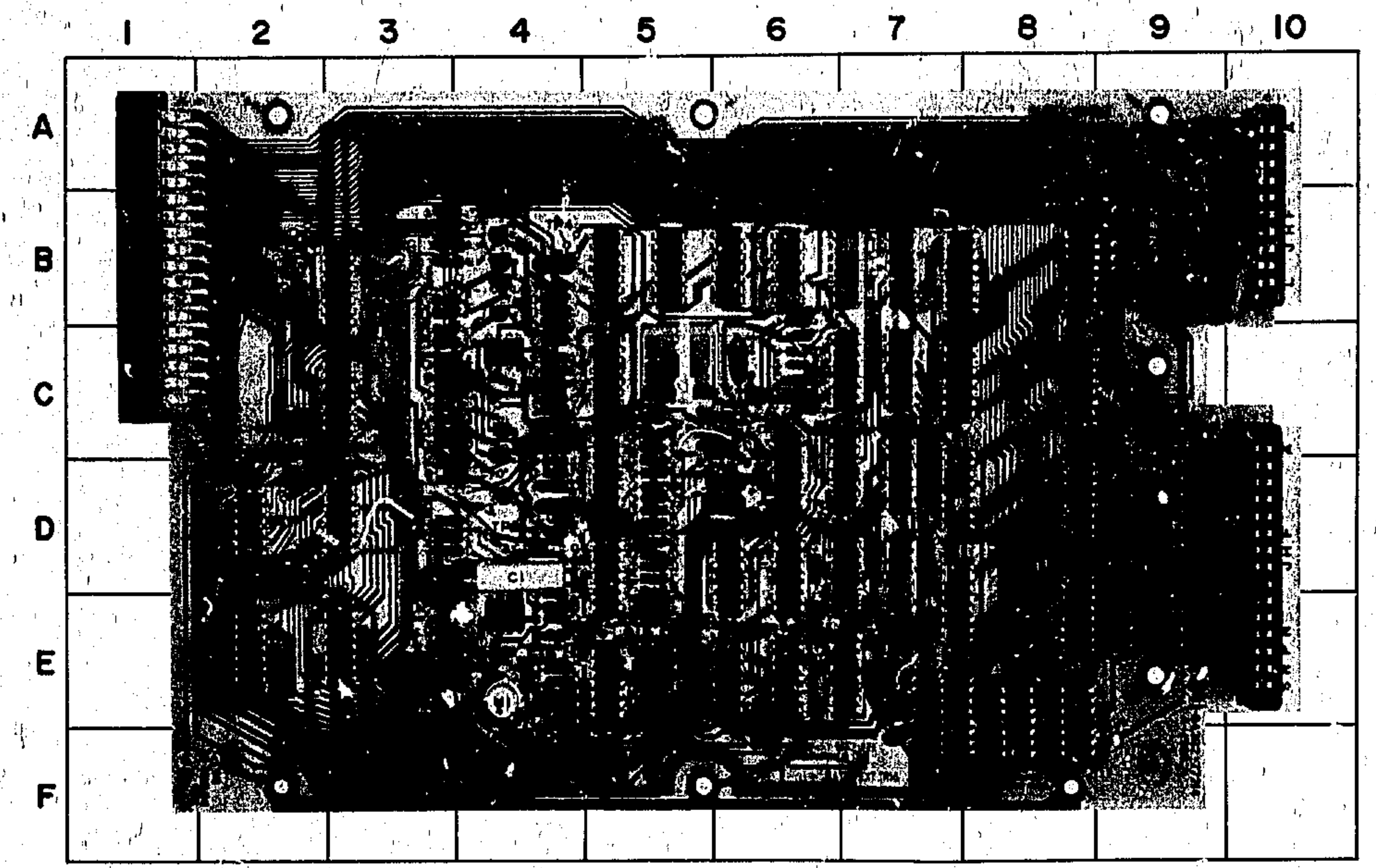
A4
C1 - 11
CR1 - 10
Q1 - 9
R1 - 53
U1 - 10
XA2
Y1

R30, not assigned.

Table of Active Components.

Reference Designations	HP Part Number
A4	
CR1, 2	1901-0376
CR3, 4	1902-3193
CR5, 6	1901-0040
CR6, 7, 8	1902-3150
CR10	1902-3070
Q1, 2	1858-0023
Q3, 5, 9	1853-0036
Q4, 6, 7	1854-0215
Q8	1853-0020
U1	5060-3621
U2, 3	1820-0493
U4	1820-1104
U5, 9	1820-0054
U6 - 8	1820-0800
U10	1820-0081
Y1	0410-0207

Figure 8-15. A4 DVM Board Ass'y. (Pulse Width Modulation)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C12	C-6	R54	D-6	R74	B-9
C13	C-6	R55	C-6	R75	B-9
C14	C-6	R56	E-4	R104	F-6
C15	E-5	R57	E-4	R105	B-9
C16	E-4	R58	E-4	U10	C-7
C17	D-6	R59	E-4	U11	E-6
C18	D-6	R60	D-5	U12	D-6
C19	D-6	R61	C-5	U13	D-6
C20	E-7	R62	C-5	U14	E-7
C21	E-6	R63	D-5	U15	E-6
C22	D-7	R64	D-5	U16	D-6
		R65	C-5	U17	D-7
CR11	F-4	R66	D-5	U18	D-7
		R67	D-5	U19	E-8
Q2	E-5	R68	D-5	U20	E-8
Q12	D-5	R69	C-6	U21	B-3
Q13	A-9	R70	E-7		
Q14	B-9	R71	E-6	XA1	B-10
Q15	B-9	R72	B-4	XA2	D-
Q16	B-9	R73	E-9	XA3	F-
Q17	B-9			XA4	B-1

SEE INSIDE

Figure 8-1?
A4 DVM Board Ass'y
(Pulse Width Modulation)

A4 DVM BOARD OPERATION

Control Logic Section.

This section includes Rate Generator, Timing Pulse Generator and various Gates. Rate Generator Q2A/D is astable MV whose period is variable from 0.3 to 2.0 seconds with RATE control.

The positive transition at U12(8) driven internally or externally causes positive transition at U13(6) or negative transition at U13(1) which holds H (high level) or L (low level) for about 80ms, respectively. They are Busy H or L and indicate busy period for one reading. Timing Pulse Generator Q12 provides negative Set Pulse at the beginning of busy period and positive Transfer Pulse and negative Print Command at the end of busy period.

When Set Pulse is issued, Dual F/F U15(13) and U17(13) are set to H and Counter U27 to U31 are set to zero. P1 Pulse Gate U11B enabled by U11B(3,4) H allows acceptance of P1 Pulse. P2 Pulse Gate U14A is closed by U17(12) L. P1 Pulse makes U15(9) H and opens Clock Gate U10C. At this point, the 2.88MHz Clock passes through U10C and goes into ÷2 Counter U18 whose output is applied to Counter U27. When Counters U27 to U31 count 8,000, U17(1) goes H and 12,000 counts of Counters returns U17(1) to L (Counter is reset to zero by itself). This negative transition makes U17(12) H and opens P2 Pulse Gate U14A. Then P2 Pulse appears at U14A(2) and makes U15(9) L to close U10C. Counters hold result which represents input voltage of PWM (Pulse Width Modulation) section. Negative transition of U15(9) also makes U15(13) L to close U11B. Above description is for positive input.

For negative input, since P2 Pulse occurs before the completion of half a period of 60Hz clock signal (before Counters count 12,000), P2 Pulse Gate U14A is closed but Gate U14D is opened. P2 Pulse passing through Gates U14D/C resets Counters.Counter again begin to count and is reset to zero by itself at 12,000 counts (after half period of 60Hz Clock from P2 Pulse). Under above conditions, next P1 Pulse is applied to U15(5). This makes U15(9) L and closes Clock Gate U10C and also P1 Pulse Gate U11B. Counters hold result which represents input voltage.

Bottom half of Dual F/F U17 provides polarity assignment. This is accomplished by checking which pulses (P1 or P2) are coincident with negative transition at U15(9) which is applied to U17(5). When P1 Pulse occurs, a negative transition at U17(5) transfers momentary H at U17(7) to U17(9) L. U17(9) L means positive input. Similarly, if a P2 Pulse occurs, it makes U17(9) H which means negative input.

U16 which forms F/F and Gates is Overload Detector. In an overload condition, P1 and P2 Pulses are not issued because of saturation of PWM section. Therefore, U15(13) remains H for one reading period after Set Pulse. When Busy L changes to H at the end of busy period, Gate U16(3) goes to L whose signal is Overload, F/F U16C/D stores this signal and U16D(11) provides Blanking L signal to blank display. This F/F is employed to keep display blanked until end of next busy period.

A4 Parts Locations under Fold

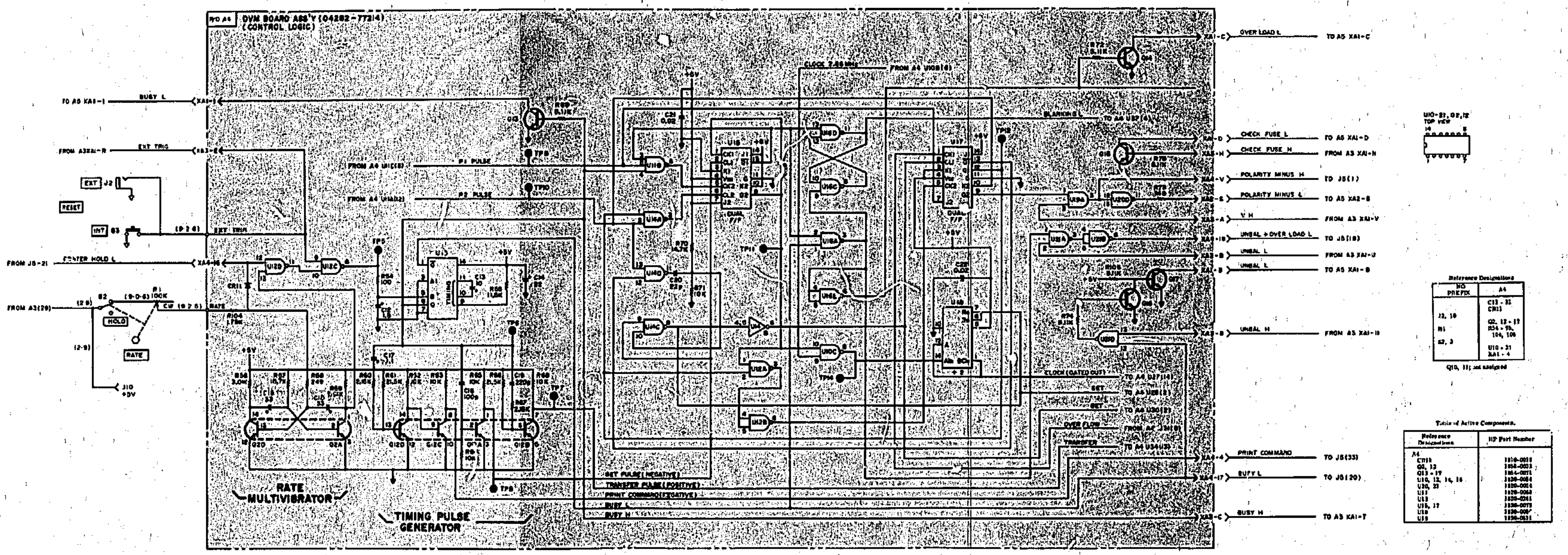
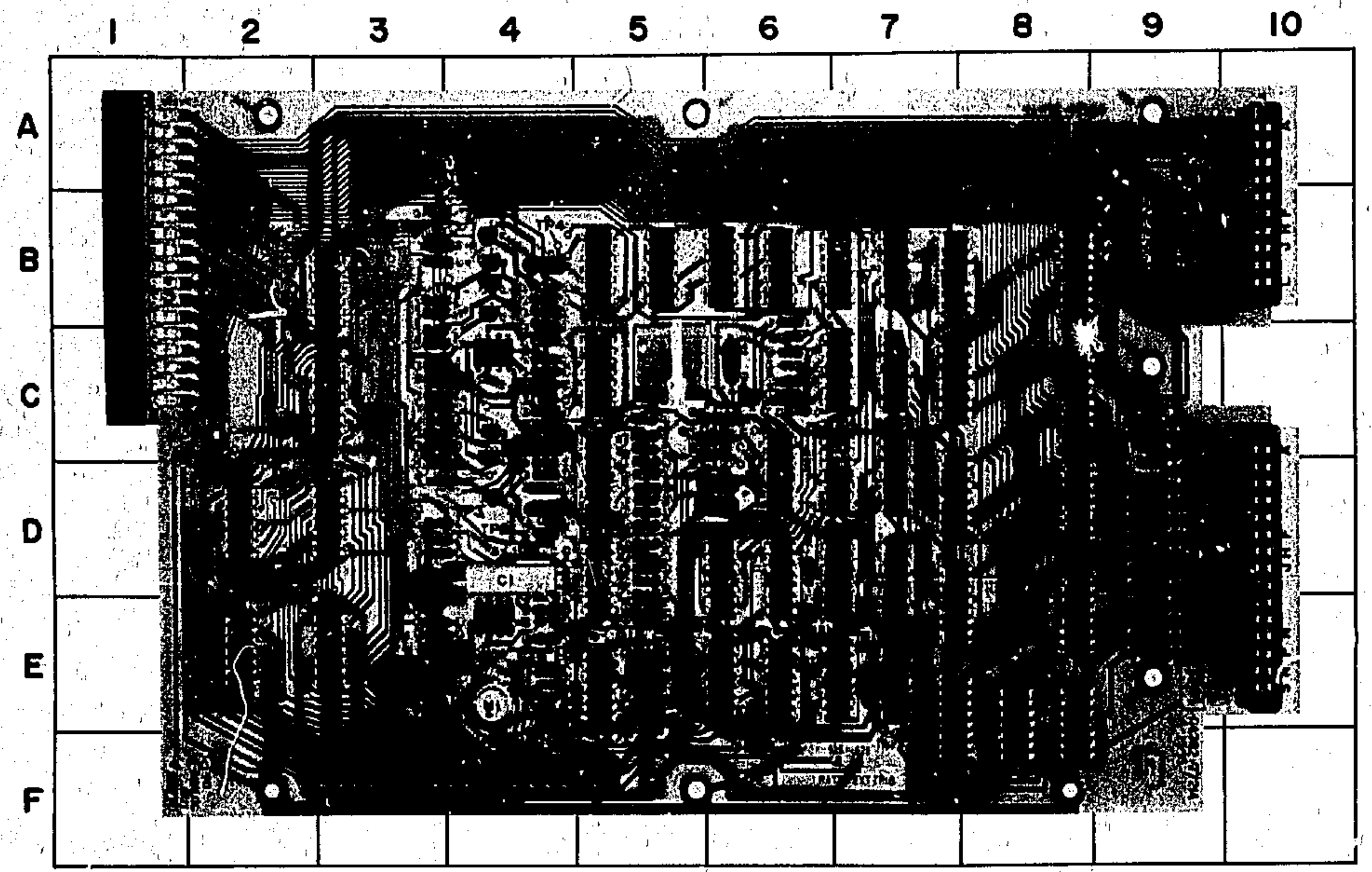


Figure 8-16. A4 DVM Board Ass'y. (Control Logic)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
U21	B-3	U24	C-3	XA1	B-10
U22	E-2	U25	D-2	XA3	F-3
U23	E-3	U26	D-3	XA4	B-1

SEE INSIDE

Figure 8-16
A4 DVM Board Ass'y
(Control Logic)

A4 DVM BOARD OPERATION

Unit and Decimal Point Logic Section.

This section converts unit and decimal point information obtained from combination of Function and Range settings to appropriate individual information. For example, when Function C and Range 1mF are selected, U26B(6) and U26 (6) go to H which means that unit is "mF" and decimal point is positioned at DP5. Same information is sent to DIGITAL OUT J5 connector.

A4 Parts Locations under Fold

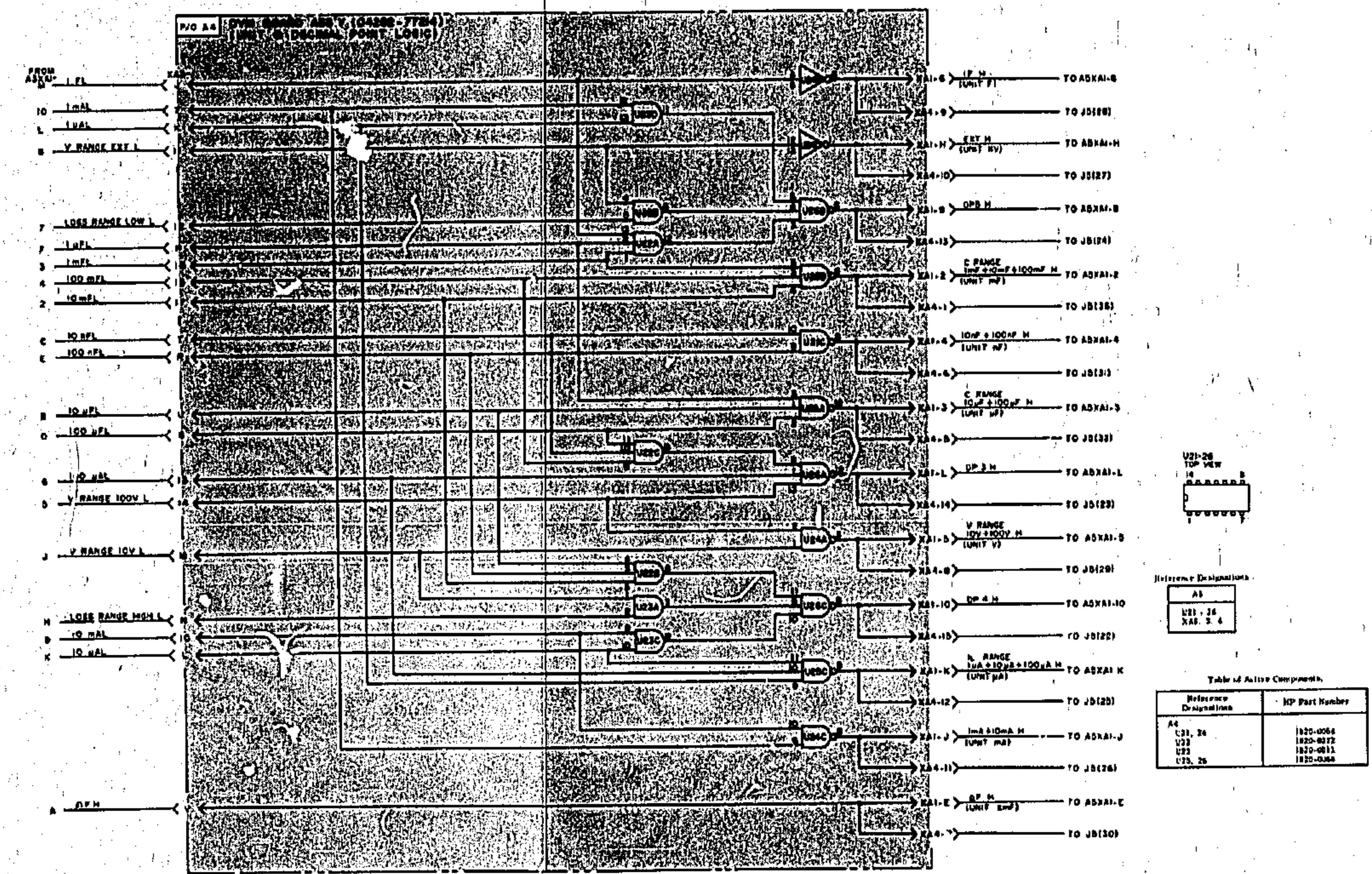
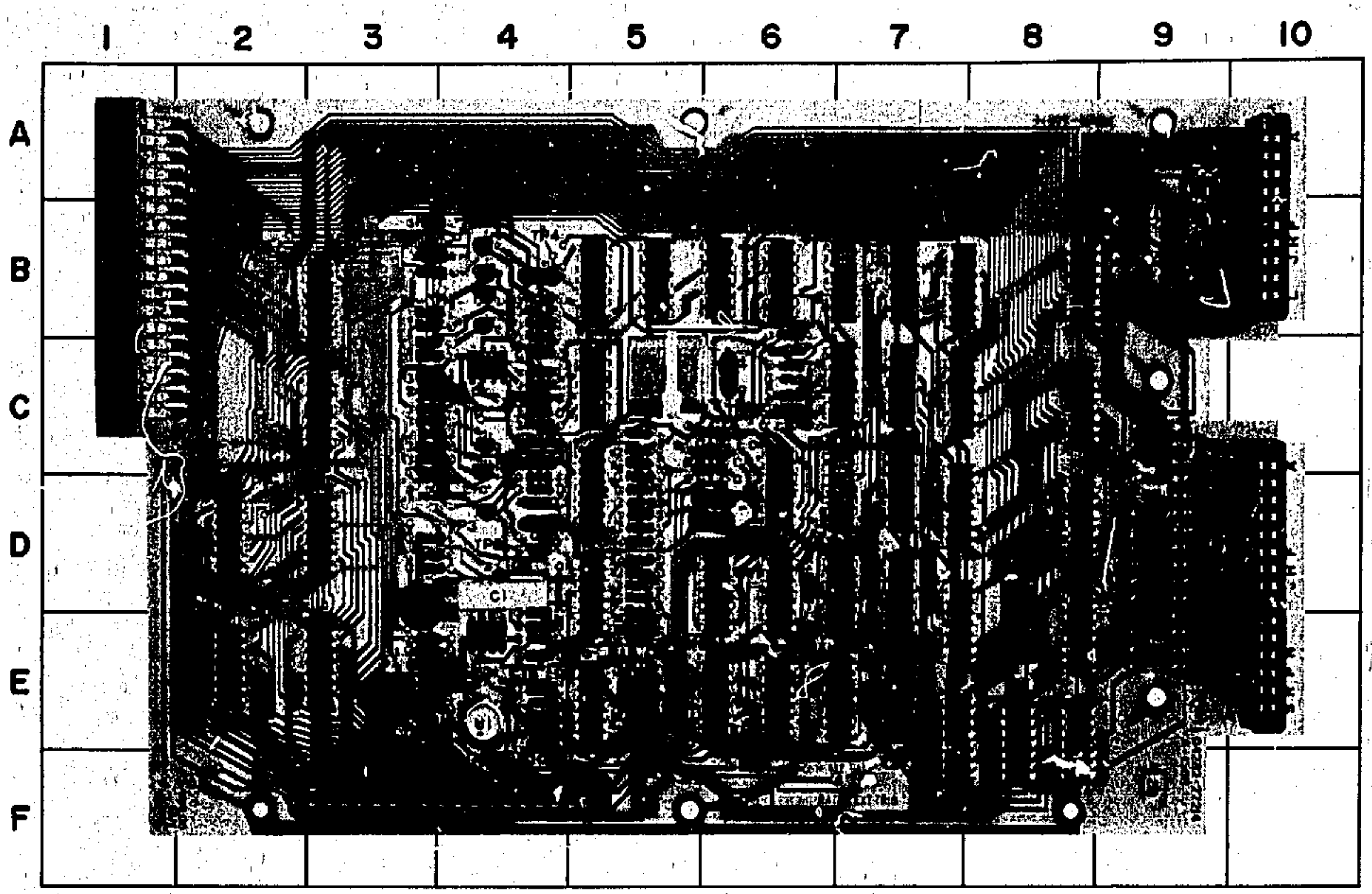
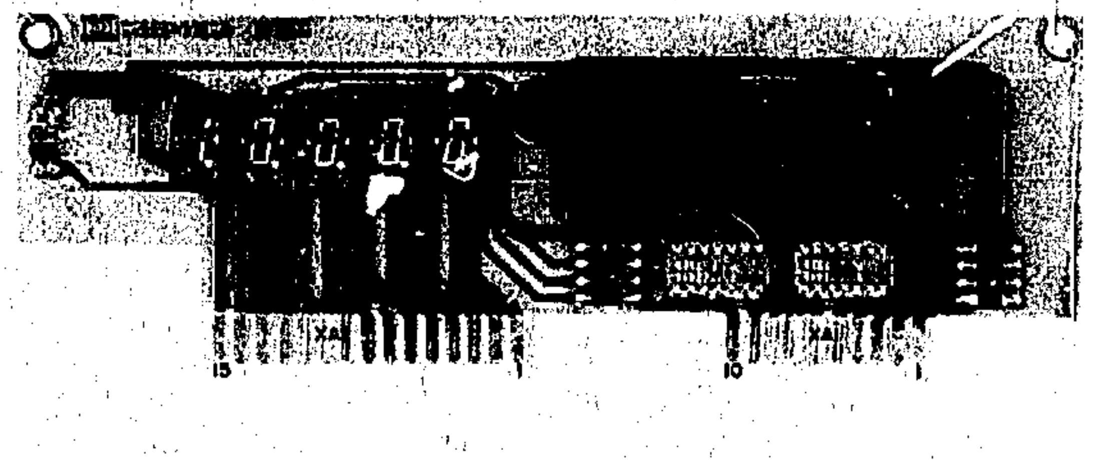


Figure 8-17. A4 DVM Board Ass'y. (Unit & Decimal Point Logic)





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C23	C-7	R90	D-9	U27	B-7
C24	F-7	R91	D-9	U28	C-7
		R92	D-9	U29	D-7
R76	C-9	R93	D-9	U30	D-7
R77	C-9	R94	D-9	U31	E-7
R78	D-9	R95	D-9	U32	B-8
R79	C-9	R96	D-9	U33	D-8
R80	C-9	R97	E-9	U34	D-8
R81	C-9	R98	D-9	U35	E-8
R82	D-9	R99	E-9	U36	C-8
R83	D-9	R100	E-9	U37	B-8
R84	D-9	R101	D-9	U38	C-8
R85	D-9	R102	E-9	U39	D-7
R86	D-9	R103	E-9	U40	E-7
R87	D-9				
R88	D-9	U19	E-8	XA2	D-10
R89	D-9	U20	E-8	XA3	F-3

SEE INSIDE

Figure 8-17
A4 DVM Board Ass'y
(Unit & Decimal Point Logic)

A4 DVM BOARD OPERATION

Counter, Buffer Storage and Decoder Circuits.

These circuits form three stages and are connected in cascade. Counter U27 to U31 consists of three different counters. U27 to U29 are decade counters, U30 is ÷4 counter and U31 is ÷3 counter, for a total maximum counting capacity of 11,999. Counter U27 to U31 is reset to zero by Set Pulse at beginning of busy period. Then Counter continues to count 2.88MHz Clock divided by two while Clock Gate U10C opens. During this period, Counter provides overflow signal at U31(9) which goes to H at 8,000 counts and returns to L at 12,000 counts. When Clock Gate U10C is closed, Counter holds result which is BCD and which represents input voltage.

Next stage is Buffer Storage U32 to U35 whose input is BCD output from Counter and whose output is previous data. The transfer between input and output is performed by Transfer Pulse issued at end of each busy period. Therefore, Buffer Storage holds data transferred for one reading period. Input for U32 to U34 is up to 9 decimal numbers and for U35 is up to 11 (to allow overranging). U19B/C and U20A/B are employed to take up this carry and enable display for overranging digit. U36, 1st Digit Enable, sends U32 output to Decoder when Function is C. In other functions, all four lines hold H to blank 1st digit.

Buffer Storage output is connected to Decoder and DIGITAL OUT J5 connector. Decoder U37 to U40 in last stage is BCD to seven segment decoder. Decoder enables to display appropriate number according to input BCD.

A5 DISPLAY BOARD OPERATION

This Assembly contains Seven Segment Numeric Display DS1 to DS4, Polarity and Overrange Display DS5, Annunciators DS6 to DS11, Rate Annunciator DS12, Unit Display DS13 to DS21 and Inverters U1 and U2. DS1 to DS5 are LED including decimal point each segment of which illuminates when corresponding pin is L (low level). Decimal point is valid only in DS3 to DS5. DS6 to DS11 light when the line is L and indicate that displayed data is invalid. DS12 is single LED which illuminates for busy period. DS13 to DS21 display measuring unit when the line is H (high level) because inputs are inverted by Inverters U1 and U2.

A4 & A5 Parts Locations under Fold

SECTION VII
MANUAL CHANGES AND OPTIONS

7-1. OPTIONS.

7-2. Options are standard modifications performed on -hp- instruments at the factory. Option 001 for Leakage Current Measurements is a currently available option. Operating instructions and other option 001 information are covered in manual corresponding to that for standard instrument.

7-3. SPECIAL INSTRUMENTS.

7-4. "Specials" are standard -hp- instruments that are modified according to customer specifications. A separate insert sheet is included with the manual for special instruments having electrical changes. Make the changes specified in addition to any other changes that are necessary.

7-5. MANUAL CHANGES.

7-6. This manual applies direcly to the Model 4282A with serials prefixed 1515. The following paragraphs explain how to adapt this manual to apply to later instruments with higher serial prefix, or earlier instruments with 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.

7-7. LATER INSTRUMENT: If the serial prefix of your Model 4282A is above 1515, refer to a separate "Manual Changes" sheet supplied with this manual. Locate the serial prefix of your instrument and make the indicated changes.

7-8. EARLIER INSTRUMENTS.
(Backdating Changes):
If the serial prefix of your Model 4282A is below 1515, refer to Table 7-1 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 7-1. Manual Backdating Changes.

Serial Prefix or Number	Make Changes
1319J00170 and below	1

CHANGE 1

Page 6-2, Table 6-2,
A1: Change to HP Part No. 04282-77201; BOARD ASSY:OSCILLATOR.

Pages 6-2 thru 6-4, Table 6-2,
Delete following parts,

A1C29 thru C33, R109 thru R120 and U13 thru U15.

Add following parts,

A1C24: HP Part No. 0180-01C6; CAPACITOR:FXD 60μF ±20% 6VDC TA-SOLID.
A1C25: HP Part No. 0180-0374; CAPACITOR:FXD 10μF ±10% 20VDC TA SOLID.
A1CR29 thru C32: HP Part No. 1901-0040; DIODE SWITCHING SI 30V MAX VRM 50MA.
A1K13 and K14: HP Part No. 0490-0226; RELAY REED.
A1Q11: HP Part No. 1853-0051; TRANSISTOR:PNP SI.
A1Q12 and Q13: HP Part No. 1854-0071; TRANSISTOR:NPN SI.
A1R64: HP Part No. 2100-2655; RESISTOR:VAR TRMR 100kΩ 10% C.
A1R73 and R74: HP Part No. 0686-2045; RESISTOR:FXD 200kΩ5% .5W CC TUBULAR.
A1R75: HP Part No. 0698-4406; RESISTOR:FXD 115Ω 1% .125W F.
A1R76: HP Part No. 0698-3454; RESISTOR:FXD 215kΩ 1% .125W F TUBULAR.
A1R77: HP Part No. 0698-3460; RESISTOR:FXD 422kΩ 1% .125W F TUBULAR.
A1R78 and R81: HP Part No. 0757-0453; RESISTOR:FXD 30.1kΩ 1% .125W F TUBULAR.
A1R79 and R82: HP Part No. 0757-0467; RESISTOR:FXD 121kΩ 1% .125W F TUBULAR.
A1R80: HP Part No. 0757-0444; RESISTOR:FXD 12.1kΩ 1% .125W F TUBULAR.
A1U10: HP Part No. 1826-0092; IC:LIN OP. AMPL DUAL.

Page 6-3, Table 6-2 and page 8-11, Figure 8-6,
Delete A1CR50 and CR51.

Page 6-3, Table 6-2,
A1K7: Change to HP Part No. 0490-0226; RELAY REED.

Page 6-4, Table 6-2,
A1R62: Change to HP Part No. 0698-2218; RESISTOR:FXD 33.5kΩ 1% .125W MET FLM.
A1R63: Change to HP Part No. 2100-2216; RESISTOR:VAR 5kΩ ±10% .5W CER.
A1R88: Change to HP Part No. 2100-2060; RESISTOR:VAR 50Ω 20% CER.

Page 8-13, Figure 8-7,
Change Figure 8-7 partially as shown in Figure 7-1.

Page 8-11, Figure 8-6 (in Table of Active Components),
Delete CR50 and 51; 1902-3059.
Change Q10 to 1854-0071

Page 8-13, Figure 8-7 (in Table of Active Components),
Add Q11; 1853-0051, Q12 and Q13; 1854-0071, U10; 1826-0092, CR29 thru 32; 1901-0040.

Page 6-5, Table 6-2,
A2: Change to HP Part No. 04282-77202; BOARD ASSY:MULTIPLIER.

Page 6-6, Table 6-2,
A2CR15: Change to HP Part No. 1902-0184; DIODE:VREG 16.2V VZ .4W MAX.

Page 6-8, Table 6-2,
A2R74: Change to HP Part No. 0757-0199; RESISTOR:FXD 21.5kΩ 1% .125W F TUBULAR.
A2R75: Change to HP Part No. 0698-3454; RESISTOR:FXD 215kΩ 1% .125W F TUBULAR.

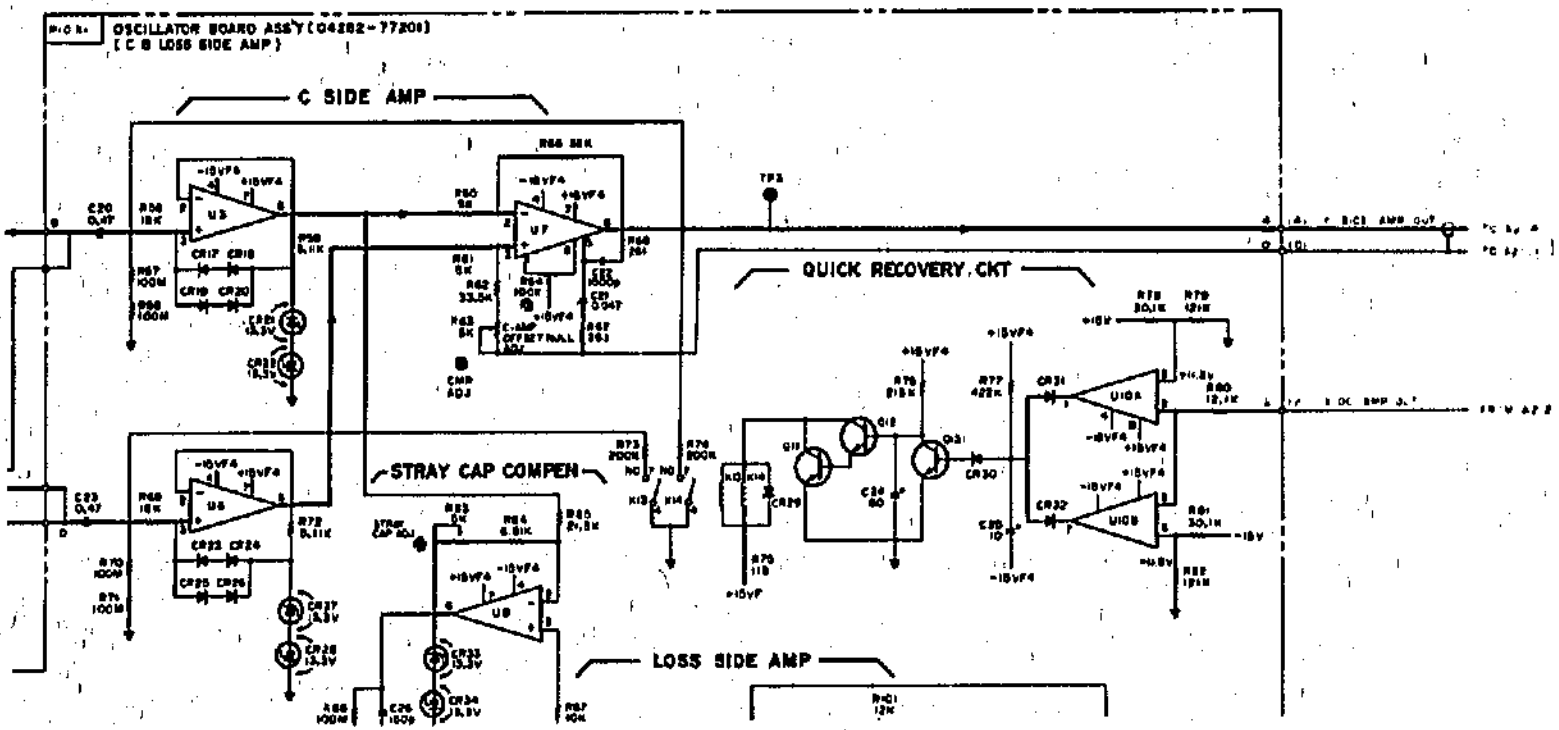
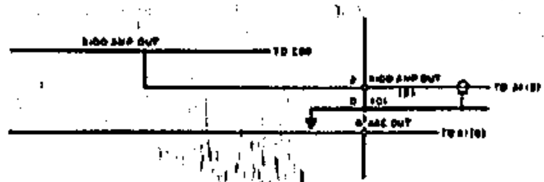

OSCILLATOR BOARD ASS'Y (04282-77201)
(C & LOSS SIDE AMP)
C SIDE AMP
QUICK RECOVERY CKT
STRAY CAP COMPEN
LOSS SIDE AMP
TP3
U5
U7
U8
U9
U10A
U10B
C-AMP OFFSET NULL ADJ
CMP ADJ
STRAY CAP ADJ

Figure 7-1.

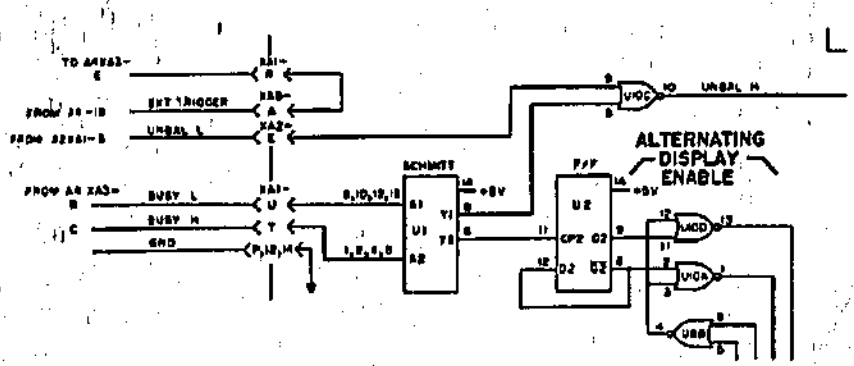
Page 8-15, Figure 8-8,
Change Figure 8-8 partially as follows:



Page 8-15, Figure 8-8 (in Table of Active Components),
CR15: Change to 1902-0184.

Page 6-10, Table 6-2,
A3: Change to HP Part No. 04282-77203; BOARD ASSY:CONTROL.

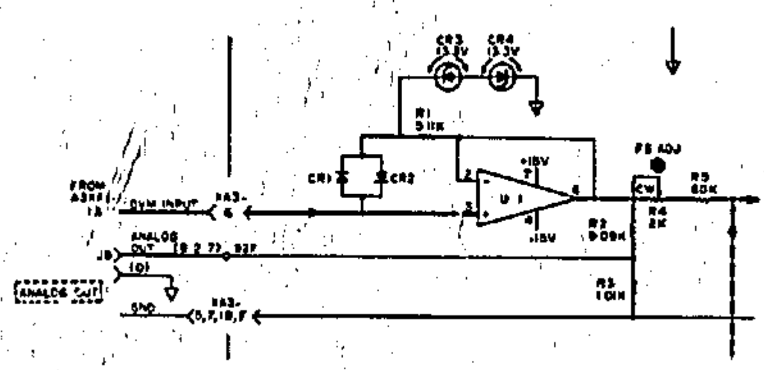
Page 8-21, Figure 8-11,
Change Figure 8-11 partially as follows:



Page 8-21, Figure 8-11 (in Table of Active Components),
Delete CR26.

Pages 6-12 through 6-14, Table 6-2,
A4: Change to HP Part No. 04282-77204; BOARD ASSY:DVM.
A4R58: Change to HP Part No. 0698-4431; RESISTOR:FXD 2.05kΩ 1% .125W F TUBULAR.
Delete following parts,
A4CR11, Q17, R104 and R105.

Page 8-29, Figure 8-15,
Change Figure 8-15 partially as follows:



Page 5-13, paragraph 5-54,
Replace with following paragraphs.

5-54. High Capacitance Ranges Adjustment (A1, A2).

5-55. This adjustment uses a standard capacitor (SOSHIN TM 520-C). Proceed as follows:

a. Set 4282A to same as paragraph 5-31 step a except set C RANGE to 10mF.

b. Set SOSHIN TM 520-C to 10mF.

c. Connect 16035A Test Leads to UNKNOWN connector.

d. Twist two current leads with each other (at lead five times) and also twist the two voltage lead together (see paragraph 3-34) and connect to SOSHIN TM-520-C.

e. Adjust 4282A display for certified 10mF capacitance value with A1R88 (10mF Range Adj.).

f. Set C RANGE and SOSHIN TM 520-C to 1F.

g. Adjust 4282A display for certified 1F capacitance value with A2R10 (1F Full-Scale Adj.).

Page 8-31, Figure 8-16,
Change Figure 8-16 partially as shown in Figure 7-2.

Page 8-31, Figure 8-16 (in Table of Active Components),
Delete CR11 and Q17.

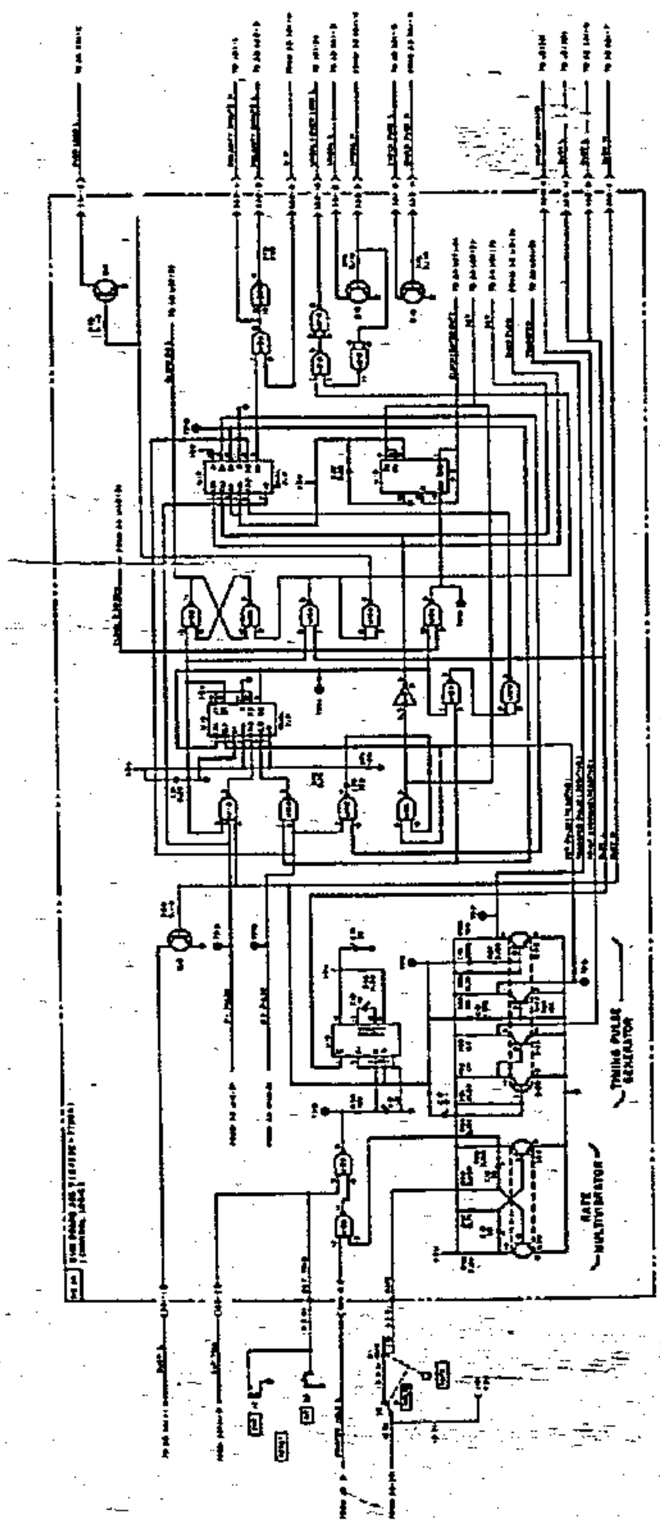


Figure 7-2.

SECTION VIII
CIRCUIT DIAGRAMS

8-1. INTRODUCTION.

8-2. This section includes the following:

a. General Notes for Schematic Diagrams.

b. Block Diagram.

c. Schematic Diagrams and part location illustrations.

d. Circuit Operations.

8-3. The Block Diagram or schematic diagrams can be unfolded and used with any other portion of the manual.

Resistance is in ohms, capacitance is in microfarads and inductance is in microhenries unless otherwise noted.

P/O = part of.

* Asterisk denotes a factory-selected value. Value shown is typical. Capacitors may be omitted or resistors jumpered.

L or H after signal name means the line goes to low or high level, respectively, when the signal is enabled.

R G (RELAY GROUND) or OPEN after signal name means the line is grounded or open, respectively, when the signal is enabled.

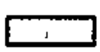
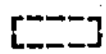
	Screwdriver adjustment.		Panel control.
	Encloses front panel designations.		Encloses rear panel designation.
	AND gate.		NAND gate.
	OR gate.		NOR gate.
	Exclusive OR gate.		Operational amplifier.
	Non-inverting.		Inverting.
	Assembly circuit common.		Floating circuit common.
	Chassis ground.		Protective ground.

Figure 8-1. Schematic Diagram Notes (sheet 1 of 2).

Circuit assembly borderline.

Other assembly borderline.

Heavy line with arrows indicates path and direction of main signal.

Heavy dashed line with arrows indicates path and direction of main feedback.

Wiper moves toward CW with clockwise rotation of control as viewed from shaft or knob.

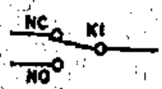
Shows location and number of test point.

(9-4-7)

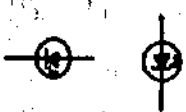
Encloses wire color code. Code used (MIL-STD-681) is the same as resistor color code. First number identifies the base color, second number the wider stripe, and third number identifies narrower stripe (e.g., 947 denotes white base, yellow wide stripe and violet narrow stripe).

A1 (5)

Shows square pin number used in circuit assembly [e.g., A1(5) denotes pin 5 in A1 assembly].



Indicates NC are normally closed contacts and NO are narmally open contacts when relay K1 is not energized.



Voltage regulator (breakdown diode).

Field Effect transistor (FET) with N-type base.

FET with P-type base.

Tunnel diode.

Light emitting diode (LED).

Figure 8-1. Schematic Diagram Notes (sheet 2 of 2).

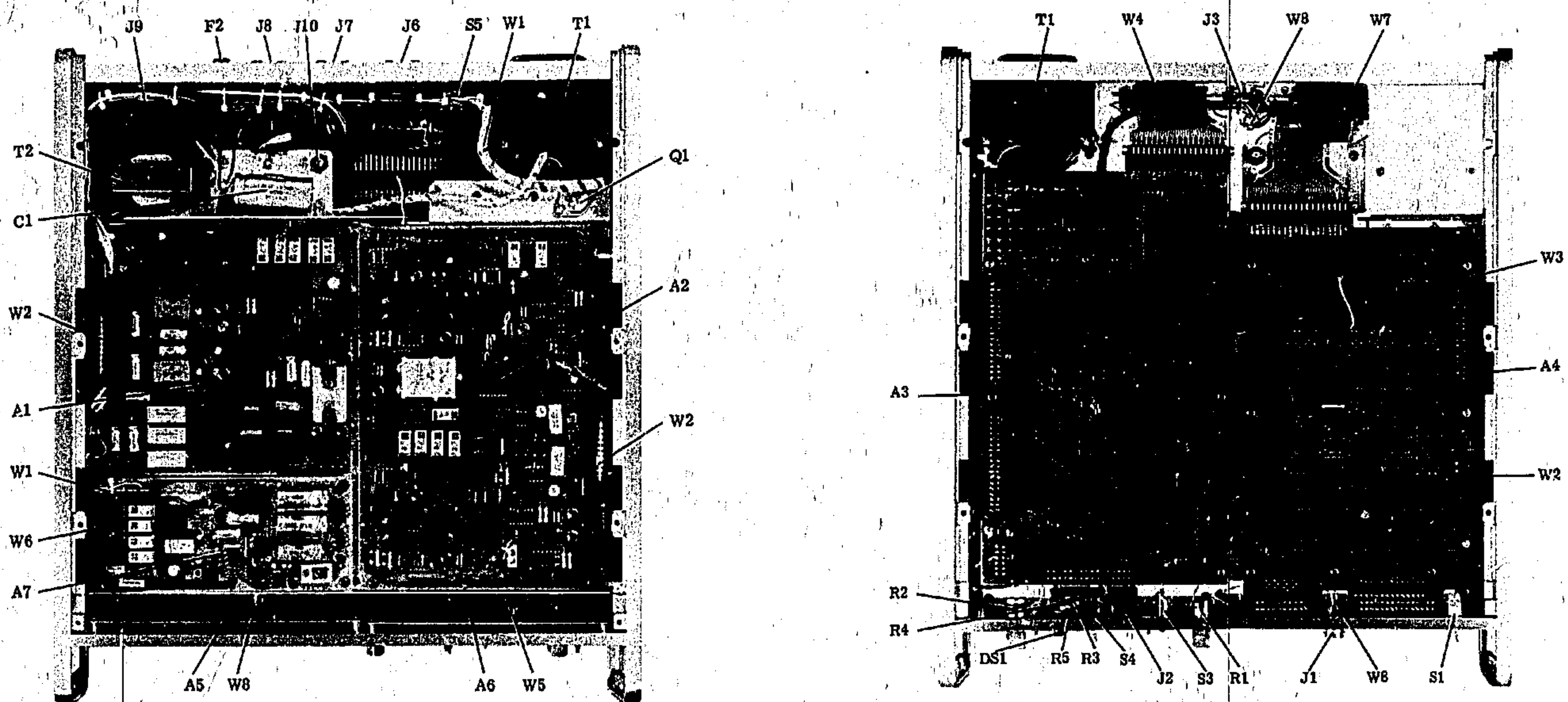


Figure 8-2. Assembly Location.

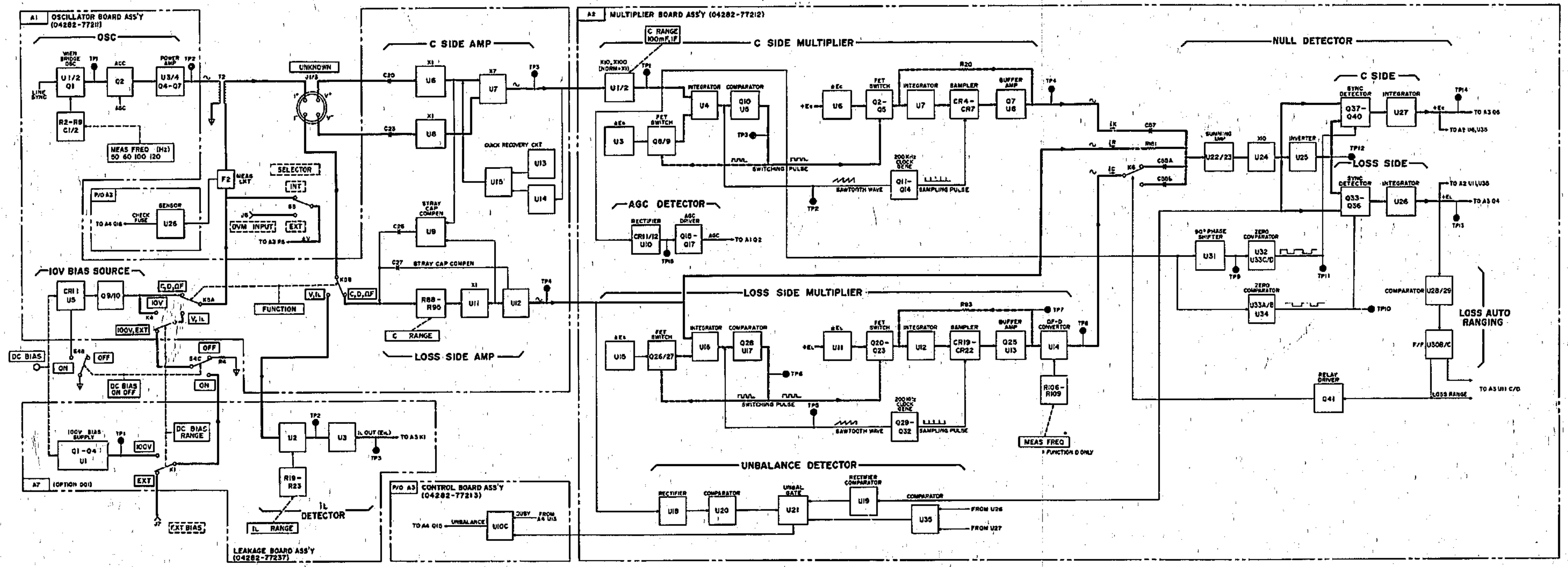


Figure 8-3. Block Diagram - Bridge Section.

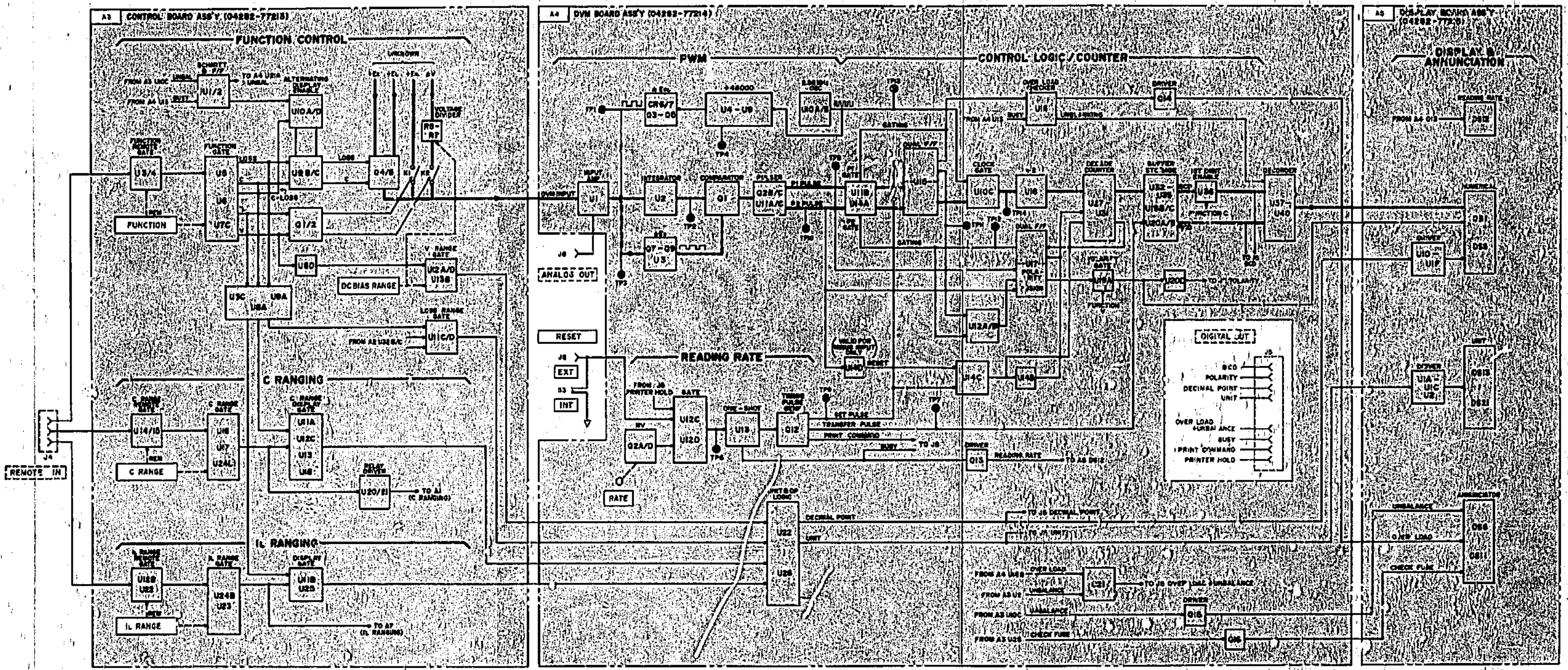


Figure 8-4. Block Diagram - Logic Section.

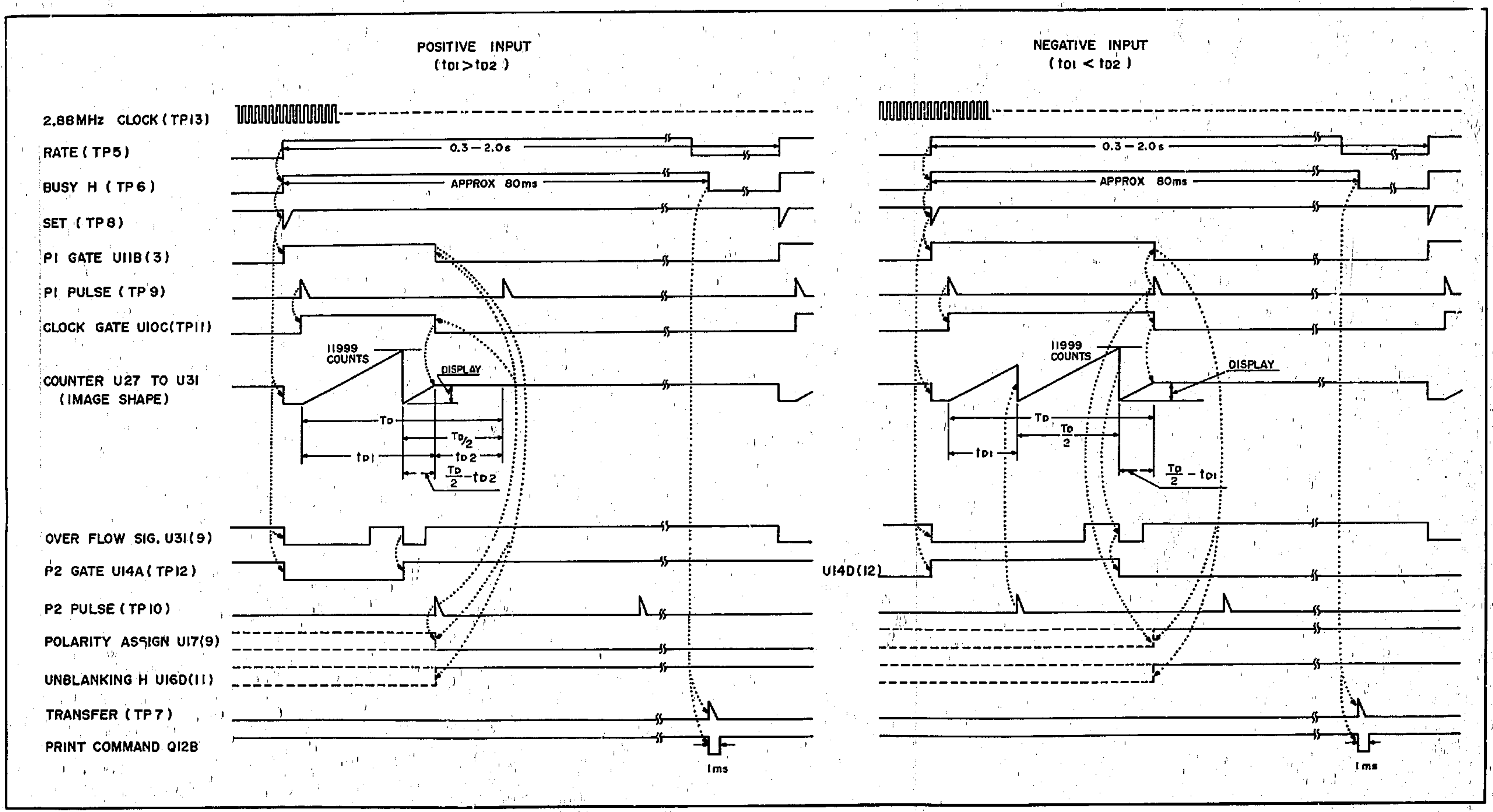
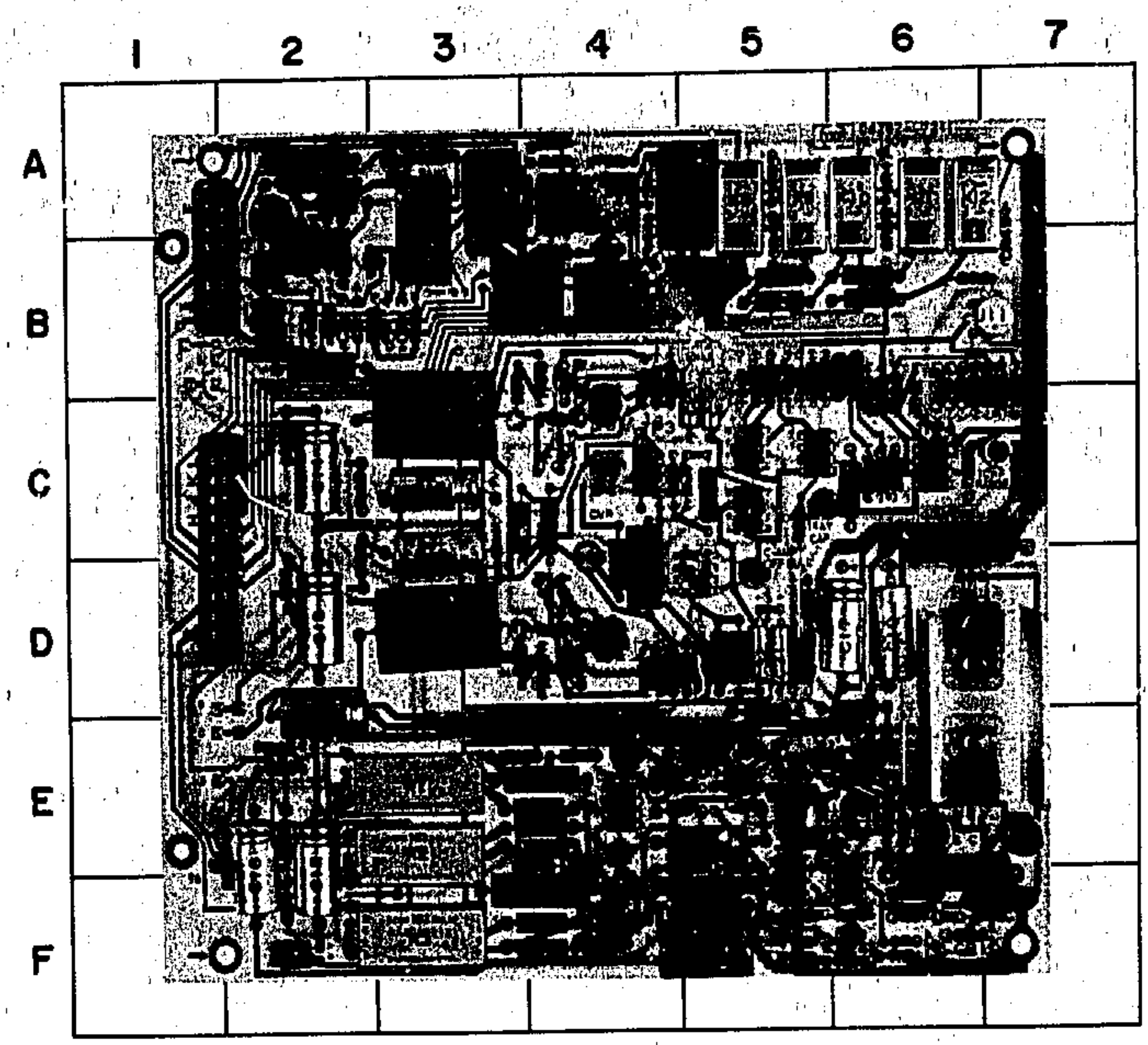


Figure 8-5. DVM Timing Diagram.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.
C1	F-5
C2	F-5
C3	E-5
C4	E-5
C5	F-5
C6	E-5
C7	E-5
C8	F-7
C9	B-2
C10	D-6
C11	E-5
C12	E-2
C13	E-2

Ref. Desig.	Grid. Loc.
C14	C-2
C15	C-3
C16	E-2
C17	D-6
C18	D-2
C19	C-3
CR1	E-2
CR2	E-2
CR3	F-3
CR4	E-5
CR5	E-3
CR6	E-5
CR7	F-6

Ref. Desig.	Grid. Loc.
CR8	F-6
CR9	F-6
CR10	F-6
CR11	B-2
CR12	A-2
CR13	B-3
CR14	B-3
CR15	B-2
CR16	B-2
CR50	F-2
CR51	F-2
K1	E-3
K2	E-3

Ref. Desig.	Grid. Loc.
K3	F-3
K4	A-3
K5	A-3
Q1	E-4
Q2	E-5
Q3	F-6
Q4	E-6
Q5	E-7
Q6	E-6
Q7	D-6
Q8	B-2
Q9	B-2

Ref. Desig.	Grid. Loc.
Q10	A-2
R1	F-2
R2	E-4
R3	E-4
R4	F-4
R5	F-5
R6	E-4
R7	E-4
R8	F-4
R9	F-4
R10	E-4
R11	E-4

Ref. Desig.	Grid. Loc.
R12	E-5
R13	F-4
R14	E-4
R15	E-4
R16	E-4
R17	E-5
R18	E-4
R19	E-4
R20	F-6
R21	F-6
R22	F-5
R23	F-5
R24	F-6

Ref. Desig.	Grid. Loc.
R25	E-6
R26	E-5
R27	E-6
R28	F-6
R29	E-6
R30	E-6
R31	F-6
R32	F-6
R33	F-6
R34	D-6
R35	B-2
R36	B-2
R37	A-2

Ref. Desig.	Grid. Loc.
R38	A-2
R39	B-2
R40	B-2
R41	B-3
R42	B-2
R43	B-3
R44	E-5
R45	E-6
R46	E-2
R47	E-2
R48	C-2
R49	C-2
R50	E-1

Ref. Desig.	Grid. Loc.
R51	E-2
R52	D-2
R53	D-2
U1	F-4
U2	E-4
U3	F-5
U4	F-6
U5	B-2
XA1	B-1
XA2	C-1

SEE INSIDE

Figure 8-5
DVM Timing Diagram

A1 OSCILLATOR BOARD OPERATION

Measuring Signal Generator.

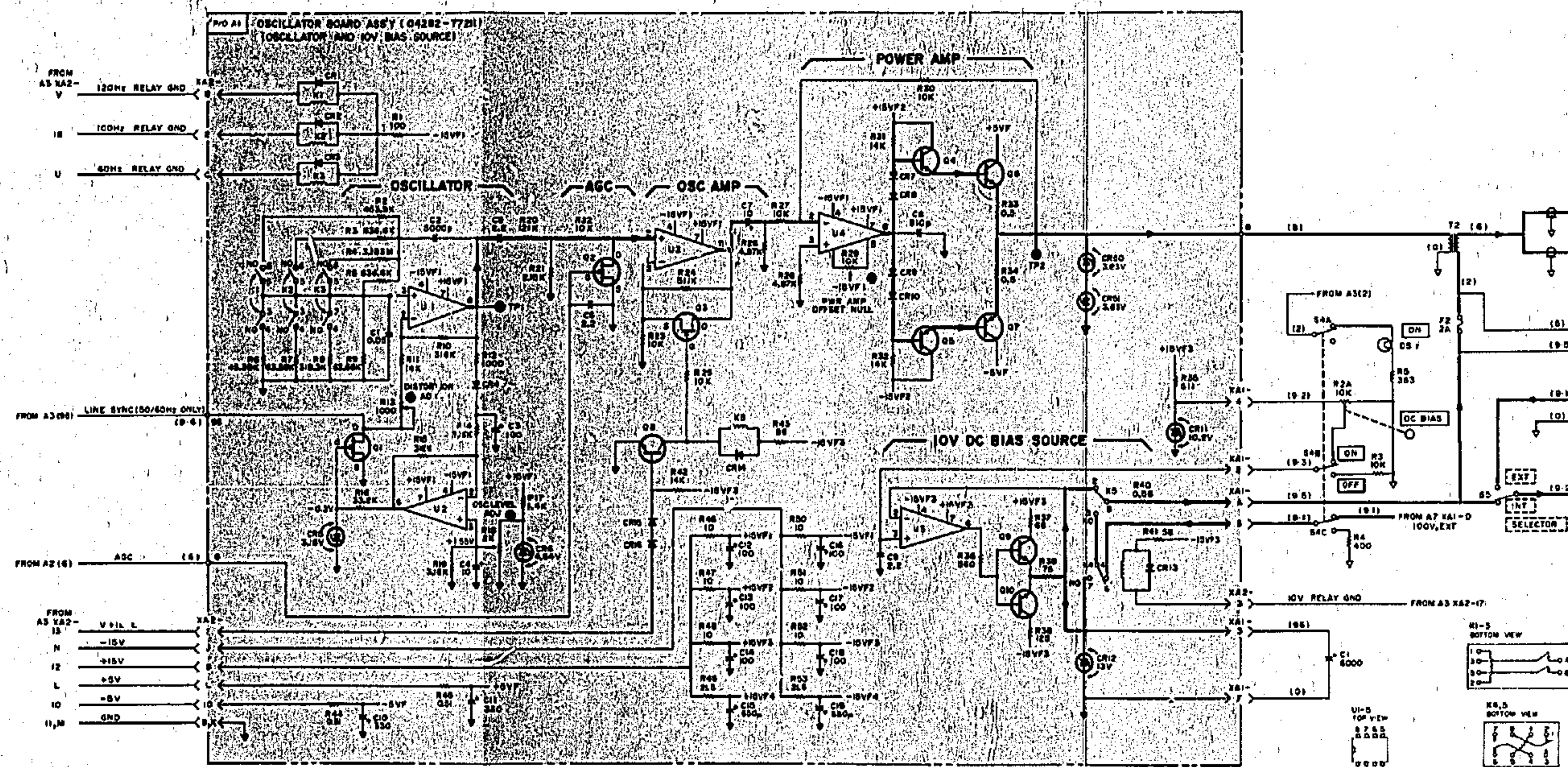
This section is the signal source of Bridge and consists of an oscillator, amplifier and power amplifier. The oscillator employs the Wien Bridge technique and provides four measuring frequencies of 50, 60, 100 and 120Hz. Selection and determination of frequency are done by relays K1, K2 and K3 which select R2 through R9 in combination with C1 and C2. FET Q1 is driven by U2 whose input is difference between Peak Detector CR4 output and reference voltage established by CR6. Q1 operates to maintain voltage ratio at U1(2) at one twenty first of voltage at U1(6) (because, for example, C1 is ten times of C2, R9 is one tenth of R5 at 50Hz setting, and so on). Output at U1(6) can be changed or maintained by potentiometer R18. When MEAS FREQ switch is set to 50 or 60Hz, line synchronous signal is applied to Q1 drain to synchronize frequency to line frequency.

AGC(Q2) only operates when C range is set to 100mF or 1F. On these two ranges, range is determined not by changing range resistances but by increasing amplifier A2U1, U2 gain from 1 to 10 or to 100. Amplifiers could be saturated depending upon unknown values. To prevent this, appropriate AGC signals reduce measuring signal level. Amplifier U3 amplifies oscillator signal to furnish sufficient drive to Power Amplifier. Both Q2 and Q3 turn on when function is set to V or I_L (option 001) which operate to extinguish oscillator signal. The Power Amplifier, which is comprised of U4 and Q4 through Q7, has unity gain and the capability to feed maximum signal current of about 660mA (equivalent to 1A) through transformer T2 which has a turns ratio of three to two. Q4, Q6 and Q5, A7 form a complementary push-pull circuit.

10V DC Bias Source.

A 10 volts DC Bias Source is provided by reference diode CR11, differential amplifier U5 and power amplifier Q9 and Q10. Bias voltage is controlled by DC BIAS control R2A. Maximum current is about 100mA.

A1 Parts Locations under Fold



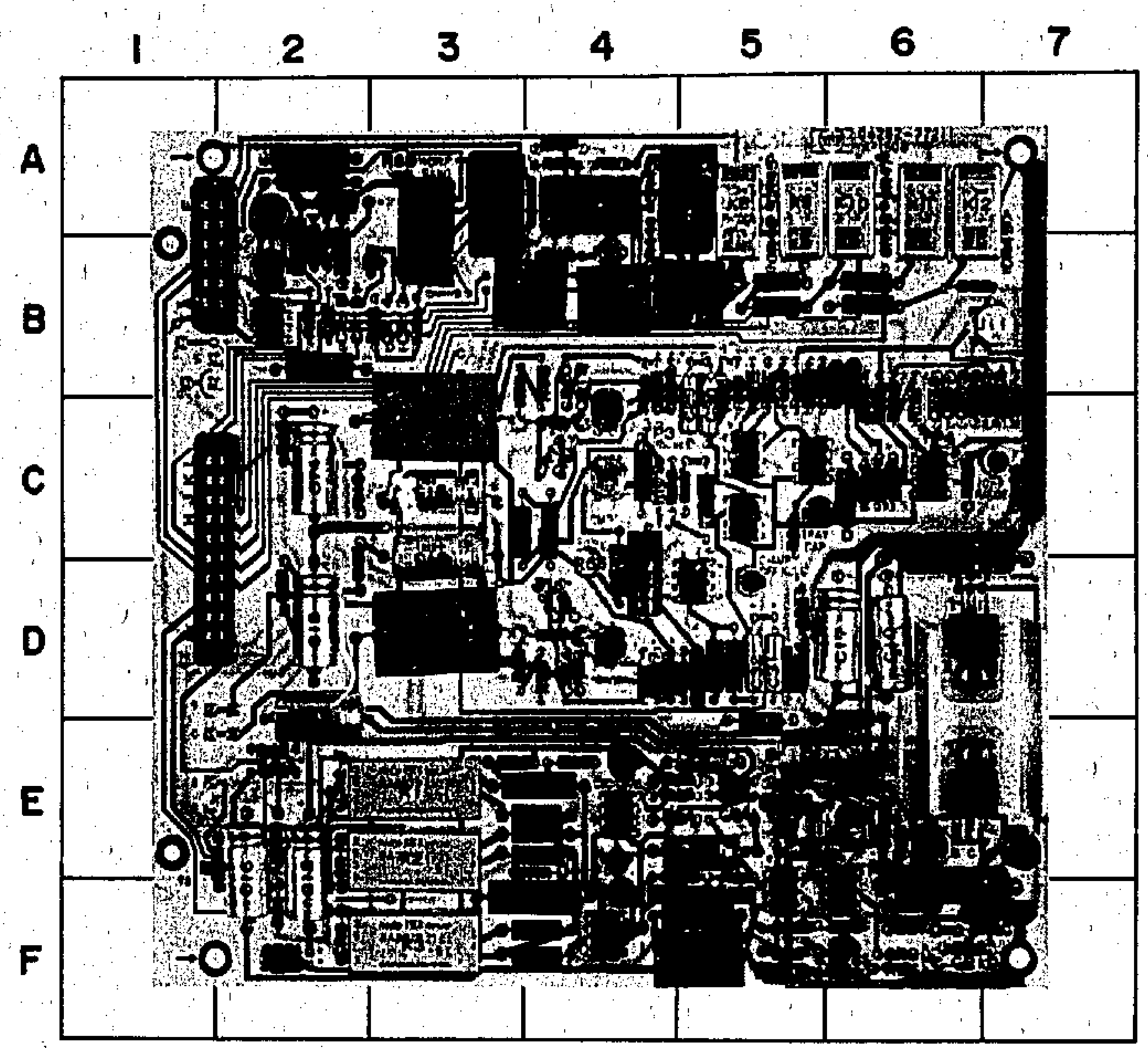
Reference Designations

NO PREFIX	A1
C1	C1 - 19 CR1 - 16, 60, 61
DS1 F2 J6	
	K1 - 5 Q1 - 10 R1 - 53
R2 - 6 S4, 5 T2	
	U1 - 5 XA1, 2

Table of Active Components

Reference Designations	HP Part Number
A1	
CR1 - 4, 7 - 10	1901-0040
CR13 - 16	1901-0040
CR5	1902-3036
CR50, 61	1902-3059
CR6	1902-3082
CR11	1902-3183
CR12	1902-0643
Q1	1855-0087
Q2, 3	1853-0001
Q4, 9	1854-0009
Q5	1853-0051
Q6	1854-0127
Q7	1853-0106
Q8	1853-0020
Q10	1853-0051
U1 - 5	1820-0216

Figure 8-6. A1 Oscillator Board Ass'y, (Oscillator and 10V Bias Source)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C20	C-3	CR20	B-4	CR34	D-5	CR48	A-6	Q11	D-5	R63	D-5	R78	B-5	R92	B-5	R107	B-5
C21	D-5	CR21	C-4	CR35	B-6	CR49	B-7	Q12	D-5	R64	B-4	R79	B-5	R93	B-5	R108	A-3
C22	C-5	CR22	C-4	CR36	B-7			Q13	D-5	R66	C-4	R80	B-5	R94	B-6		
C23	D-3	CR23	D-4	CR37	B-6	K5	A-2			R67	D-5	R81	B-5	R95	B-6	U6	C-4
C24	D-5	CR24	D-4	CR38	B-6	K6	A-4	R43	B-3	R68	C-5	R82	B-5	R96	B-7	U7	C-5
C25	D-5	CR25	D-4	CR39	B-7	K7	A-5	R54	A-4	R69	D-4	R83	C-5	R97	B-7	U8	D-4
C26	B-6	CR26	D-4	CR40	B-7	K8	A-5	R55	A-4	R70	D-3	R84	C-5	R98	B-6	U9	C-5
C27	B-6	CR27	D-4	CR41	C-6	K9	A-5	R56	C-4	R71	D-4	R85	B-5	R99	B-6	U10	C-5
C28	C-6	CR28	D-4	CR42	C-6	K10	A-6	R57	C-3	R72	D-4	R86	B-5	R100	B-6	U11	B-7
		CR29	D-4	CR43	A-4	K11	A-6	R58	B-4	R73	D-3	R87	B-5	R101	B-6	U12	C-6
CR14	B-3	CR30	D-5	CR44	B-4	K12	A-7	R59	B-4	R74	C-3	R88	A-3	R103	C-6		
CR17	C-4	CR31	C-5	CR45	A-5	K13	C-4	R60	C-5	R75	D-4	R89	B-4	R104	C-7	XA1	B-1
CR18	C-4	CR32	C-5	CR46	A-5	K14	C-4	R61	D-5	R76	C-5	R90	B-4	R105	C-7		
CR19	B-4	CR33	D-5	CR47	A-6			R62	D-5	R77	C-5	R91	B-5	R106	C-6		

SEE INSIDE

MEASURING CIRCUIT OPERATION

C, D, and ΩF Measurements.

Both UNKNOWN connectors J1 (front) and J3 (rear) each have the two current terminals and the two voltage terminals required for Four-Terminal operation. Measuring current from T2 appears at current terminal I^+ and flows through unknown to current terminal I^- into the range resistors in A1. Voltage terminals detect voltage across unknown and send it to C Side Amplifier in A1. When dc bias is superimposed, dc bias is fed from A1XA1-A and applied to unknown through T2. Quick action fuse F2 (2A) works to protect measuring circuit from excessive current. If fuse blows, measuring signal becomes input of Check Fuse Sensor in A3.

V (Voltage) Measurement.

When FUNCTION is set to V, voltage across unknown is connected to DVM Board (A4) through Control Board (A3). Both external input voltage and biasing voltages up to 600V are measureable. Selection is made with DVM INPUT SELECTOR switch S5.

I_L Measurement (Option 001).

When FUNCTION is set to I_L or V and DC BIAS ON-OFF switch S4 to ON, dc bias is fed from A1XA1-A and applied to unknown through current lead I^+. Leakage current through unknown is connected to A1XA1-6 and fed to Leakage Current Board (A7) through current lead I^-. A7 assembly converts this current to voltage. When S4 is set to OFF, discharge resistor R4 is connected to unknown.

Figure 8-6
A1 Oscillator Board Ass'y
(Oscillator and 10V Bias Source)

A1 OSCILLATOR BOARD OPERATION
(C and Loss Side Amplifier Section).

C Side Amplifier.

The C side Amplifier contains two Impedance Converters U6 and U8 plus Amplifier U7. The impedance converters, whose inputs are connected to voltage terminals V^+ or V^-, provide high input impedance so as not to affect unknown. Amplifier U7 amplifies voltage across unknown seven times and sends an output opposite in phase to Multiplier Board A2. CR17 to CR22 and CR23 to CR28 form a protective circuit for large changes of dc bias. U13 to U15 provides negative feed back loop for stable dc offset nulling.

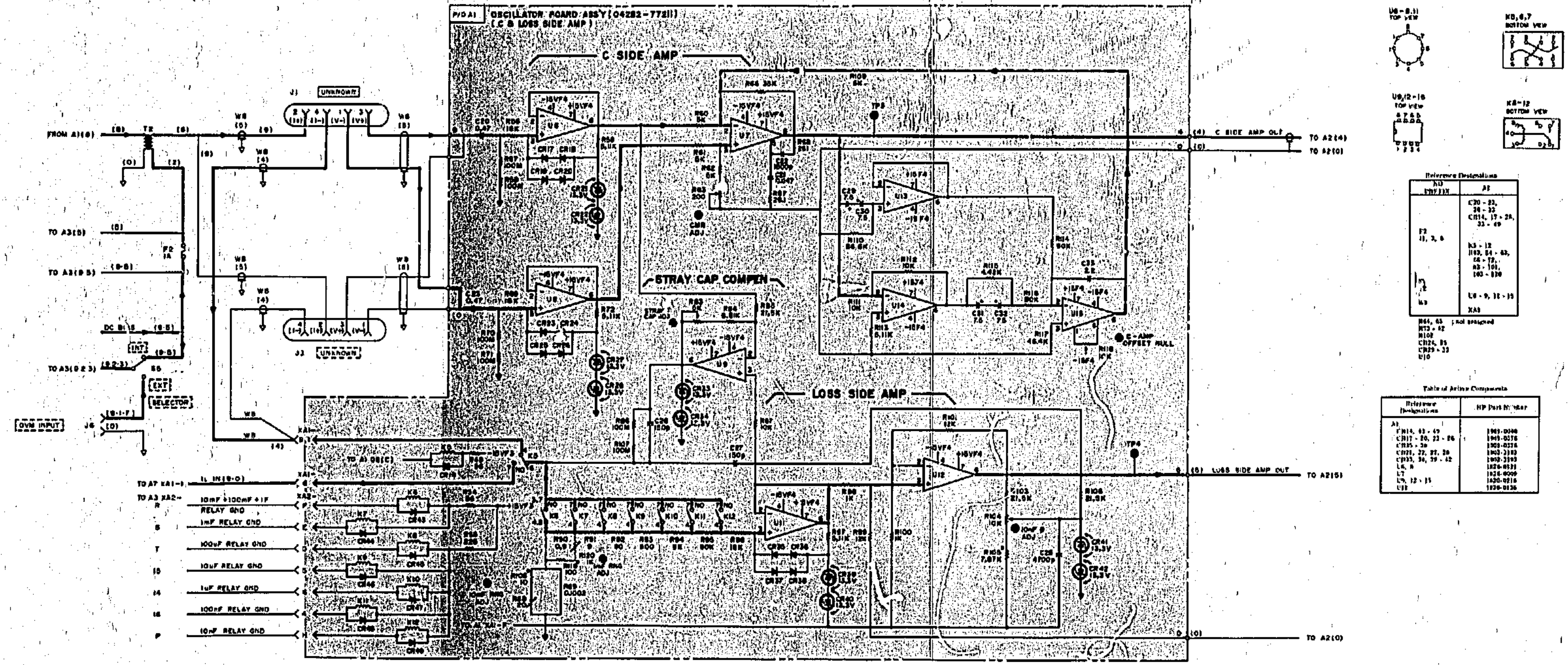
Loss Side Amplifier.

The Loss Side Amplifier includes C Range resistors R88 to R95, Impedance Converter U11 and Amplifier U12. Measuring signal goes to ground through current lead I^- and selected C Range Resistor. Impedance Converter U11 sends voltage across C Range resistor to Amplifier U12. U12 amplifies U11 output and provides an output in phase with measuring current which is sent to Multiplier Board A2.

Stray Capacitance Compensation Circuit.

Differential amplifier U9 and C26 compensate for stray capacitance between measuring leads and C27 compensates for stray capacitance of C Range Resistors.

A1 Part Locations under Fold



Reference Designations

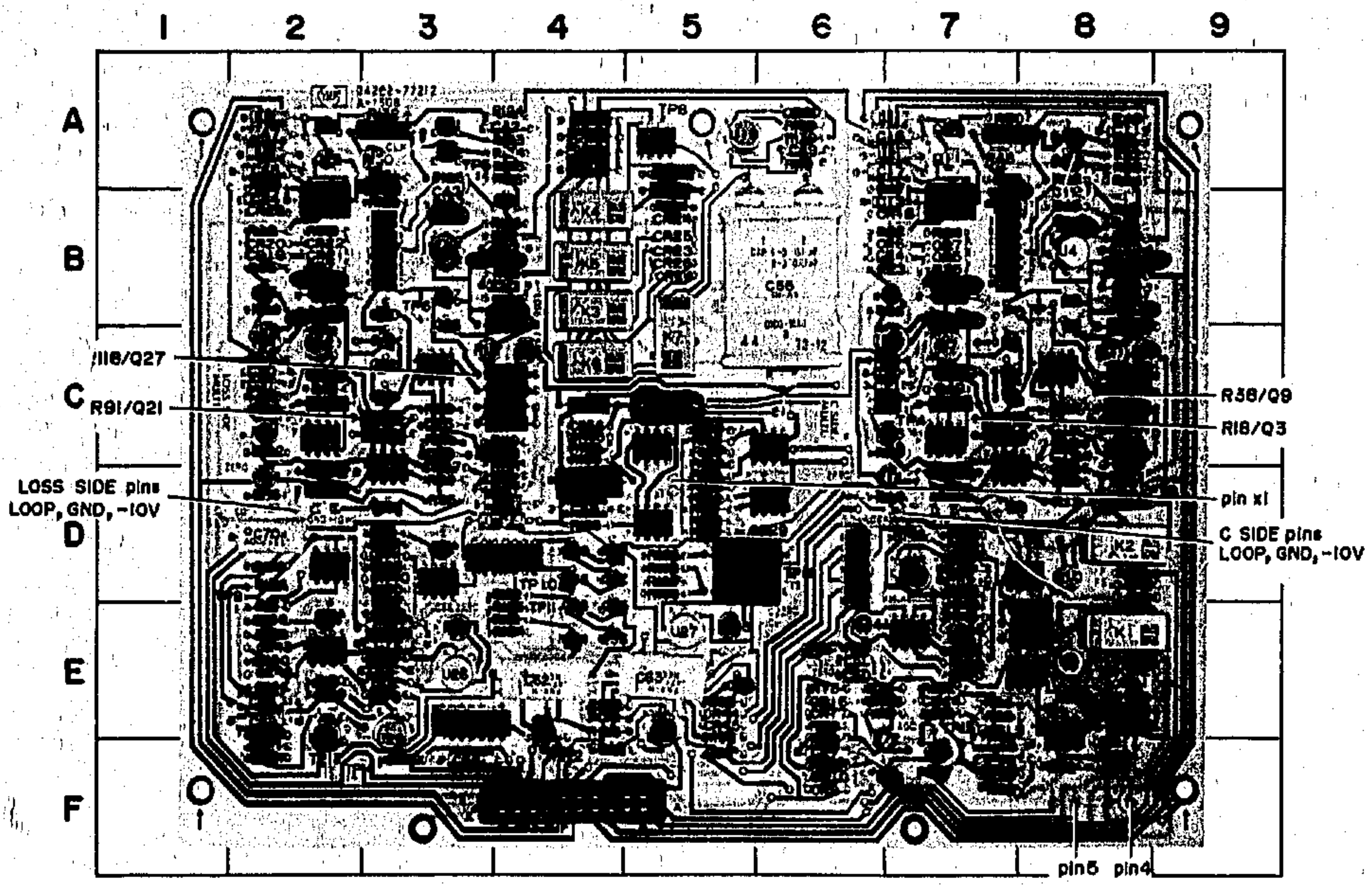
NO PREFIX	A1
F2 J1, 3, 6 W3	C20 - 23, 30 - 33 CR14, 17 - 28, 33 - 49 K5 - 12 R63, 64 - 63, 66 - 72, 83 - 101, 103 - 120 U6 - 9, 12 - 15 XA1

R64, 65 ; not assigned
R73 - 82
R102
CR24, 25
CR29 - 32
U10

Table of Active Components

Reference Designations	HP Part Number
A1	
CR14, 43 - 49	1901-0040
CR17 - 20, 23 - 26	1901-0376
CR35 - 36	1902-0376
CR21, 22, 27, 28	1902-3182
CR33, 34, 39 - 42	1902-3193
U6, 8	1826-0131
U7	1826-0009
U9, 12 - 15	1820-0216
U11	1820-0126

Figure 8-7. A1 Oscillator Board Ass'y. (C & Loss Side Amp)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	E-8	Q4	C-7	R39	C-8
C2	D-7	Q5	C-7	R40	B-8
C3	B-7	Q6	C-6	R41	B-8
C4	C-7	Q7	B-6	R42	B-8
C5	B-7	Q8	B-8	R43	A-8
C6	D-8	Q9	B-8	R44	B-8
C7	D-8	Q10	B-8	R45	B-8
C8	C-8	Q11	A-7	R46	B-7
C9	B-8	Q12	A-7	R47	B-6
C10	B-8	Q13	A-8	R48	A-7
C11	A-8	Q14	A-8	R49	B-7
C12	B-8	Q15	E-7	R50	A-7
C13	B-6	Q16	F-6	R51	A-8
C14	B-7	Q17	F-7	R52	A-8
C15	A-7			R53	A-8
C16	A-6	R1	E-8	R54	C-8
C17	A-6	R2	D-8	R55	C-6
C18	C-8	R3	E-8	R56	B-8
C19	C-8	R4	E-8	R57	C-8
C20	C-6	R5	E-8	R58	C-6
C21	C-6	R6	E-8	R59	B-8
C22	B-8	R7	D-8	R60	F-8
C23	B-8	R8	E-8	R61	E-8
C24	D-8	R9	D-7	R62	F-8
C25	E-7	R10	D-8	R63	F-8
C26	F-7	R11	D-6	R64	E-7
C27	E-6	R12	D-6	R65	E-7
		R13	D-7	R66	F-7
CR1	E-8	R14	D-7	R67	E-7
CR2	E-8	R15	D-8	R68	F-7
CR3	D-8	R16	D-8	R69	E-7
CR4	B-6	R17	C-7	R70	E-6
CR5	B-7	R18	C-7	R71	E-6
CR6	B-6	R19	C-7	R72	E-6
CR7	B-7	R20	C-7	R73	E-6
CR8	C-8	R21	B-7	R74	E-6
CR9	F-6	R22	B-6	R75	E-6
CR10	F-6	R23	B-6	R76	F-6
CR11	E-8	R24	B-6		
CR12	E-8	R25	B-7	T1	B-7
CR13	E-7	R26	B-6		
CR14	E-7	R27	C-6	U1	E-7
CR15	E-6	R28	C-6	U2	D-7
CR16	E-6	R29	C-6	U3	C-8
CR17	E-6	R30	C-8	U4	B-8
CR13	B-6	R31	C-8	U5	B-7
		R32	C-8	U6	C-7
K1	E-8	R33	D-8	U7	C-7
K2	D-8	R34	C-8	U8	C-7
		R35	D-8	U10	E-8
Q1	D-7	R36	C-8		
Q2	B-7	R37	C-8	XA1	F-4
Q3	C-7	R38	C-8		

SEE INSIDE

Figure 8-7
A1 Oscillator Board Ass'y
(C & Loss Side Amp)

A2 MULTIPLIER BOARD OPERATION
(C Side Multiplier and AGC Detector Section).

C Side Multiplier.

The C Side Multiplier, shown in top section of schematic Figure 8-8, produces the product of C Side Amplifier output in A1 and C Side Integrator output (E_C) in A2. Amplifiers U1 and U2 (x10 and x100) have a gains of 1 below a C Range 10mF and increase their gains to 10 on 100mF range and to 100 on 1F range. U2 output is applied to integrator U4. The $\pm E_S$ Generator CR8 and U3 provide plus and minus references through R38 and R37, respectively. The $+E_S$ is switched by FET Switch Q8 and Q9 as U4 input goes to zero during one period of 200kHz clock. U4 output produces both positive and negative going ramps during one clock period. Changing of ramp polarity occurs at the same level of U4 output and sawtooth waveform of Q14 in 200kHz Clock Generator. This is sensed by Comparator Q10, which changes state of U5C and U5B whose output is connected to FET Switch Q8 and Q9 (to complete negative feedback loop) and also to FET switch Q2 to Q5. U5 is driven in negative domain to match action of FET Switches and provides a waveform modulated to pulse width by U2 output.

The $\pm E_C$ Generator U6 accepts C Side Integrator output ($+E_C$) and develops $-E_C$. Q1 is temperature compensator for U6. The $+E_C$ is connected to Integrator U7 through R17 and the $-E_C$ is connected to U7 through R18 and FET Switch Q2 to Q5 which is switched by timing from U5. U7 integrates the sum of these two inputs. U7 output through Q6 is sampled by applying sampling pulse issued at each end of sawtooth from T1 in 200kHz Clock Generator to Sampler (CR4 to CR7) and is stored in C5. Charge stored in C5 maintains input to Buffer Amplifier Q7 and U8. Therefore, U8 output forms staircase which is similar to and in phase with C Side Amp output in A1. Negative feedback loop through R20 operates to cancel result of previous integration. The heart of 200kHz Clock Generator is the Blocking Oscillator (Q11, T1 and CR18). This provides two outputs, one is sampling pulse of 10V peak at T1 (1-2) and the other is sawtooth at Q14 emitter.

AGC Detector.

AGC Detector, shown on bottom section of schematic Figure 8-8, provides a valid signal only when C Range is 100mF or 1F to reduce Oscillator signal level in A1 according to conditions of U1 and U2. On the other ranges, U2 output never exceeds about 7Vrms but on two ranges the 7Vrms may be exceeded which saturates U1 and U2 due to increased gain. Rectifier CR11 and CR12 and U10 rectifies U2 output and sends it to Smoothing Circuit and again to AGC Driver Q16. Q16 emitter level is normally negative and goes towards positive when U2 output increases. Q17 is on when Function is V or I_L to break out Oscillator signal in A1.

A2 Parts Locations under Fold

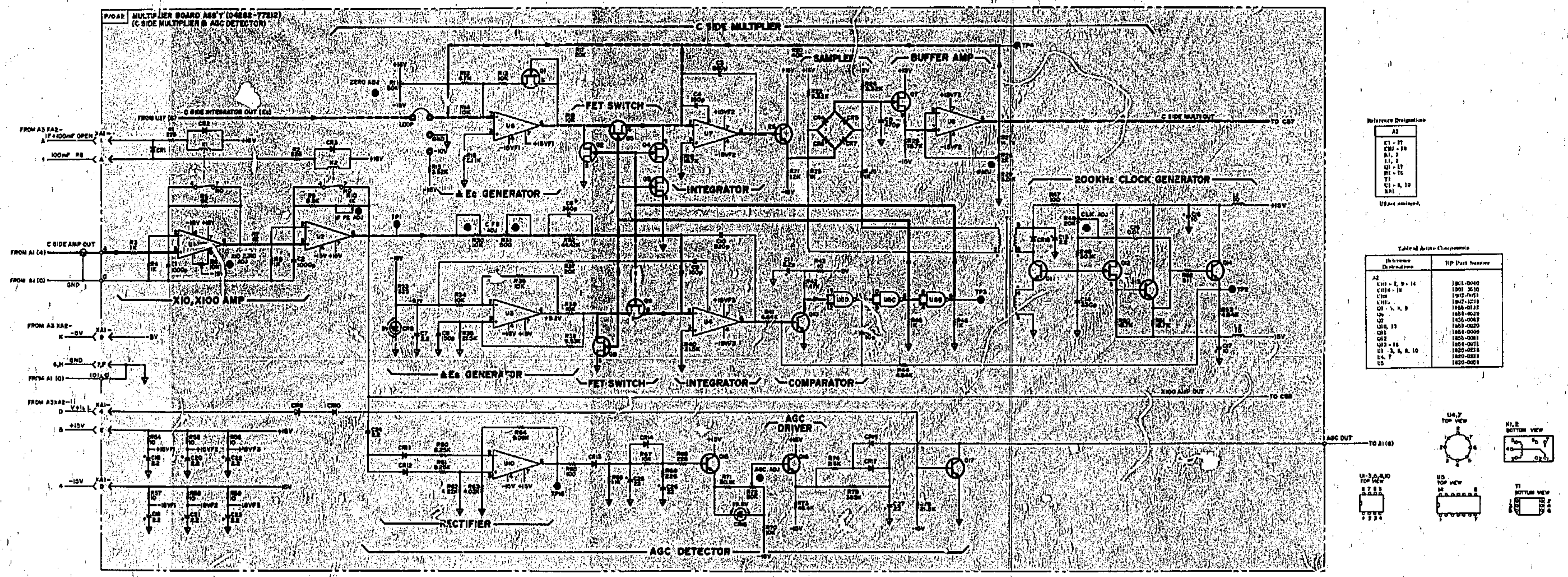
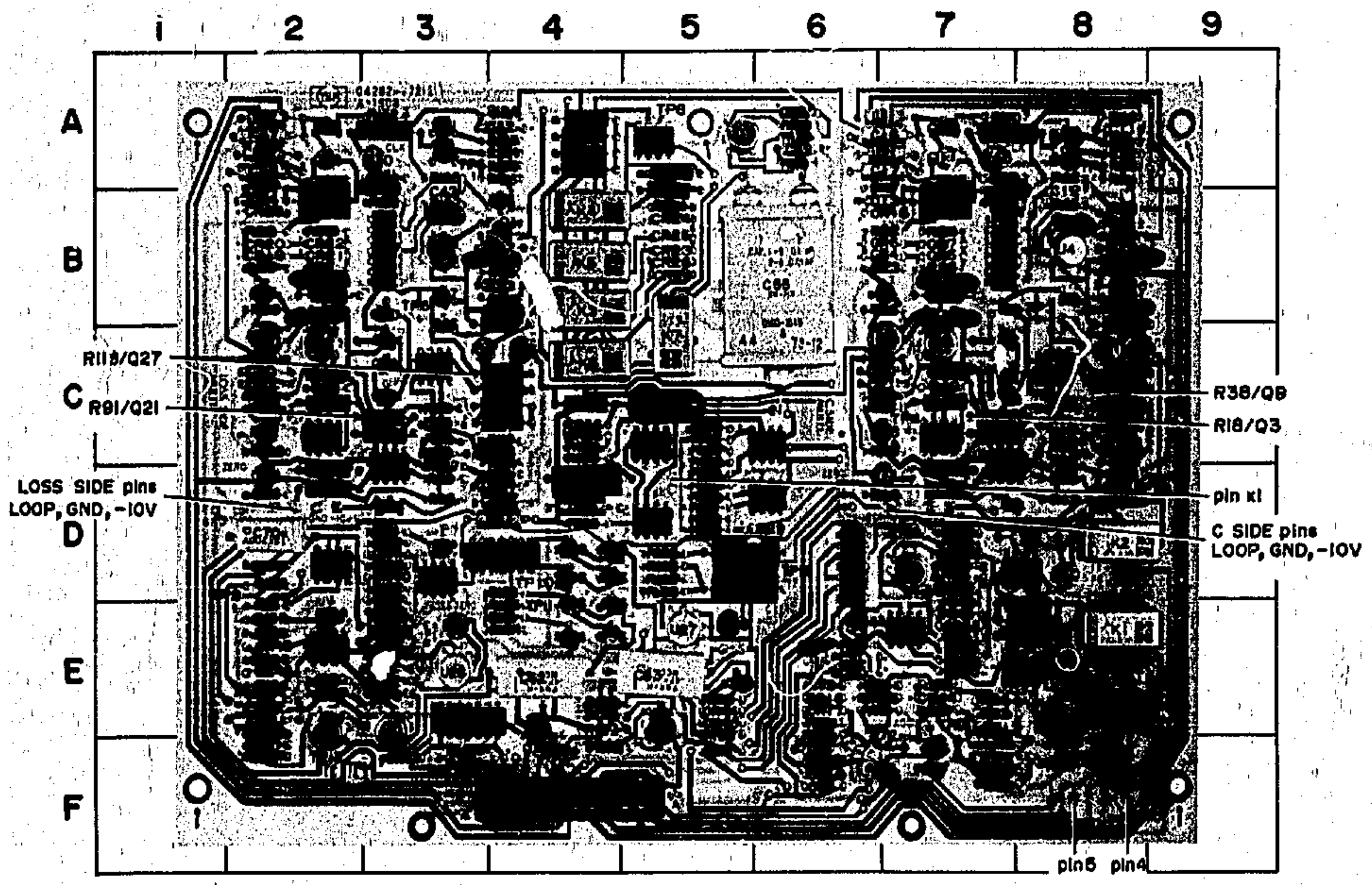


Figure 8-8. A2 Multiplier Board Ass'y.
(C Side Multiplier & AGC Detector)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C28	C-3	Q19	D-3	R115	C-4
C29	C-3	Q20	B-3	R116	C-4
C30	C-2	Q21	C-3	R117	C-3
C31	C-2	Q22	C-3	R118	C-4
C32	B-4	Q23	C-3	R119	C-4
C33	B-4	Q24	C-2	R120	B-4
C34	C-2	Q25	B-2	R121	C-4
C35	B-2	Q26	B-3	R122	B-4
C36	B-2	Q27	B-3	R123	D-4
C37	D-4	Q28	B-4	R124	A-4
C38	C-4	Q29	A-2	R125	A-3
C39	B-4	Q30	A-2	R126	A-4
C40	B-3	Q31	A-3	R127	B-3
C41	B-4	Q32	A-3	R128	B-3
C42	A-4			R129	B-2
C43	B-3	R77	E-5	R130	A-3
C44	B-2	R78	C-3	R131	A-3
C45	B-3	R79	C-3	R132	A-3
C46	A-3	R80	C-2	R133	A-4
C47	A-2	R81	C-2	R134	A-4
C48	A-2	R82	B-4	R135	A-4
C49	A-6	R83	B-4	R136	D-5
C50	E-6	R84	D-2	R137	D-5
C51	E-6	R85	D-3	R138	A-6
C52	D-7	R86	D-2	R139	A-6
C53	D-7	R87	D-2	R140	E-7
C54	E-6	R88	C-2	R141	E-6
		R89	D-3	R142	E-7
CR19	B-2	R90	C-3	R143	E-7
CR20	B-2	R91	C-3	R144	E-6
CR21	B-2	R92	C-2	R145	E-7
CR22	B-2	R93	C-2	R146	D-7
CR23	B-5	R94	B-2	R147	D-7
CR24	B-5	R95	B-2	R148	D-7
CR25	B-5	R96	B-2	R149	D-7
CR26	B-5	R97	B-2	R150	D-7
CR27	C-3	R98	B-2		
CR28	B-2	R99	B-2	T2	B-2
CR29	D-5	R100	C-2		
CR30	A-6	R101	C-2	U11	C-3
CR31	E-7	R102	C-2	U12	C-2
CR32	E-7	R103	E-5	U13	C-2
CR33	D-7	R104	B-5	U14	A-5
		R105	A-4	U15	C-3
K3	B-4	R106	A-4	U16	B-3
K4	B-4	R107	A-4	U17	B-3
K5	B-4	R108	A-4	U18	E-7
K6	C-4	R109	B-5	U19	A-5
		R110	A-6	U20	D-7
L3	A-2	R111	A-5	U21	D-6
L4	A-2	R112	C-4		
		R113	C-4	XA1	F-4
Q18	E-5	R114	C-4		

SEE INSIDE

Figure 8-8
A2 Multiplier Board Ass'y
(C Side Multiplier & AGC Detector)

A2 MULTIPLIER BOARD OPERATION
(Loss Side Multiplier and Unbalance Detector Section).

Loss Side Multiplier.

Loss Side Multiplier produces the product of Loss Side Integrator output (E_L) in A2 and Loss Side Amplifier output in A1. This operation is very similar to C Side Multiplier. Loss Side Amplifier output is sent to Integrator U16 and reference resistor R151. The $\pm E_S$ Generator CR27 and U15 provides plus and minus references through R118 and R121, respectively. The $+E_S$ is switched by FET Switch Q26 and Q27 as U16 input goes to zero during one period of 200kHz Clock. U16 output produces positive and negative going ramps in one clock period. Changing of ramp polarity occurs at the same level of U16 output and sawtooth waveform of Q32 in 200kHz Clock Generator. This is sensed by Comparator Q28, which changes state of U17C and U17B whose output is connected to FET Switch Q26 and Q27 to complete negative feedback loop and also to FET switch Q20 to Q23. U17 is driven in negative domain to match operation of FET Switches and provides waveform modulated to pulse width by Loss Side Amp output in A1.

The $\pm E_L$ Generator U11 accepts Loss Side Integrator output ($+E_L$) and provides $-E_L$. Q19 is temperature compensator for U11. The $+E_L$ is connected to Integrator U12 through R90 and $-E_L$ is connected to U12 through R91 and FET Switch Q20 to Q23 which is switched by timing from U17. U12 integrates the sum of these two inputs. U12 output through Q24 is sampled by applying sampling pulse, issued at each end of sawtooth from T2 in 200kF Clock Generator, to Sampler (CR19 to CR22) and is stored in C36. Charge stored in C36 maintains input of Buffer Amplifier Q25 and U13. Therefore, U13 output forms staircase which is similar to and 180° out of phase with Loss Side Amp output in A1. Negative feedback loop through R93 operates to cancel result of previous integration. Following stage, U14, is ΩF-D Converter. The gain is one for Function ΩF and is $1000/2\pi f$ for Function D (f is measuring frequency in Hz). The heart of 200kHz Clock Generator is the Blocking Oscillator (Q29, T2 and CR28). This provides two outputs, one is a sampling pulse of 10V peak at T2(1-2) and the other is sawtooth at Q32 emitter.

Unbalance Detector.

Unbalance Detector judges unbalance condition from three sources of information. The first is sensed by U18 and U20 when unknown capacitance is too low compared to C Range setting. The second is by U19 when an error signal always exists on Null Detector. The third is by A2U35 when E_C or E_L exceeds +12V. U18 and CR31 plus CR32 form a Rectifier and the smoothed output is applied to Comparator U20. U20 output goes to L (low level) when the level at U20(3) goes lower than at U20(2), which means that Loss Side Amp output is too small. If an error signal exists, it is rectified by CR29 and fed to Comparator U19. U19(6) goes L when the level at U19(2) exceeds that at U19(3). Either one, when conditioned, drives Gate U21D(11) to H (high level) and also U21B(6) L. Finally, A2U35 output goes to L when E_C or E_L exceed +12V and similarly makes U21A(3) H, and U21B (6) L. Gate U21B is disabled when Function is V or I_L.

A2 Parts Locations under Fold

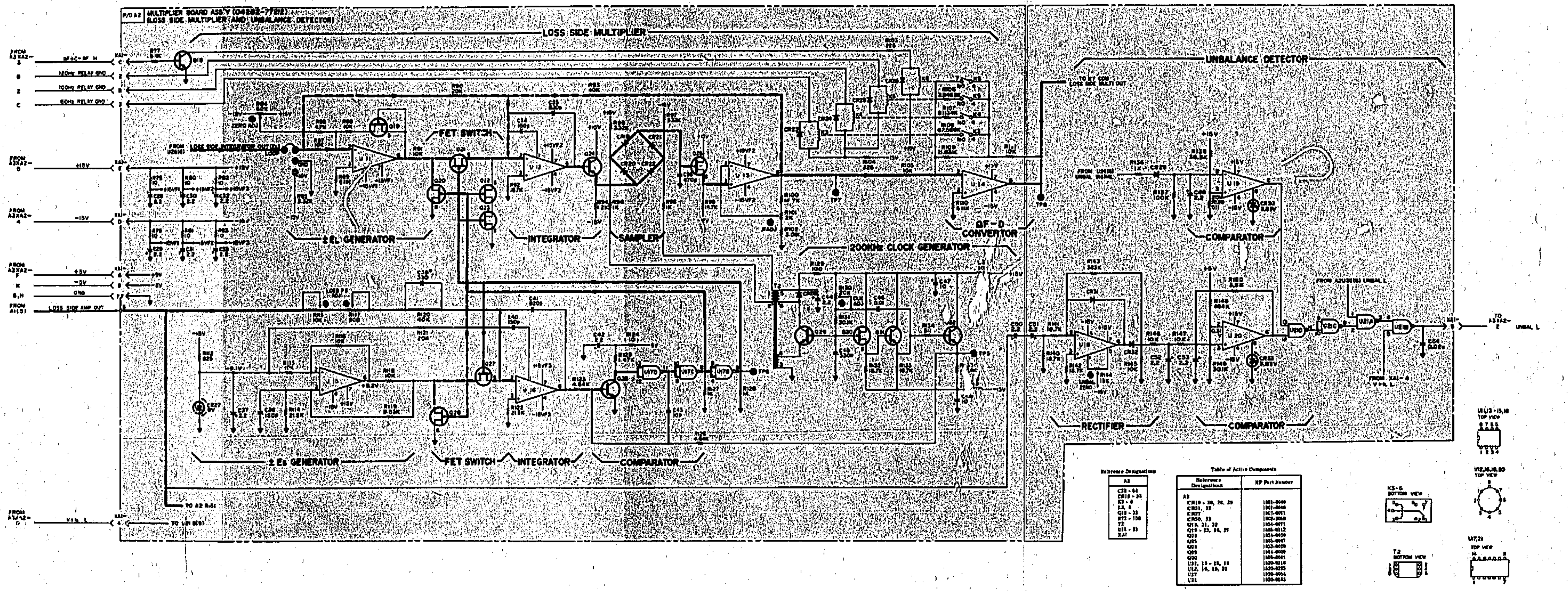
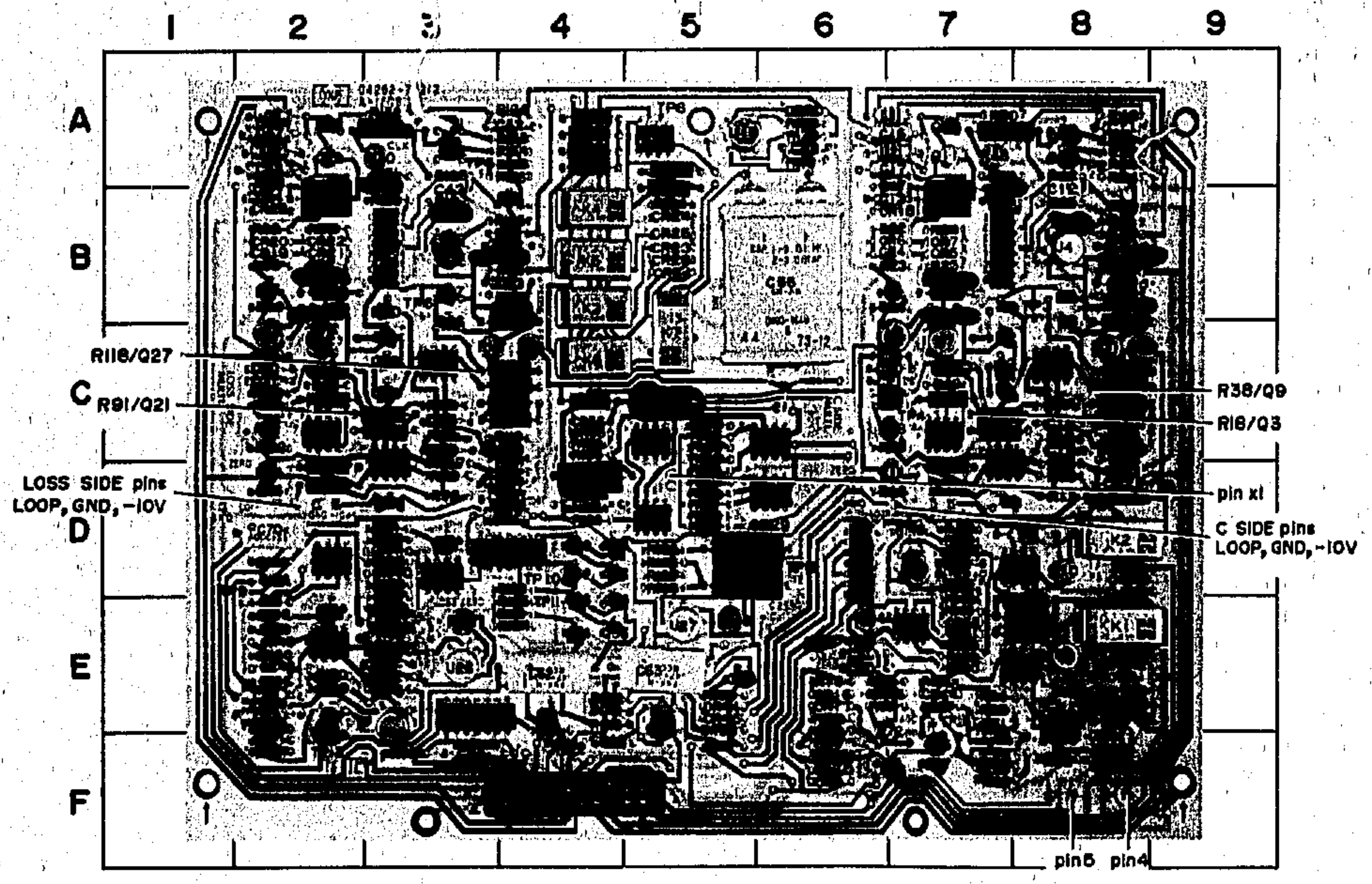


Figure 8-9. A2 Multiplier Board Ass'y.
(Loss Side Multiplier and Unbalance Detector)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C55	B-6	Q35	D-4	R179	E-3
C57	C-5	Q36	D-4	R180	D-3
C58	D-4	Q37	D-4	R181	D-3
C59	D-4	Q38	D-4	R182	D-3
C60	D-5	Q39	D-4	R183	D-3
C61	D-5	Q40	D-4	R184	E-4
C62	E-4	Q41	E-4	R185	D-4
C63	E-5	Q42	D-3	R186	E-2
C64	E-3	Q43	E-2	R187	D-3
C65	E-3			R188	E-2
C66	E-3	R151	C-4	R189	E-2
C67	D-4	R152	C-4	R190	E-2
C68	E-2	R153	C-4	R191	E-4
C69	E-2	R154	C-5	R192	D-4
C70	D-2	R155	D-4	R193	E-5
C71	D-3	R156	C-5	R194	E-4
C72	D-3	R157	C-5	R195	E-4
		R158	C-5	R196	E-4
CR34	B-5	R159	D-5		
CR35	C-4	R160	D-5	U22	C-5
CR36	C-4	R161	D-5	U23	D-5
CR37	E-2	R162	D-5	U24	C-6
CR38	E-2	R163	D-5	U25	D-6
CR39	E-3	R164	D-5	U26	E-3
CR40	D-3	R165	D-5	U27	E-5
CR41	D-3	R166	D-5	U28	E-2
CR42	E-2	R167	E-3	U29	E-3
CR43	E-2	R168	E-5	U30	E-3
CR44	E-5	R169	E-2	U31	D-2
CR45	E-5	R170	E-2	U32	D-3
CR46	E-4	R171	E-2	U33	D-4
		R172	E-4	U34	E-2
K7	C-5	R173	E-4	U35	E-5
		R174	E-3		
L5	D-4	R175	E-3	XA1	F-4
		R176	D-2		
Q33	E-4	R177	D-2		
Q34	E-4	R178	D-2		

SEE INSIDE

Figure 8-9
A2 Multiplier Board Ass'y
(Loss Side Multiplier and Unbalance Detector)

A2 MULTIPLIER BOARD OPERATION

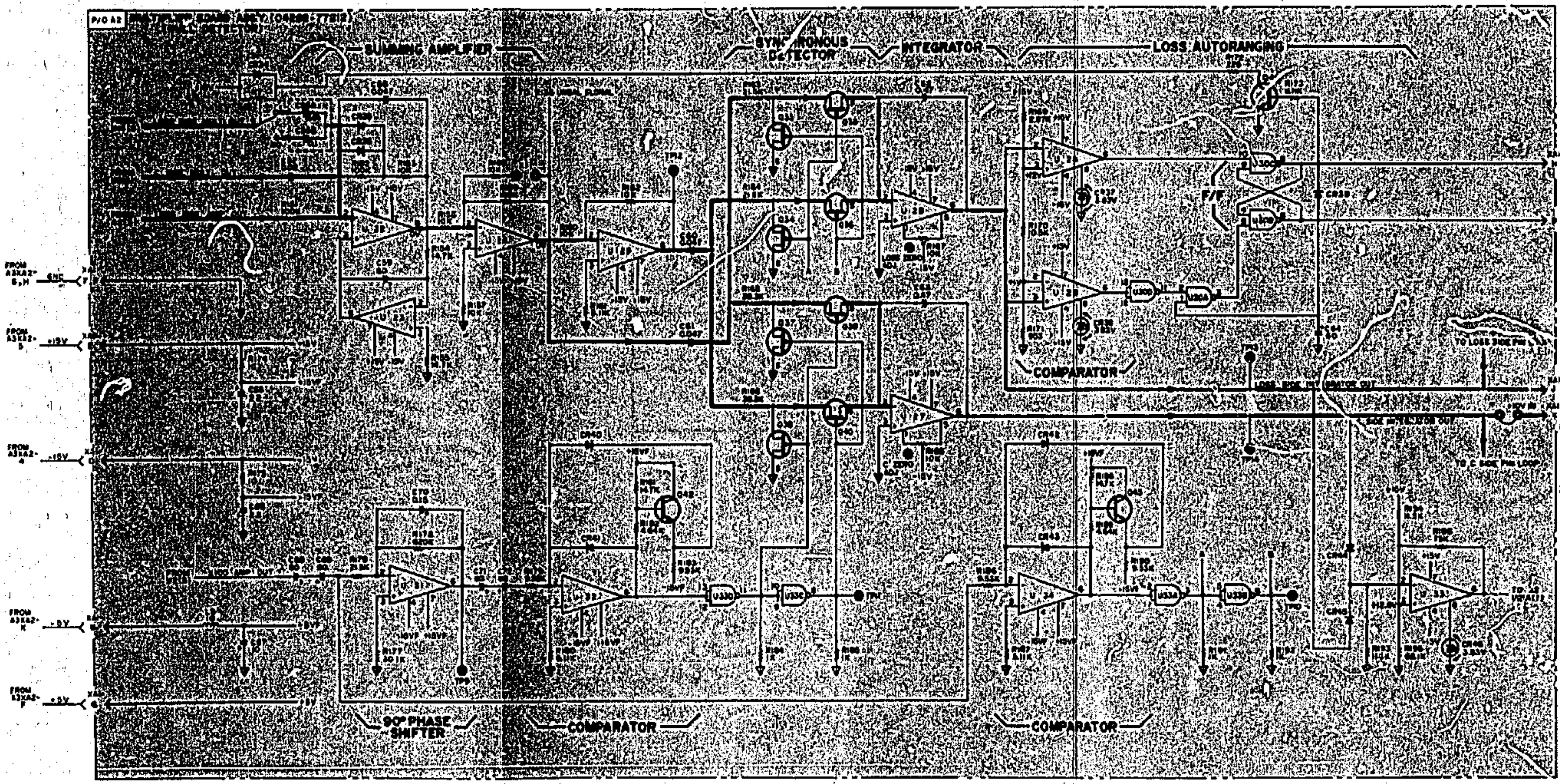
Null Detector Section.

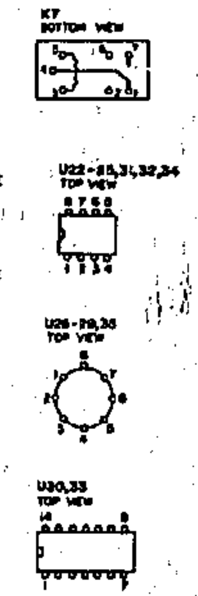
This section contains Summing Amplifier U22 to U24, Synchronous Detectors Q33 to Q40 and Integrators U26 and U27. Also included are Loss Auto Ranging Circuit U28 to U30 and Synchronous Detector Driver U31 to U34.

The three outputs, C Side Multiplier, Loss Side Multiplier and Loss Side Amplifier, are fed to Standard Capacitors C57 and C55 and Standard Resistor R151, respectively. They are summed at summing node of U22(2). U22 detects the summed difference as error and feeds it to U24. CR35 and CR36 work to reduce gain of U22 to prevent saturation during balancing process. U23 is employed to verify zero of dc level at U22(6). U24, which has a gain of 10, amplifies error signal and feeds it to Sync Detectors. One input is fed directly and the other is fed through Inverter U25. The two Sync Detector (FET Switches) are driven by pulses having a 90° phase difference with each other. Therefore, the two Detectors detect in phase and 90° phase different components and feed them to Integrators U26 (Loss Side) and U27 (C Side), respectively. U26 and U27 integrate error signals detected and provide outputs as E_L and E_C.

Loss Auto ranging Circuit selects proper Loss Range from two available ranges. This information is received from Comparators U28 and U29. U28(6) is L when U28(2) is above about +12V. Since U29(6) is H, F/F U30B/C is H at U30(8) and L at U30(6). This means up-ranging is required so Q41 is turned on to energize K7 to connect Standard Capacitor C55B. This operates to reduce U26 output E_L to one-tenth. Additionally, CR39 is turned off and U28A(1) is maintained L which prevents frequent range changing until charge of C64 reaches H. On the other hand, when E_L is below about +1V, U29(3) goes to L. This makes U30B(5) L. Since U30C(10) is H, F/F changes state as U30C(8) is L and U30B(6) is H. This means down-ranging is required so Q41 is turned off to connect C55A. Synchronous Detector Driver circuitry includes 90° Phase Shifter U31 and two comparators U32 and U34. U31 provides a sine wave 90° out of phase with input. U32 produces a square wave output in phase with U31 output. U33D/C is driven in negative domain to match operation of FET Switches. U34 also produces square wave in phase with input. U33A/B are similar to U33C/D.

A2 Parts Locations under Fold





Reference Designations

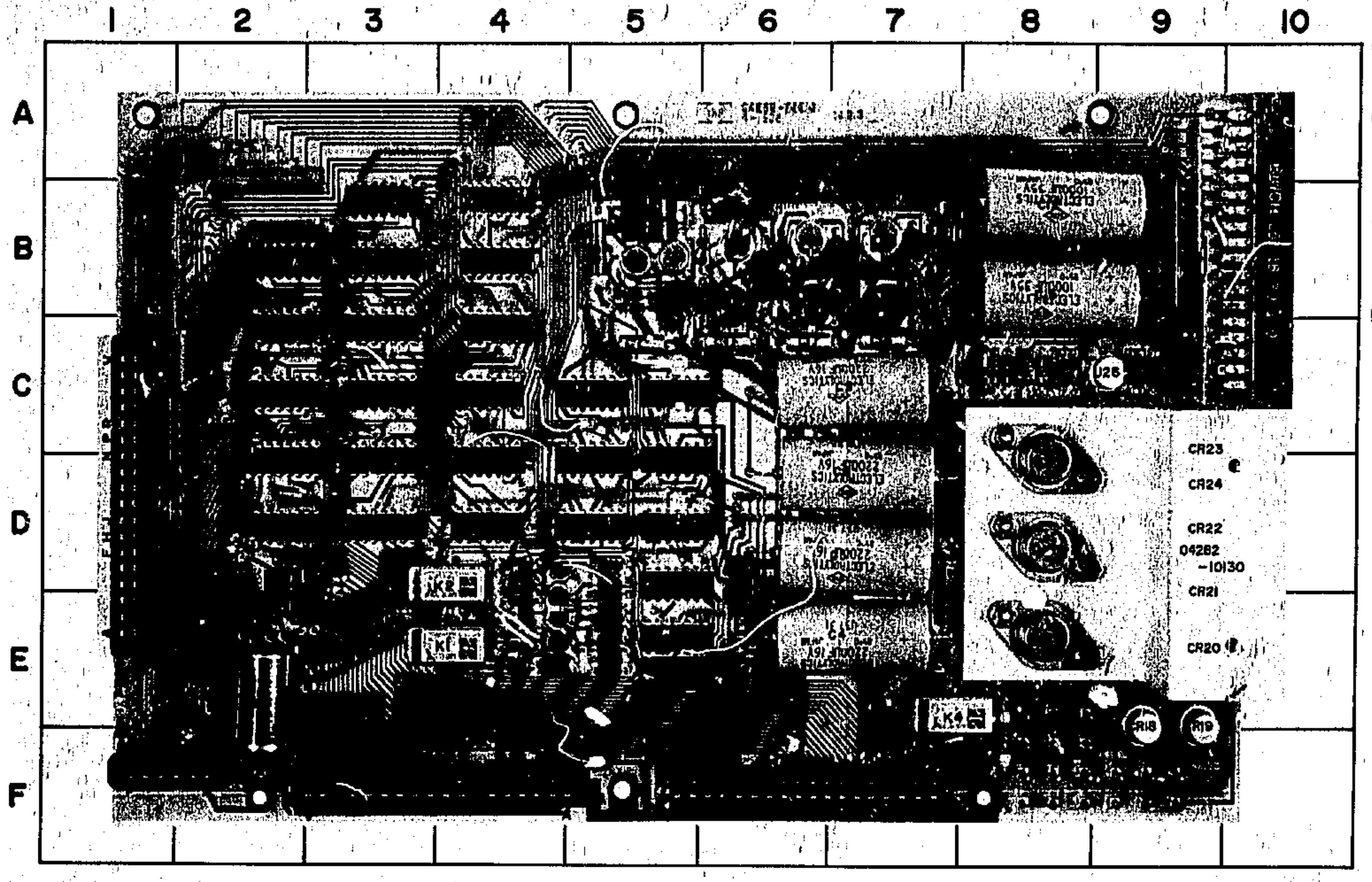
A2
C55, 57 - 72 CR34 - 46 K7 L5 Q33 - 43 R151 - 190 U22 - 35 XA1

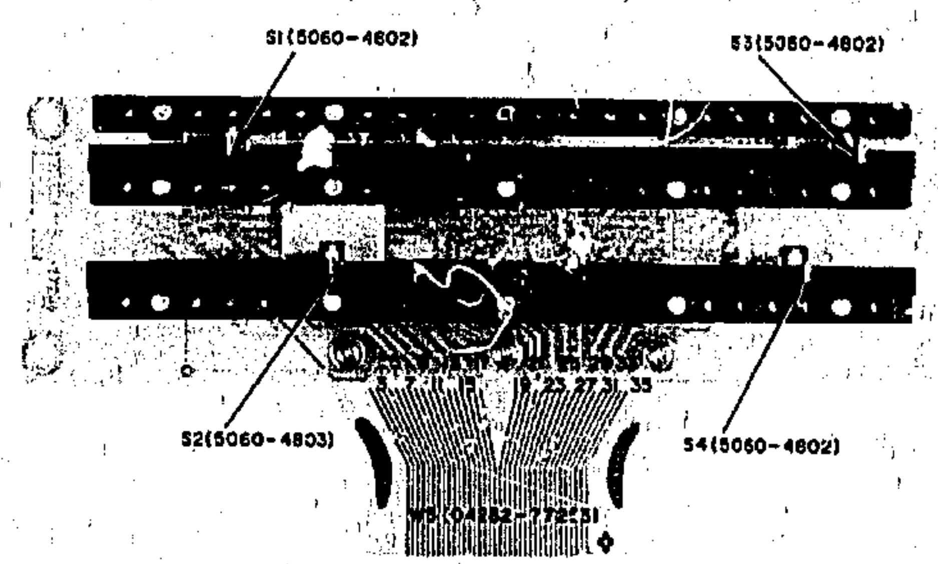
C56, not assigned.

Table of Active Components.

Reference Designation	HP Part Number
A2	
CR34 - 36, 40 - 45	1901-0040
CR37, 38, 46	1902-3001
CR39	1910-0016
Q33 - 40	1855-0133
Q41 - 43	1854-0071
U22 - 25, 31, 32, 34	1820-0224
U26, 27	5080-3031
U28, 29, 35	1820-0223
U30, 33	1820-0054

Figure 8-10. A2 Multiplier Board Ass'y. (Null Detector)





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C20	D-5	R1	E-4	U1	E-5
		R2	E-4	U2	D-5
CR1	E-4	R3	D-4	U3	C-5
CR2	E-3	R4	E-4	U4	D-4
CR3	E-2	R5	D-2	U5	D-5
CR4	D-4	R6	D-2	U6	D-4
CR5	D-5	R7	D-2	U7	C-5
CR6	E-5	R8	E-3	U8	D-5
CR7	D-5	R9	D-4	U9	D-5
CR8	E-5	R10	D-4	U10	D-5
CR9	E-4	R11	D-5	U11	C-2
CR26	D-5	R12	D-5	U12	D-2
		R13	E-5	U13	D-3
K1	E-4	R14	E-5		
K2	D-4	R15	E-5	XA1	F-6
K3	E-2	R16	E-6	XA2	F-3
		R17	E-5	XA3	F-1
Q1	E-4	R18	E-4	XA4	D-1
Q2	E-4	R19	C-9	XA5	B-10
Q3	D-4	R20	B-9		
Q4	D-4	R21	B-2		
Q5	E-4	R52	E-5		
Q6	E-4	R53	D-6		

SEE INSIDE

Figure 8-10
A2 Multiplier Board Ass'y
(Null Detector)

A3 CONTROL BOARD OPERATION

Function Control Section.

This section contains the various logic circuits. For explanatory purposes (in text and in diagrams), H or L after function letter abbreviation shows TTL logic level when that function is enabled, e.g., C H shows that C signal line is at TTL high level when Function C is selected.

Function Remote Gate is enabled to allow Function to be remotely programmed when FUNCTION switch is set to REM. Function Gate provides H (high level) when either one input goes L (low level). When C Function is selected, U5B(4) or U5B(5) go to L and U5B(6) is H. This makes U9C (8) L and C Enable Switch Q6 turns on. Q6 on means that C Side Integrator A2U27 output E_C is connected to DVM input in A4. U5B(6) H also makes U8A(1) L to enable transfer of C Range information.

Similarly, when D or ΩF Function is selected, Q4 is turned on to Loss Side Integrator A2U26 whose output E_L is connected to DVM input. Then U9A(12) becomes L to enable transfer of Loss (D or ΩF) range and units information.

When Functions C-D or C-ΩF are selected, U6B(4) goes to L to enable U10A/D. On the other hand, each negative transition of Busy H signal which comes from A4U13 causes a positive transition is Schmitt U1(6). This positive transition, which occurs at the same time as data transfer pulse, alternately changes F/F U2 state. Assuming U10D(13) is H (U2(9) = L) is equivalent to assuming an independent selection of Function C. The difference is that U10D(13)H makes U9A(12) L. This is required to enable transmission of information of range and unit of Loss (D or ΩF) because the display is Loss while DVM is measuring E_C (capacitance value) and vice versa.

When Function is V, U6A(3) H turns relay driver Q2 on which turns K2 on to connect voltage (V) to DVM input and makes U10B(4) L which completes voltage measurement circuit and also U6D(11) L which enables V Range Gate. Input voltage is attenuated by Voltage Divider R5 to R7 determined by DC BIAS RANGE switch A6S4 setting.

When Function is I_L, U6B(6) H turns relay driver Q1 on which turns K1 on to connect I_L Detector output (E_{IL}) to DVM input and makes U10B(4) L which completed I_L measurement circuit and also U6C(8) L which enables transfer of I_L Range and unit information.

A3 & A6 Parts Locations under Fold

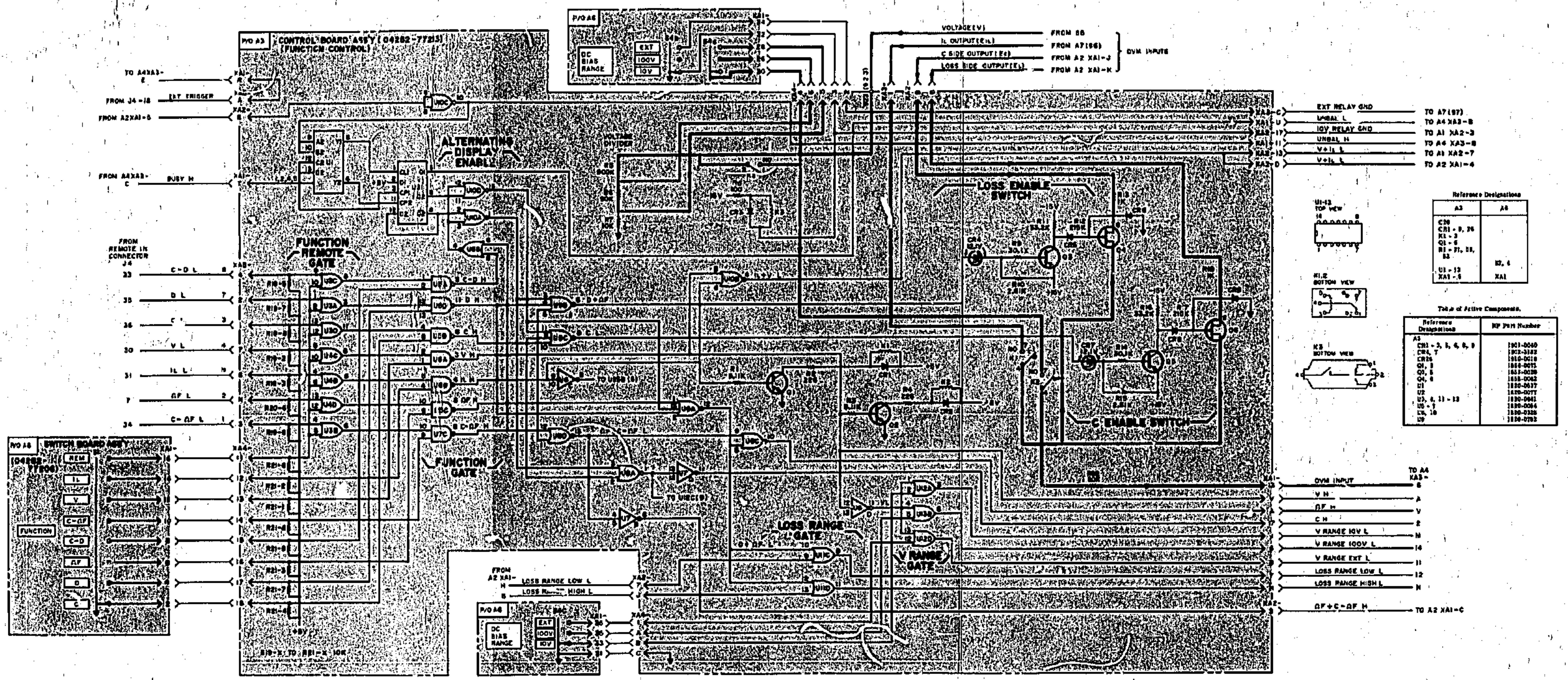
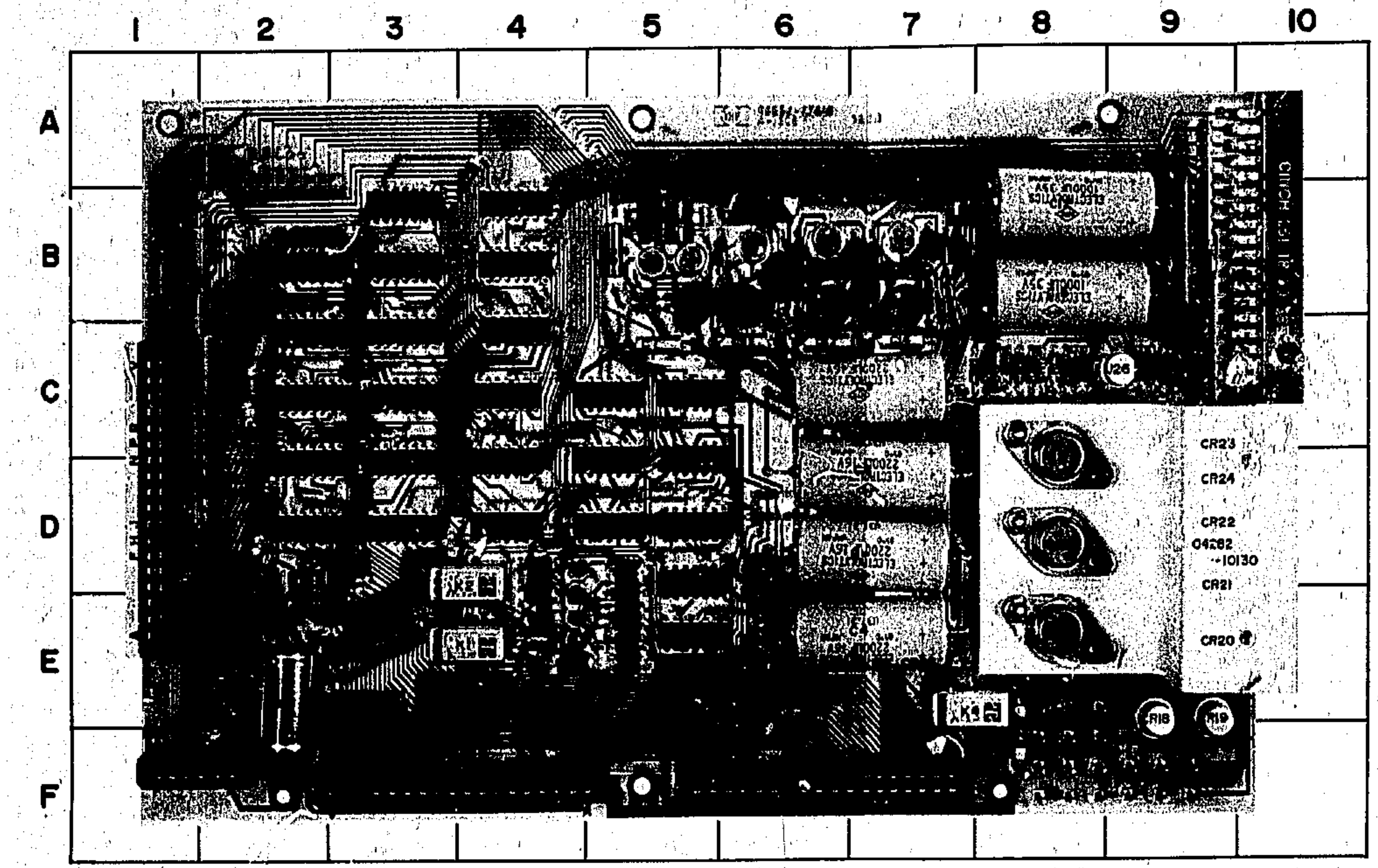
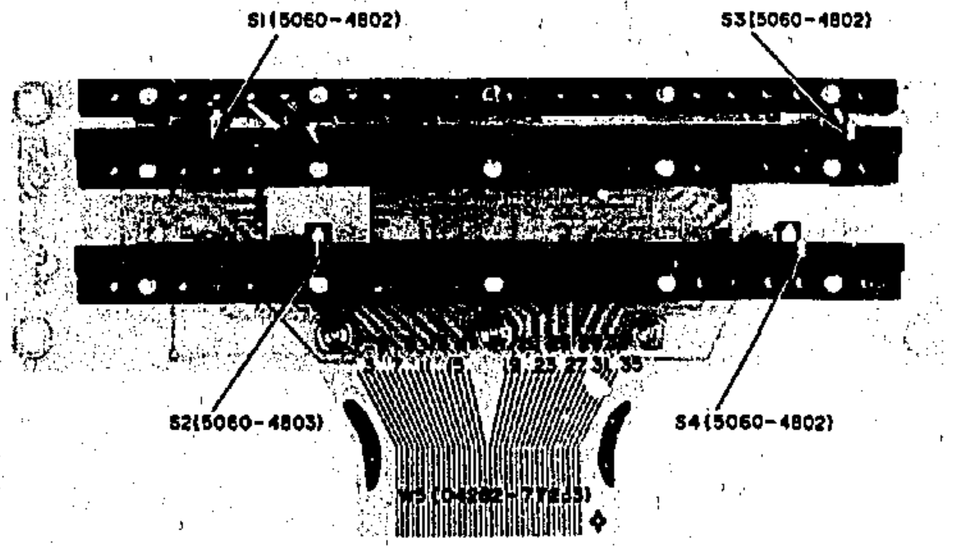


Figure 8-11. A3 Control Board Ass'y. (Function Control)
A6 Switch Board Ass'y.





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
R19	C-9	U12	D-2	U20	B-2
R20	B-9	U13	D-3	U21	B-3
R22	B-9	U14	B-4		
R23	C-1	U15	B-4	XA1	F-6
R24	B-1	U16	C-4	XA2	F-3
		U17	C-4	XA4	D-1
U4	D-4	U18	D-3	XA5	B-10
U11	C-2	U19	B-3		

SEE INSIDE

Figure 8-11
A3 Control Board Ass'y
(Function Control)
A6 Switch Board Ass'y

A3 CONTROL BOARD OPERATION

C Range Control Section.

This section contains C Range Remote Gate, C Range Gate, C Range Display Gate and Open Collector Relay Driver. The Remote Gate is enabled to allow C Range remote program when C RANGE switch is set to REM. C Range Gate is at L (low level) when either input goes L. This drives Open Collector Relay Driver to select a C range. Display Gate is enabled to display appropriate unit and decimal point when Function C is selected.

A3 & A6 Parts Locations under Fold

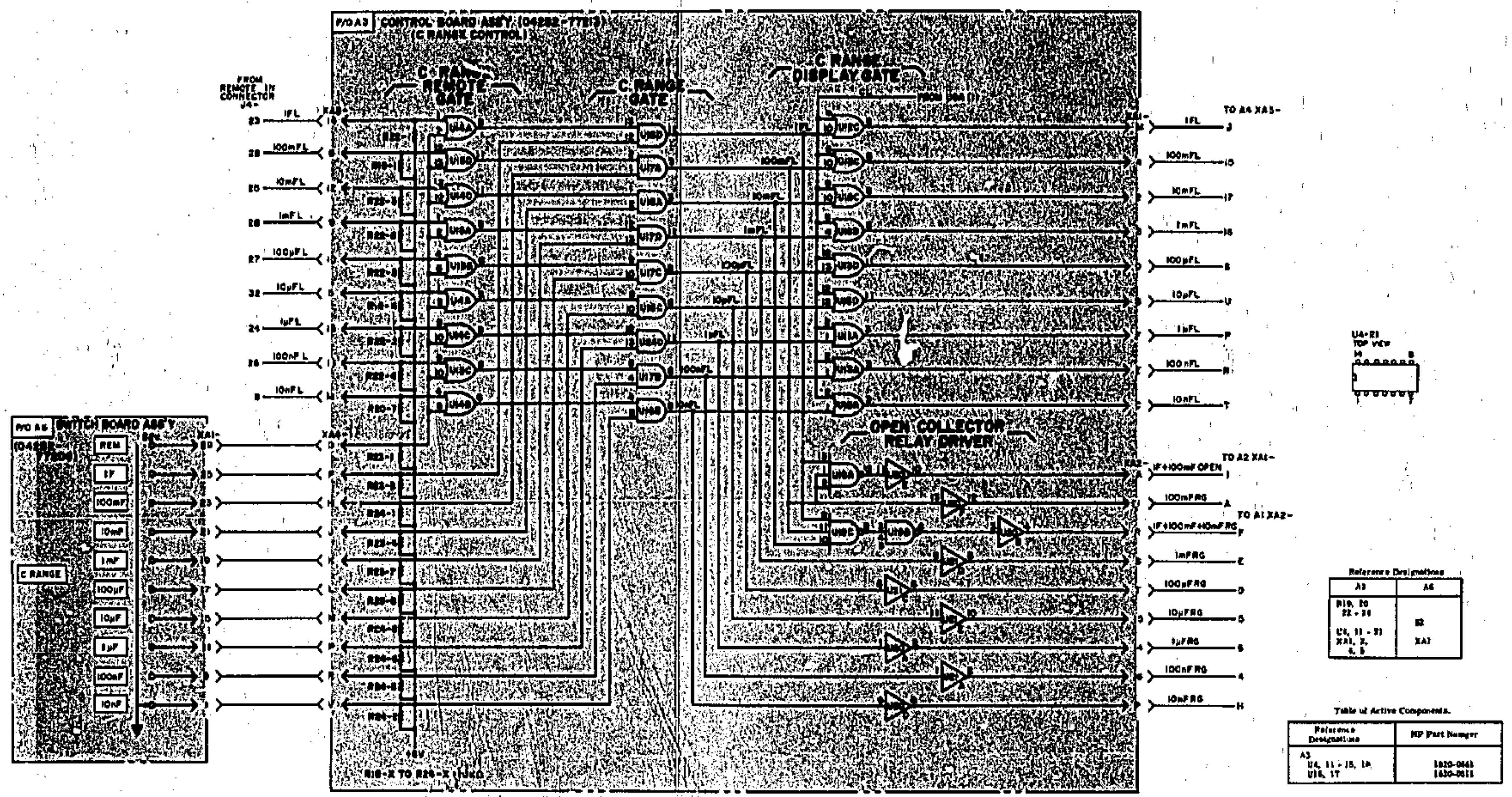
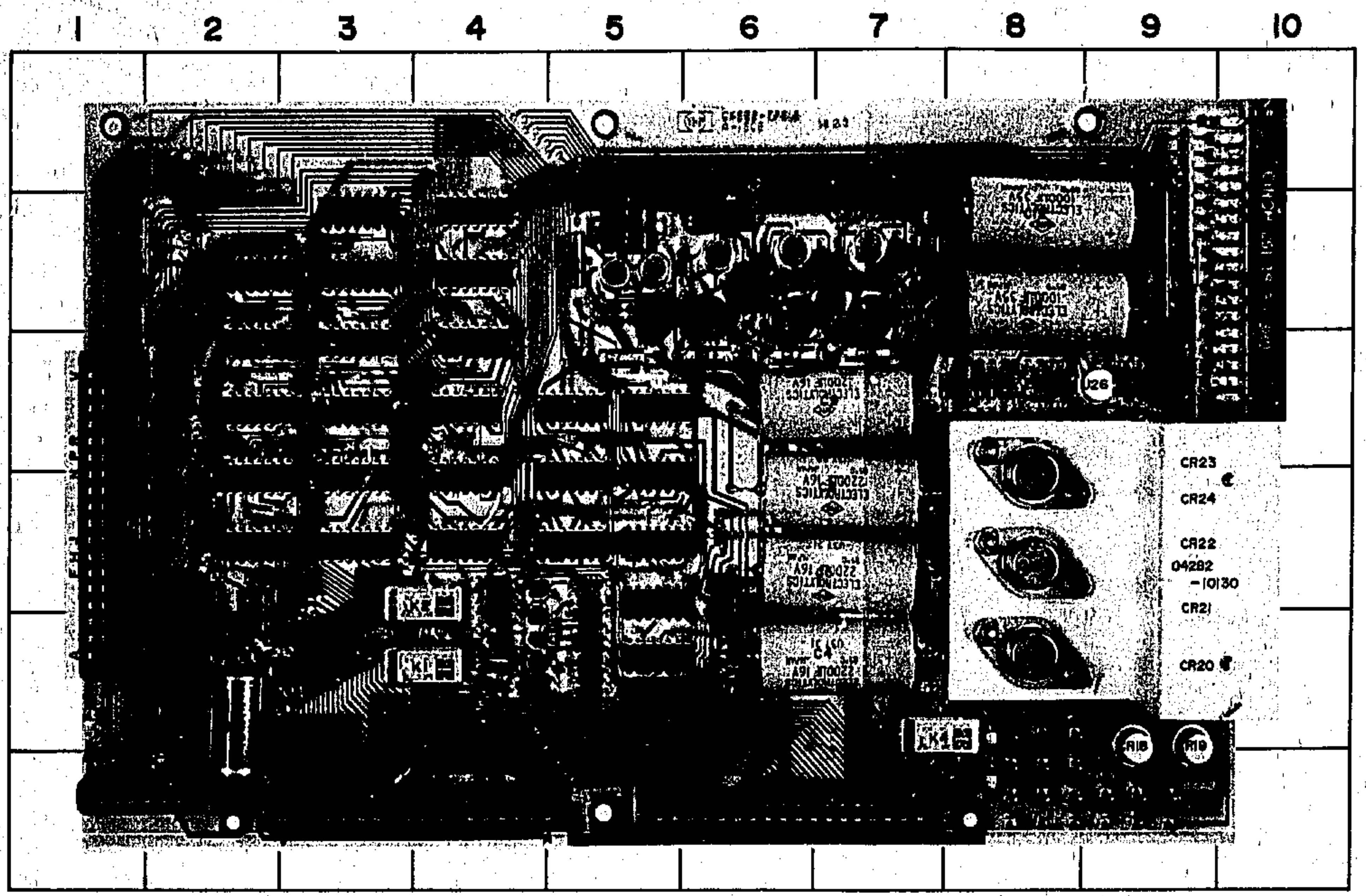
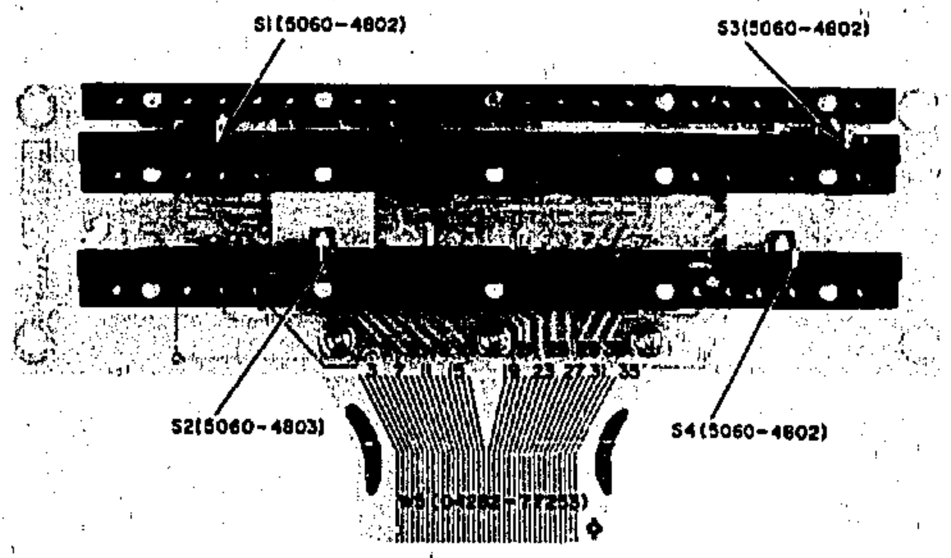


Figure 8-12. A3 Control Board Ass'y. (C Range Control)
A6 Switch Board Ass'y.





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Lod.	Ref. Desig.	Grid. Loc.
C1	B-7	R20	B-9	U11	C-2
C2	B-7	R23	C-1	U12	D-2
C3	C-8	R24	B-1	U22	C-3
		R25	E-2	U23	C-2
		R26	B-7	U24	C-3
CR10	C-8	R27	B-7	U25	D-2
CR11	C-8	R28	C-8	U26	C-9
CR12	C-8	R29	C-8		
CR13	C-8	R30	C-8	XA1	F-6
CR14	C-8	R31	C-8	XA2	F-3
CR15	C-8	R32	C-8	XA3	F-1
CR16	C-9			XA4	D-1
CR17	C-9			XA5	B-10

SEE INSIDE

Figure 8-12
A3 Control Board Ass'y
(C Range Control)
A6 Switch Board Ass'y

A3 CONTROL BOARD OPERATION

I_L Range Control Section.

This section contains I_L Range Remote Gate, I_L Range Gate and I_L Range Display Gate. Remote Gate is enabled to allow I_L Range remote programming when I_L RANGE switch set to REM. I_L Range Gate is at L (low level) when either input goes L. This is used for I_L Range selection in A7. Display Gate is enabled to display appropriate unit and decimal point when Function I_L is selected.

Check Fuse Sensor.

This circuit annunciates when measuring circuit fuse F2 is blown. When F2 blows, measuring signal is applied across R24. This signal is rectified by CR10, CR11 and fed to Comparator U26. U26 provides positive output and CR17 limits it to TTL high level.

A3 & A6 Parts Locations under Fold

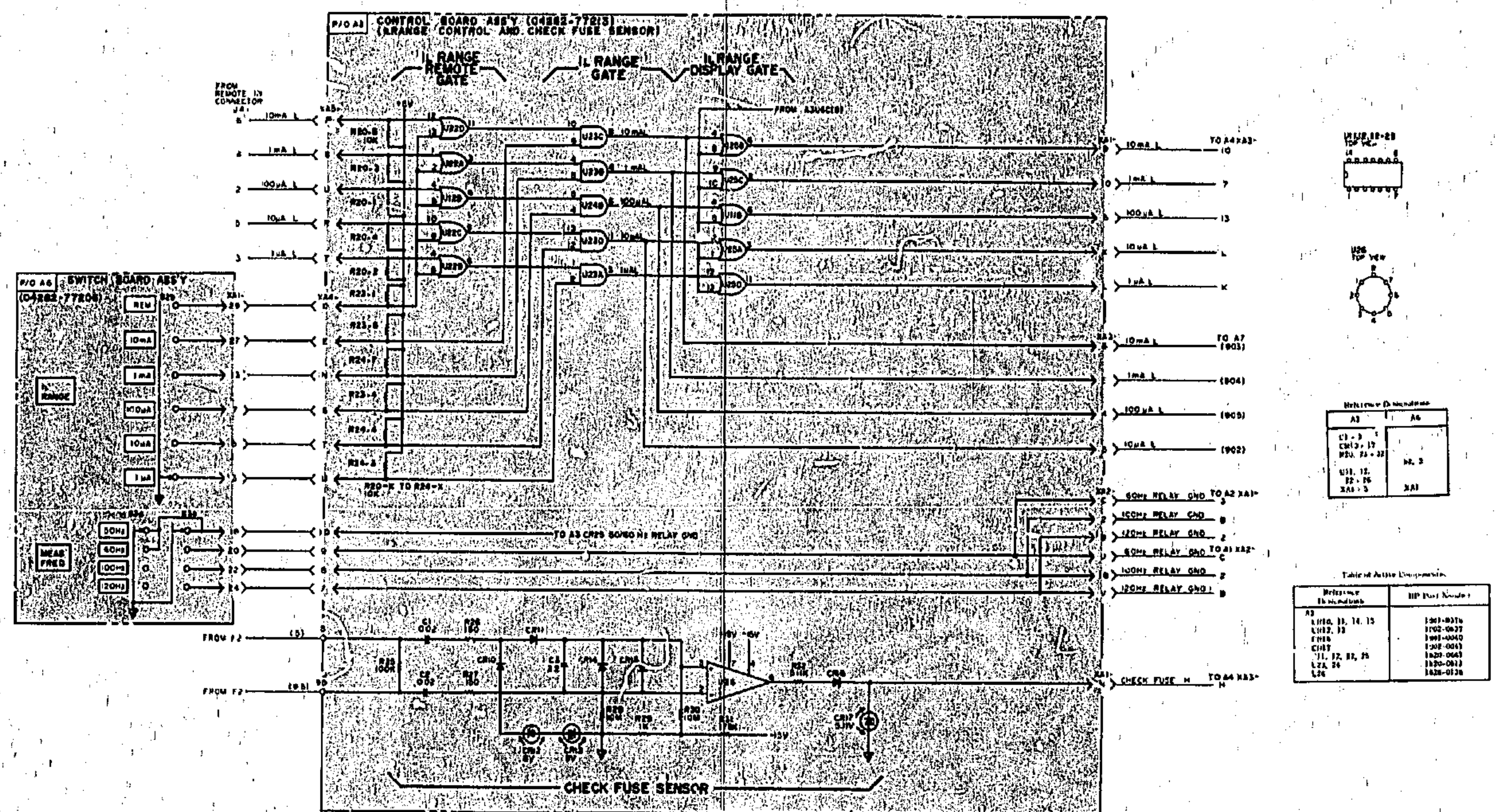
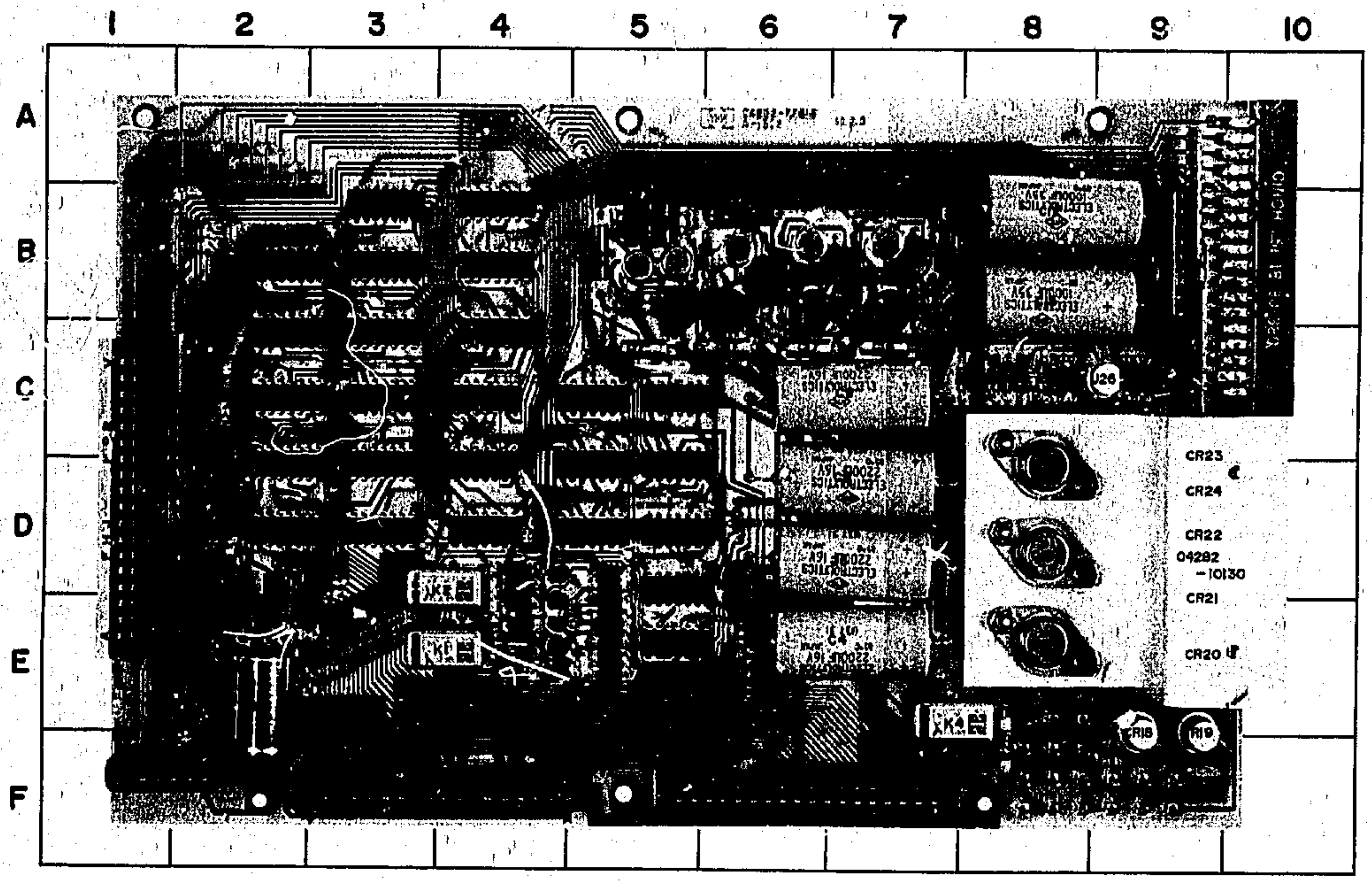


Figure 8-13. A3 Control Board Ass'y.
(I_L Range Control and Check Fuse Sensor)

A6 Switch Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C4	E-7	CR22	D-10	R42	B-7
C5	D-7	CR23	C-10	R43	B-7
C6	B-5	CR24	D-10	R44	B-7
C7	C-5	CR25	E-7	R45	B-7
C8	D-7			R46	B-6
C9	C-7	K4	E-[illegible]	R47	B-7
C10	B-6			R48	B-6
C11	C-6	Q7	B-5	R49	B-7
C12	B-8	Q8	E-8	R50	E-8
C13	B-7	Q9	C-8	R51	E-7
C14	C-7	Q10	D-8		
C15	B-8			U27	B-5
C16	B-6	R33	B-5	U28	B-6
C17	C-6	R34	B-5	U29	B-7
C18	F-8	R35	B-5	U30	B-6
C19	F-8	R36	B-5		
		R37	B-5	XA1	F-6
CR18	E-9	R38	B-6	XA2	F-3
CR19	E-9	R39	B-6	XA3	F-1
CR20	E-9	R40	B-6	XA4	D-1
CR21	D-9	R41	B-6	XA5	B-10

Figure 8-13
A3 Control Board Ass'y
(I_L Range Control and Check Fuse Sensor)
A6 Switch Board Ass'y

SEE INSIDE

A3 CONTROL BOARD OPERATION

Power Supply Section.

This section contains four regulated dc sources, +5V, -5V, +15V and -15V and one non-regulated dc source, +26V. Also included is an ac 120V source sent to Leakage Current Board A7 (Option 001). The +15V regulator output is used in +5V regulator and the +5V output is used in -5V regulator. A3 also furnishes the Line Synchronous signal which is taken from Relay K4. The four dc regulators are very similar. Only +5V Regulator is described. Rectifier CR18 to CR21 is bridge type rectifier. Series Regulator Q1 is placed on main chassis to enhance radiation of heat. Voltage Controller U27 has a reference and current limiter in itself. Its equivalent circuit is shown as an inset on the schematic (Figure 8-14). Control signals appear at U27(6) and are fed to Q1 through Q7. Current limiting signal is taken from R36 and R37.

A3 Parts Locator under Fold

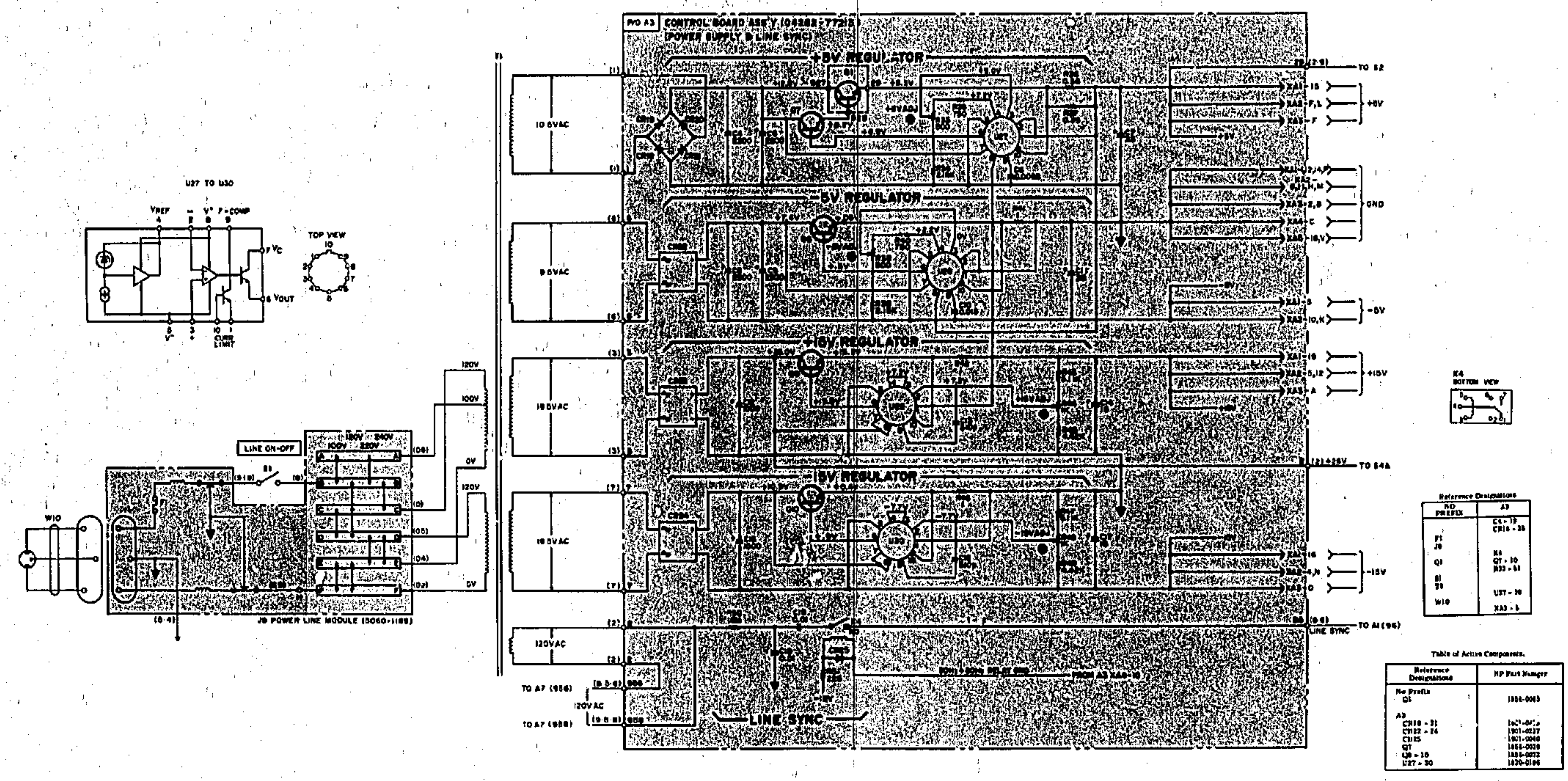
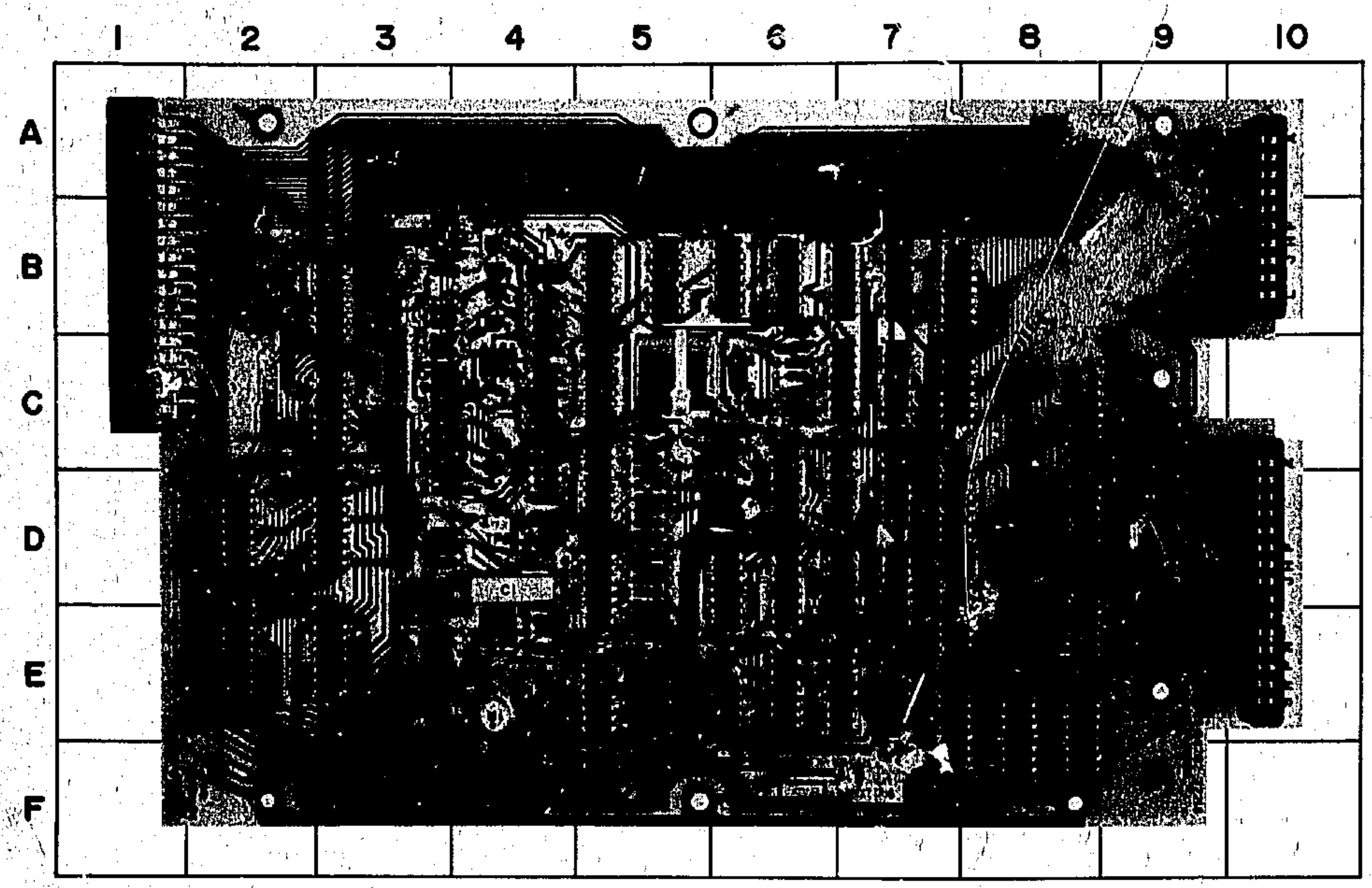


Figure 8-14. A3 Control Board Ass'y.
(Power Supply & Line Sync)
J9 Power Line Module.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	D-4	R1	E-4	R34	C-6
C2	D-4	R2	E-4	R35	C-6
C3	E-5	R3	E-4	R36	C-6
C4	E-5	R4	E-3	R37	C-6
C5	C-6	R5	E-4	R38	D-4
C6	C-6	R6	E-4	R39	E-4
C7	B-4	R7	D-4	R40	D-4
C8	D-4	R8	D-4	R41	D-3
C9	D-4	R9	D-5	R42	E-4
C10	C-4	R10	D-5	R43	D-4
C11	C-4	R11	D-5	R44	C-4
		R12	E-5	R45	C-4
CR1	E-4	R13	E-5	R46	C-4
CR2	E-4	R14	D-5	R47	C-4
CR3	E-4	R15	E-5	R48	C-4
CR4	E-4	R16	D-5	R49	C-4
CR5	D-4	R17	E-5	R50	C-4
CR6	B-4	R18	E-5	R51	C-4
CR7	B-4	R19	E-4	R52	D-4
CR8	C-4	R20	E-4	R53	D-4
CR9	C-4	R21	C-4		
CR10	D-4	R22	C-4	U1	E-4
CR11	E-4	R23	B-4	U2	E-4
		R24	C-4	U3	C-4
Q1	D-5	R25	D-4	U4	C-5
Q2	E-5	R26	C-4	U5	B-5
Q3	B-4	R27	C-4	U6	B-5
Q4	B-4	R28	C-4	U7	B-6
Q5	B-4	R29	C-4	U8	B-6
Q6	B-4	R31	C-4	U9	B-7
Q7	C-4	R32	B-4	U10	C-7
Q8	C-4	R33	B-4		
Q9	D-4			XA3	F-3
				Y1	C-5

SEE INSIDE

Figure 8-14
A3 Control Board Ass'y
(Power Supply & Line Sync)
J9 Power Line Module

A4 DVM BOARD OPERATION

Pulse Width Modulation (PWM) Section.

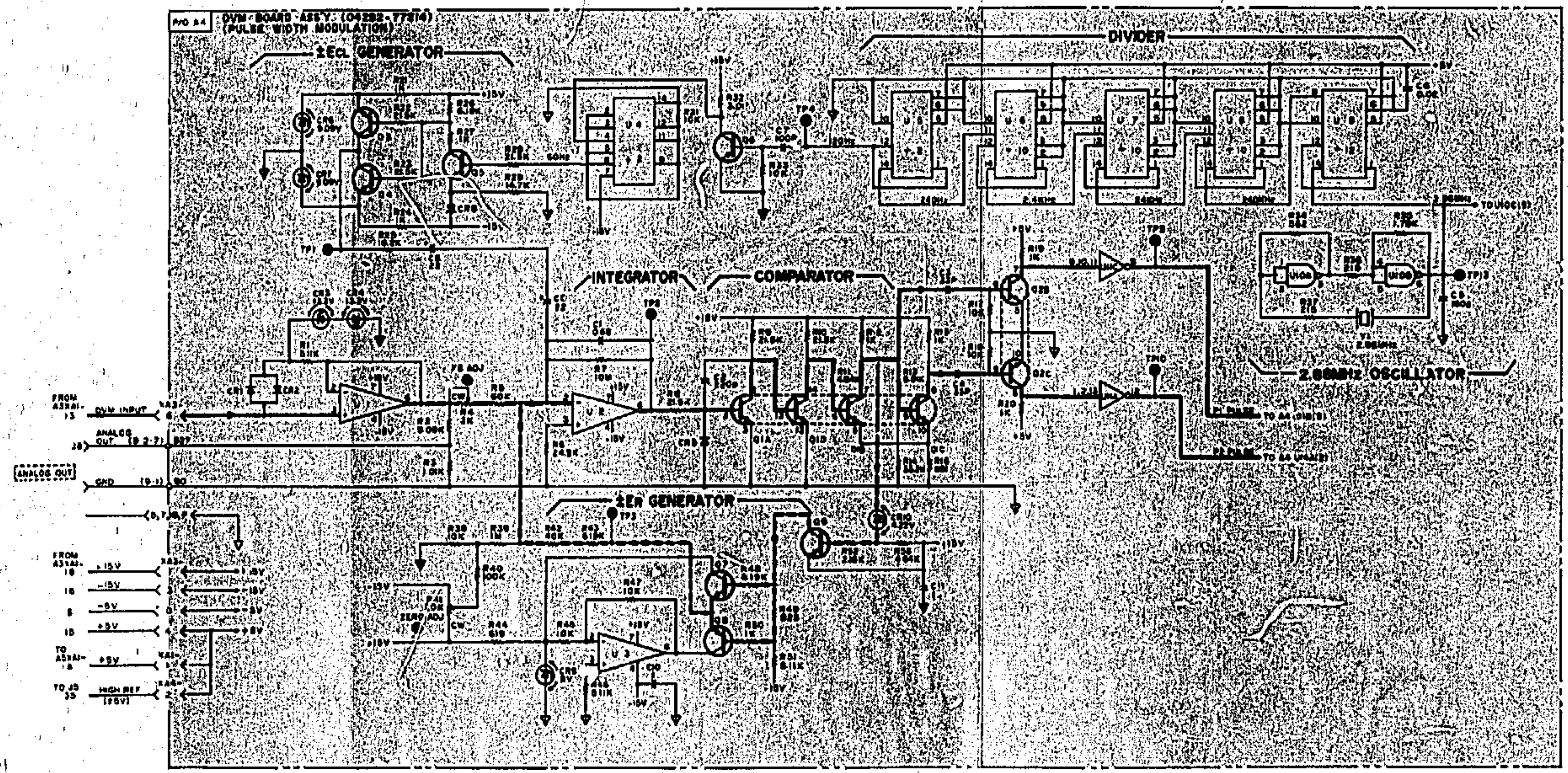
This section is employed to convert input voltage to time interval, which is accomplished by an $\pm E_{CL}$ Generator, an E_R Generator, an Integrator and a Comparator.

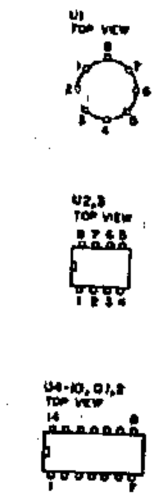
The $\pm E_{CL}$ Generator Q3 to Q5 and CR6/7 provide a 60Hz clock signal to determine the period of integration. The clock signal is obtained by dividing a 2.88MHz Crystal Oscillator output by 48,000 through Dividers U4 to U9. Q6 converts TTL level to negative level to fit Q5 drive requirements. Q3 and Q4 are switched alternately by Q5 and provide a symmetrical square wave whose frequency is 60Hz and whose amplitude is ±9.09V referred to CR6/7. The $\pm E_R$ Generator, whose duty cycle is determined by input voltage and whose frequency is 60Hz, provides ±9V referred to CR9 by alternately switching Q7 and Q8. Integrator U2 receives two inputs $\pm E_{CL}$ and $\pm E_R$ plus another input which is either E_C, E_L, V or E_{IL} (unknowns).

When E_{CL} and E_R are positive, the most rapid negative going ramp is produced at U2(6). When this ramp reaches zero, Comparator Q1A is turned off and a positive pulse (called P1) occurs at U11C(8). This also turns Q9 off to connect minus reference ($-E_R$) to U2(2) through Q8. Since the sum of three inputs is still positive, U2(6) continues to produce a slowed down negative going ramp until 60Hz clock changes to $-E_{CL}$. Then U(6) changes to the most rapid positive going ramp and, when crossing zero point, turns Q1A on. At this point a positive pulse (called P2) is produced at U11A(12). Q9 is also turned on to connect positive reference ($+E_R$) through Q7 to U2(2). The slowed down negative going ramp continues until 60Hz clock changes to $+E_{CL}$. This completes one cycle which has created P1 and P2 Pulses whose interval represents unknown input voltage.

Analog output is Impedance Converter U1 output divided by 10 and produces 1V output for a 10V input.

A4 Parts Locations under Fold





Reference Designations

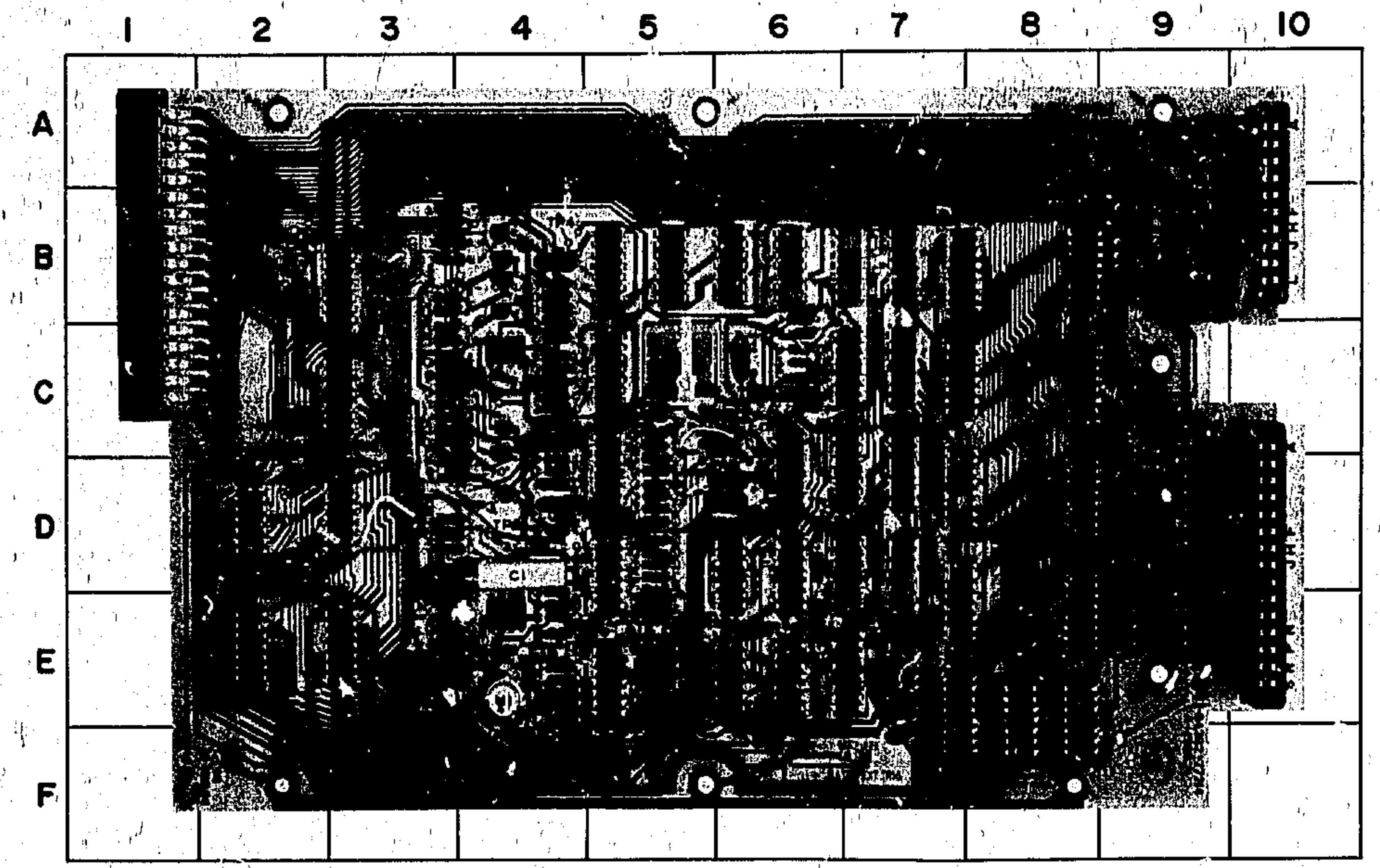
A4
C1 - 11
CR1 - 10
Q1 - 9
R1 - 53
U1 - 10
XA3
Y1

R30, not assigned.

Table of Active Components.

Reference Designations	HP Part Number
A4	
CR1, 2	1901-0376
CR3, 4	1902-3193
CR5, 6	1901-0040
CR4, 7, 8	1902-3150
CR10	1902-3070
Q1, 2	1858-0033
Q3, 5, 9	1853-0036
Q4, 6, 7	1854-0215
Q8	1853-0020
U1	5060-3621
U2, 3	1820-0493
U4	1820-1104
U5, 9	1820-0054
U6 - 8	1820-0600
U10	1820-0081
Y1	0410-0707

Figure 8-15. A4 DVM Board Ass'y. (Pulse Width Modulation)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C12	C-6	R54	D-6	R74	B-9
C13	C-6	R55	C-6	R75	B-9
C14	C-6	R56	E-4	R104	F-6
C15	E-5	R57	E-4	R105	B-9
C16	E-4	R58	E-4	U10	C-7
C17	D-6	R59	E-4	U11	E-6
C18	D-6	R60	D-5	U12	D-6
C19	D-6	R61	C-5	U13	D-6
C20	E-7	R62	C-5	U14	E-7
C21	E-6	R63	D-5	U15	E-6
C22	D-7	R64	D-5	U16	D-6
		R65	C-5	U17	D-7
CR11	F-4	R66	D-5	U18	D-7
		R67	D-5	U19	E-8
Q2	E-5	R68	D-5	U20	E-8
Q12	D-5	R69	C-6	U21	B-3
Q13	A-9	R70	E-7		
Q14	B-9	R71	E-6	XA1	B-10
Q15	B-9	R72	B-4	XA2	D-
Q16	B-9	R73	E-9	XA3	F-
Q17	B-9			XA4	B-

SEE INSIDE

Figure 8-1?
A4 DVM Board Ass'y
(Pulse Width Modulation)

A4 DVM BOARD OPERATION

Control Logic Section.

This section includes Rate Generator, Timing Pulse Generator and various Gates. Rate Generator Q2A/D is astable MV whose period is variable from 0.3 to 2.0 seconds with RATE control.

The positive transition at U12(8) driven internally or externally causes positive transition at U13(6) or negative transition at U13(1) which holds H (high level) or L (low level) for about 80ms, respectively. They are Busy H or L and indicate busy period for one reading. Timing Pulse Generator Q12 provides negative Set Pulse at the beginning of busy period and positive Transfer Pulse and negative Print Command at the end of busy period.

When Set Pulse is issued, Dual F/F U15(13) and U17(13) are set to H and Counter U27 to U31 are set to zero. P1 Pulse Gate U11B enabled by U11B(3, 4) H allows acceptance of P1 Pulse. P2 Pulse Gate U14A is closed by U17 (12) L. P1 Pulse makes U15(9) H and opens Clock Gate U10C. At this point, the 2.88MHz Clock passes through U10C and goes into ÷2 Counter U18 whose output is applied to Counter U27. When Counters U27 to U31 count 8,000, U17(1) goes H and 12,000 counts of Counters returns U17(1) to L (Counter is reset to zero by itself). This negative transition makes U17(12) H and opens P2 Pulse Gate U14A. Then P2 Pulse appears at U14A(2) and makes U15(9) L to close U10C. Counters hold result which represents input voltage of PWM (Pulse Width Modulation) section. Negative transition of U15(9) also makes U15(13) L to close U11B. Above description is for positive input.

For negative input, since P2 Pulse occurs before the completion of half a period of 60Hz clock signal (before Counters count 12,000), P2 Pulse Gate U14A is closed but Gate U14D is opened. P2 Pulse passing through Gates U14D/C resets Counters.Counter again begin to count and is reset to zero by itself at 12,000 counts (after half period of 60Hz Clock from P2 Pulse). Under above conditions, next P1 Pulse is applied to U15(5). This makes U15(9) L and closes Clock Gate U10C and also P1 Pulse Gate U11B. Counters hold result which represents input voltage.

Bottom half of Dual F/F U17 provides polarity assignment. This is accomplished by checking which pulses (P1 or P2) are coincident with negative transition at U15(9) which is applied to U17(5). When P1 Pulse occurs, a negative transition at U17(5) transfers momentary H at U17(7) to U17(9) L. U17(9) L means positive input. Similarly, if a P2 Pulse occurs, it makes U17(9) H which means negative input.

U16 which forms F/F and Gates is Overload Detector. In an overload condition, P1 and P2 Pulses are not issued because of saturation of PWM section. Therefore, U15(13) remains H for one reading period after Set Pulse. When Busy L changes to H at the end of busy period, Gate U16(3) goes to L whose signal is Overload, F/F U16C/D stores this signal and U16D(11) provides Blanking L signal to blank display. This F/F is employed to keep display blanked until end of next busy period.

A4 Parts Locations under Fold

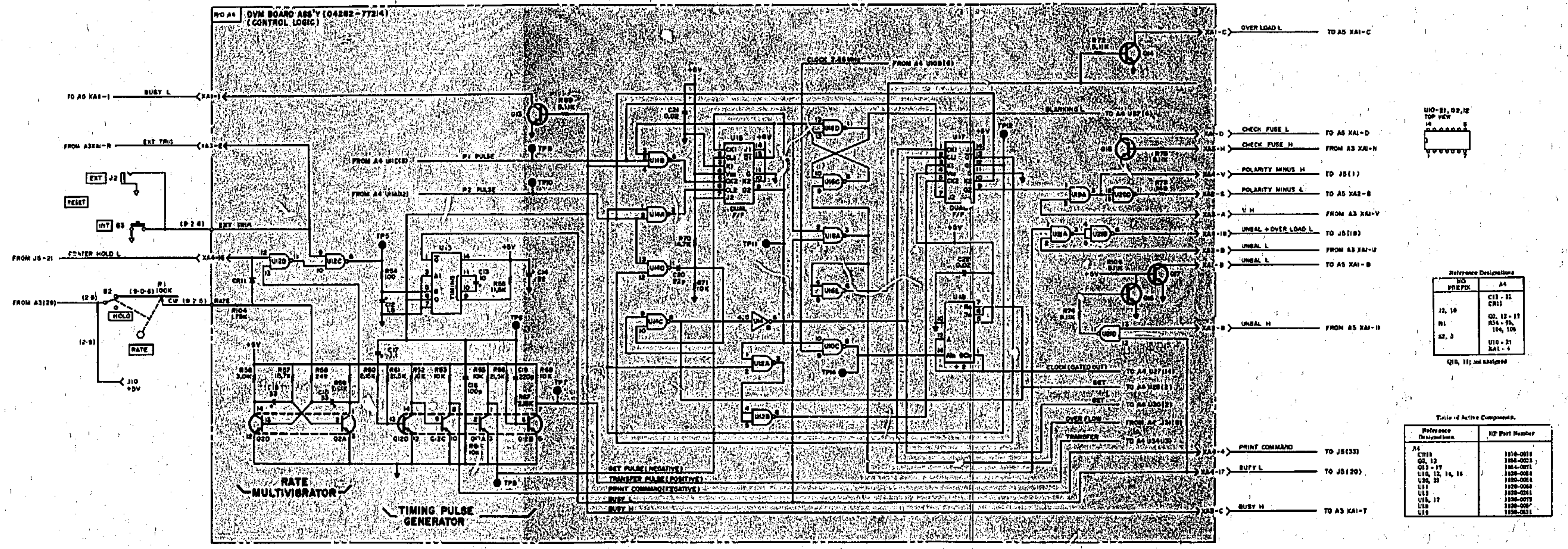
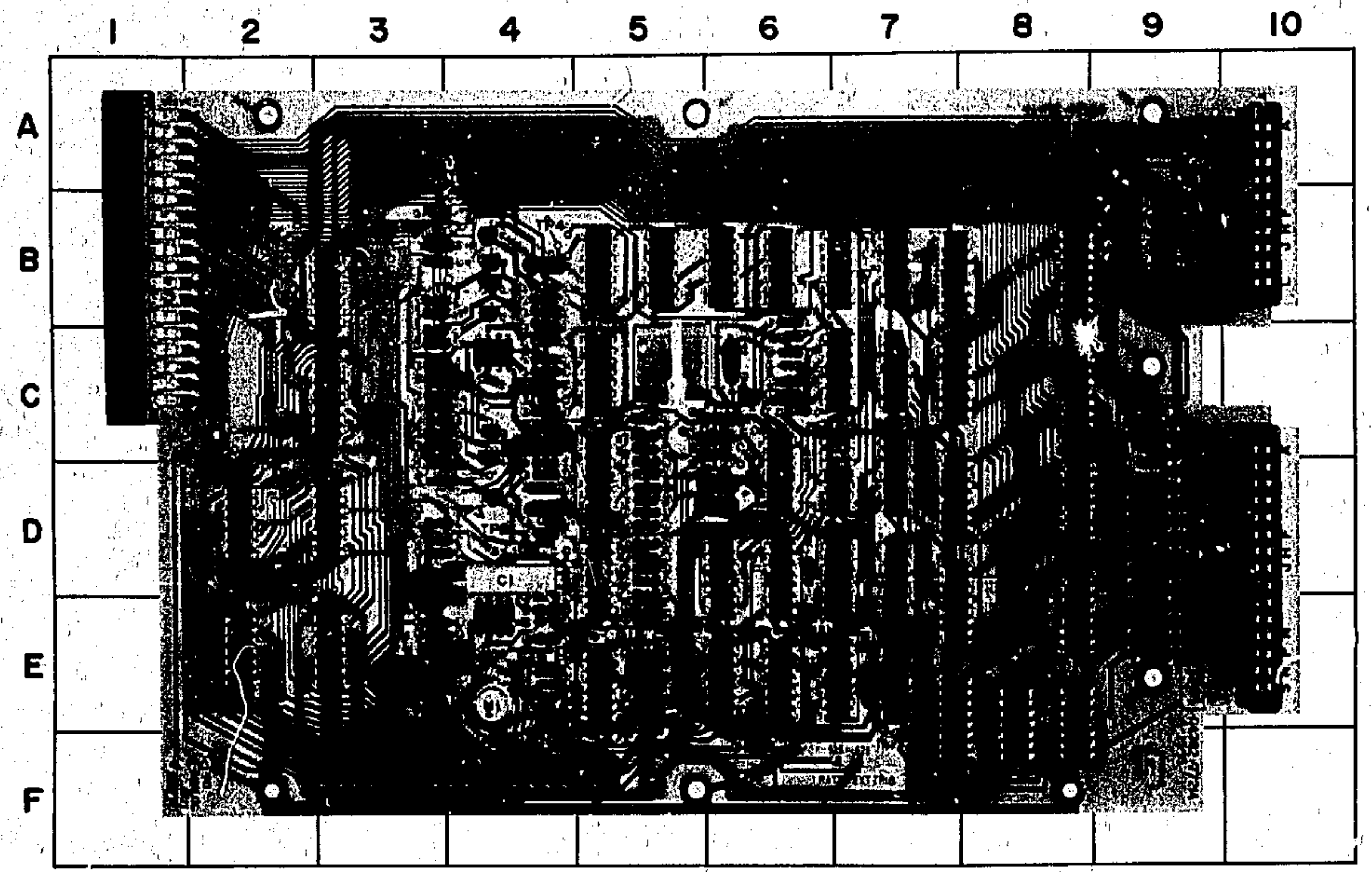


Figure 8-16. A4 DVM Board Ass'y. (Control Logic)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
U21	B-3	U24	C-3	XA1	B-10
U22	E-2	U25	D-2	XA3	F-3
U23	E-3	U26	D-3	XA4	B-1

SEE INSIDE

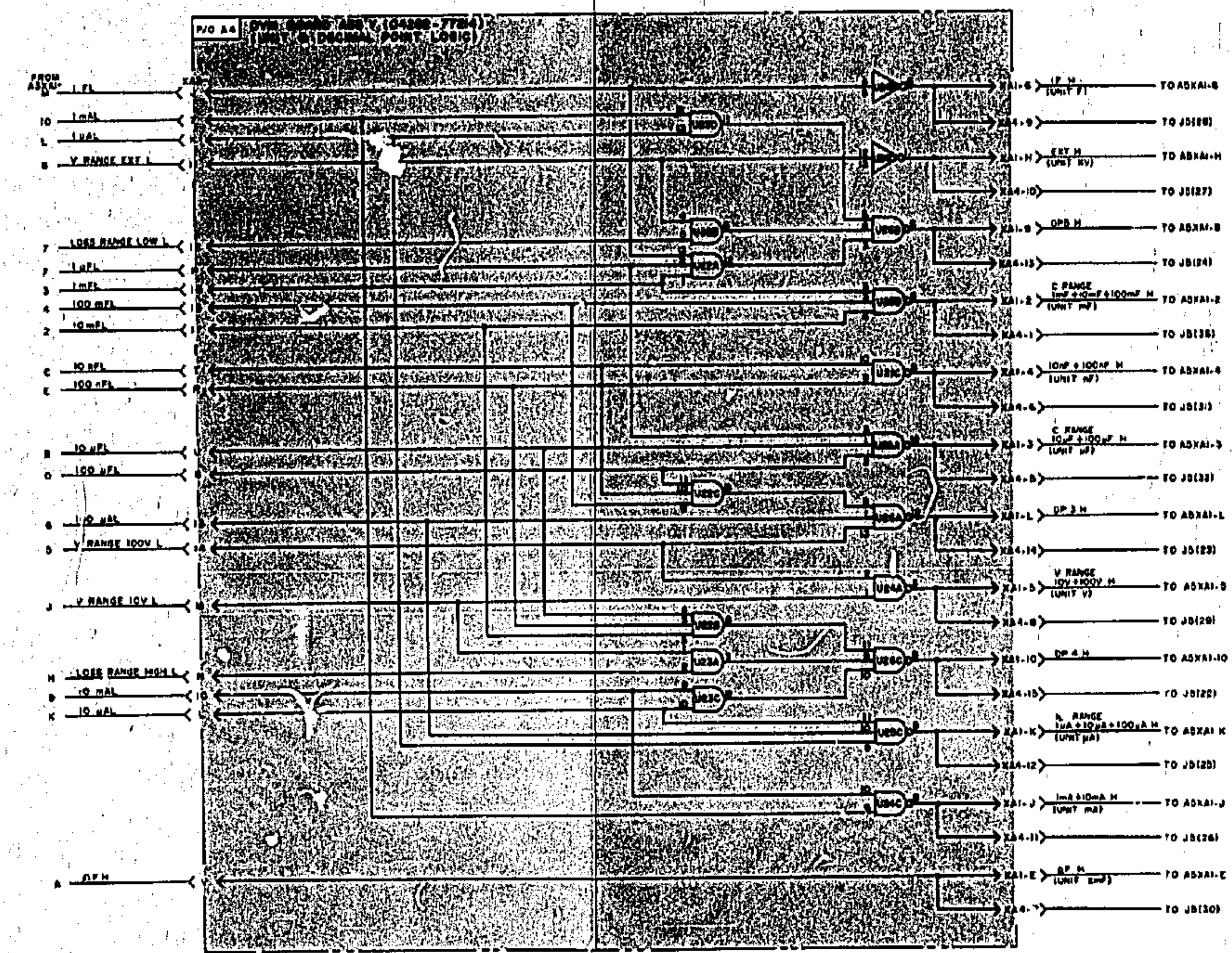
Figure 8-16
A4 DVM Board Ass'y
(Control Logic)

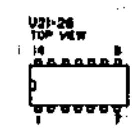
A4 DVM BOARD OPERATION

Unit and Decimal Point Logic Section.

This section converts unit and decimal point information obtained from combination of Function and Range settings to appropriate individual information. For example, when Function C and Range 1mF are selected, U25B(6) and U26 (6) go to H which means that unit is "mF" and decimal point is positioned at DP5. Same information is sent to DIGITAL OUT J5 connector.

A4 Parts Locations under Fold





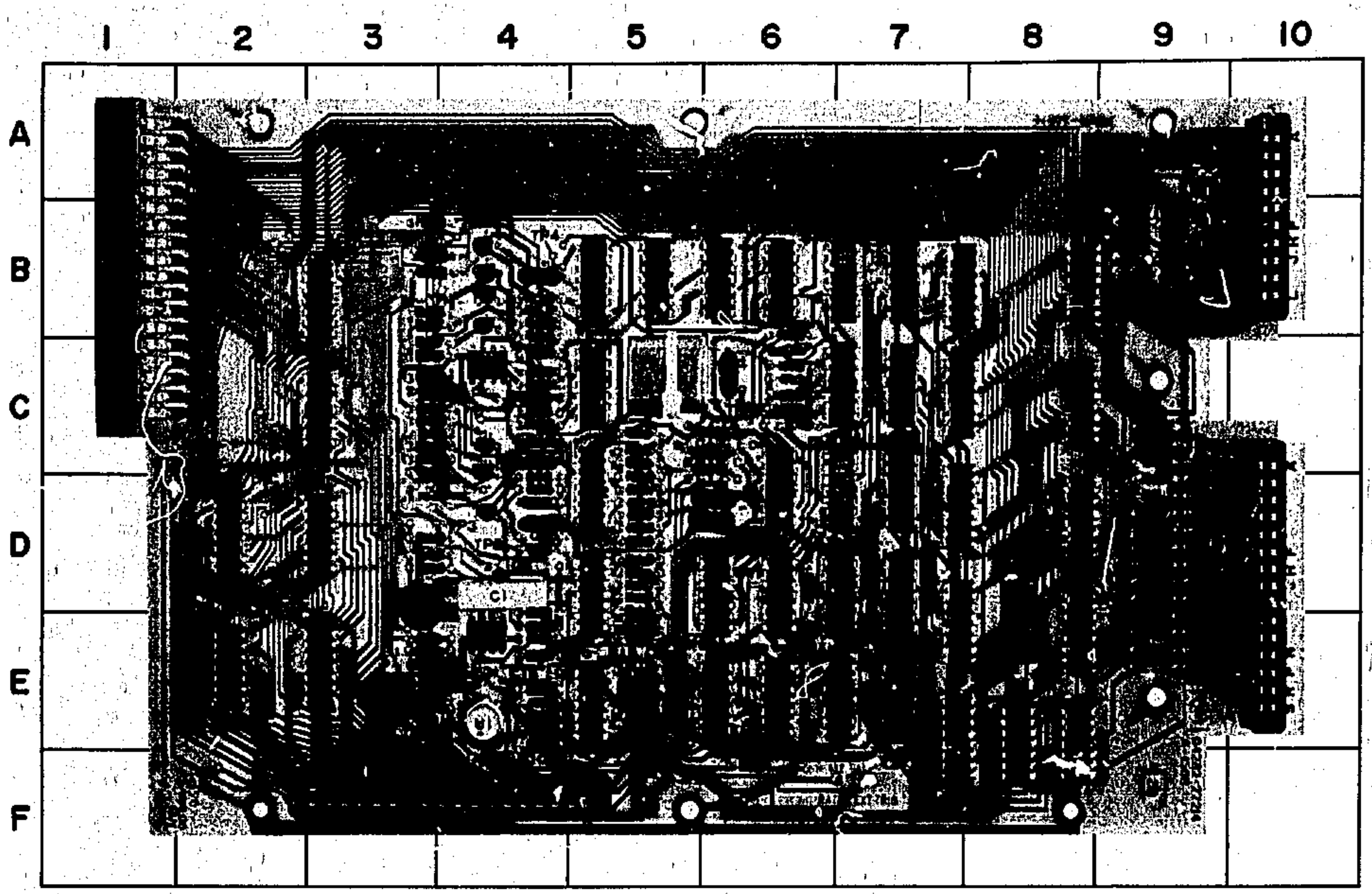
Reference Designations

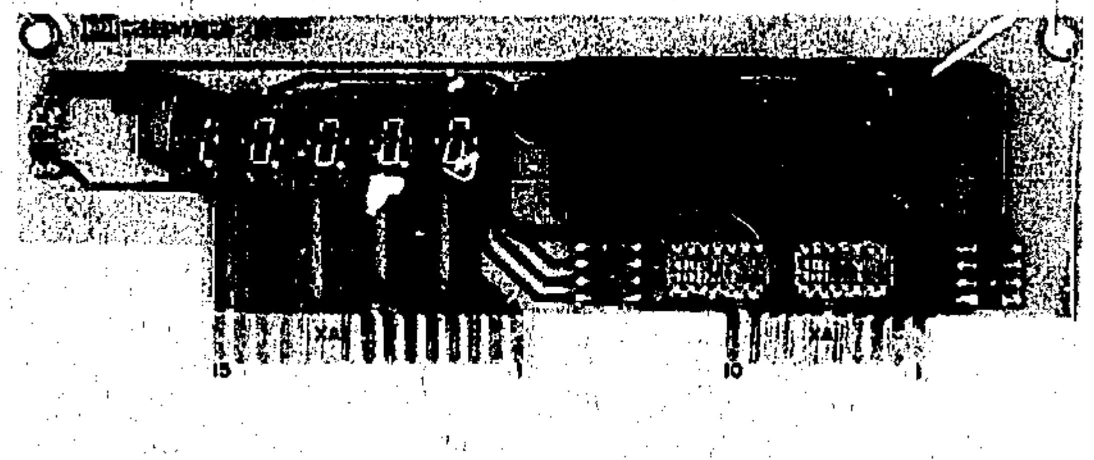
A4
U21 - 26 XA5, 3, 4

Table of Active Components

Reference Designations	HP Part Number
A4	
U21, 24	1820-0064
U22	1820-0372
U23	1820-0511
U25, 26	1820-0068

Figure 8-17. A4 DVM Board Ass'y. (Unit & Decimal Point Logic)





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C23	C-7	R90	D-9	U27	B-7
C24	F-7	R91	D-9	U28	C-7
		R92	D-9	U29	D-7
R76	C-9	R93	D-9	U30	D-7
R77	C-9	R94	D-9	U31	E-7
R78	D-9	R95	D-9	U32	B-8
R79	C-9	R96	D-9	U33	D-8
R80	C-9	R97	E-9	U34	D-8
R81	C-9	R98	D-9	U35	E-8
R82	D-9	R99	E-9	U36	C-8
R83	D-9	R100	E-9	U37	B-8
R84	D-9	R101	D-9	U38	C-8
R85	D-9	R102	E-9	U39	D-7
R86	D-9	R103	E-9	U40	E-7
R87	D-9				
R88	D-9	U19	E-8	XA2	D-10
R89	D-9	U20	E-8	XA3	F-3

SEE INSIDE

Figure 8-17
A4 DVM Board Ass'y
(Unit & Decimal Point Logic)

A4 DVM BOARD OPERATION

Counter, Buffer Storage and Decoder Circuits.

These circuits form three stages and are connected in cascade. Counter U27 to U31 consists of three different counters. U27 to U29 are decade counters, U30 is ÷4 counter and U31 is ÷3 counter, for a total maximum counting capacity of 11,999. Counter U27 to U31 is reset to zero by Set Pulse at beginning of busy period. Then Counter continues to count 2.88MHz Clock divided by two while Clock Gate U10C opens. During this period, Counter provides overflow signal at U31(9) which goes to H at 8,000 counts and returns to L at 12,000 counts. When Clock Gate U10C is closed, Counter holds result which is BCD and which represents input voltage.

Next stage is Buffer Storage U32 to U35 whose input is BCD output from Counter and whose output is previous data. The transfer between input and output is performed by Transfer Pulse issued at end of each busy period. Therefore, Buffer Storage holds data transferred for one reading period. Input for U32 to U34 is up to 9 decimal numbers and for U35 is up to 11 (to allow overranging). U19B/C and U20A/B are employed to take up this carry and enable display for overranging digit. U36, 1st Digit Enable, sends U32 output to Decoder when Function is C. In other functions, all four lines hold H to blank 1st digit.

Buffer Storage output is connected to Decoder and DIGITAL OUT J5 connector. Decoder U37 to U40 in last stage is BCD to seven segment decoder. Decoder enables to display appropriate number according to input BCD.

A5 DISPLAY BOARD OPERATION

This Assembly contains Seven Segment Numeric Display DS1 to DS4, Polarity and Overrange Display DS5, Annunciators DS6 to DS11, Rate Annunciator DS12, Unit Display DS13 to DS21 and Inverters U1 and U2. DS1 to DS5 are LED including decimal point each segment of which illuminates when corresponding pin is L (low level). Decimal point is valid only in DS3 to DS5. DS6 to DS11 light when the line is L and indicate that displayed data is invalid. DS12 is single LED which illuminates for busy period. DS13 to DS21 display measuring unit when the line is H (high level) because inputs are inverted by Inverters U1 and U2.

A4 & A5 Parts Locations under Fold

SECTION VII
MANUAL CHANGES AND OPTIONS

7-1. OPTIONS.

7-2. Options are standard modifications performed on -hp- instruments at the factory. Option 001 for Leakage Current Measurements is a currently available option. Operating instructions and other option 001 information are covered in manual corresponding to that for standard instrument.

7-3. SPECIAL INSTRUMENTS.

7-4. "Specials" are standard -hp- instruments that are modified according to customer specifications. A separate insert sheet is included with the manual for special instruments having electrical changes. Make the changes specified in addition to any other changes that are necessary.

7-5. MANUAL CHANGES.

7-6. This manual applies direcly to the Model 4282A with serials prefixed 1515. The following paragraphs explain how to adapt this manual to apply to later instruments with higher serial prefix, or earlier instruments with 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.

7-7. LATER INSTRUMENT: If the serial prefix of your Model 4282A is above 1515, refer to a separate "Manual Changes" sheet supplied with this manual. Locate the serial prefix of your instrument and make the indicated changes.

7-8. EARLIER INSTRUMENTS.
(Backdating Changes):
If the serial prefix of your Model 4282A is below 1515, refer to Table 7-1 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 7-1. Manual Backdating Changes.

Serial Prefix or Number	Make Changes
1319J00170 and below	1

CHANGE 1

Page 6-2, Table 6-2,
A1: Change to HP Part No. 04282-77201; BOARD ASSY:OSCILLATOR.

Pages 6-2 thru 6-4, Table 6-2,
Delete following parts,

A1C29 thru C33, R109 thru R120 and U13 thru U15.

Add following parts,

A1C24: HP Part No. 0180-0106; CAPACITOR:FXD 60μF ±20% 6VDC TA-SOLID.
A1C25: HP Part No. 0180-0374; CAPACITOR:FXD 10μF ±10% 20VDC TA SOLID.
A1CR29 thru C32: HP Part No. 1901-0040; DIODE SWITCHING SI 30V MAX VRM 50MA.
A1K13 and K14: HP Part No. 0490-0226; RELAY REED.
A1Q11: HP Part No. 1853-0051; TRANSISTOR:PNP SI.
A1Q12 and Q13: HP Part No. 1854-0071; TRANSISTOR:NPN SI.
A1R64: HP Part No. 2100-2655; RESISTOR:VAR TRMR 100kΩ 10% C.
A1R73 and R74: HP Part No. 0686-2045; RESISTOR:FXD 200kΩ5% .5W CC TUBULAR.
A1R75: HP Part No. 0698-4406; RESISTOR:FXD 115Ω 1% .125W F.
A1R76: HP Part No. 0698-3454; RESISTOR:FXD 215kΩ 1% .125W F TUBULAR.
A1R77: HP Part No. 0698-3460; RESISTOR:FXD 422kΩ 1% .125W F TUBULAR.
A1R78 and R81: HP Part No. 0757-0453; RESISTOR:FXD 30.1kΩ 1% .125W F TUBULAR.
A1R79 and R82: HP Part No. 0757-0467; RESISTOR:FXD 121kΩ 1% .125W F TUBULAR.
A1R80: HP Part No. 0757-0444; RESISTOR:FXD 12.1kΩ 1% .125W F TUBULAR.
A1U10: HP Part No. 1826-0092; IC:LIN OP. AMPL DUAL.

Page 6-3, Table 6-2 and page 8-11, Figure 8-6,
Delete A1CR50 and CR51.

Page 6-3, Table 6-2,
A1K7: Change to HP Part No. 0490-0226; RELAY REED.

Page 6-4, Table 6-2,
A1R62: Change to HP Part No. 0698-2218; RESISTOR:FXD 33.5kΩ 1% .125W MET FLM.
A1R63: Change to HP Part No. 2100-2216; RESISTOR:VAR 5kΩ ±10% .5W CER.
A1R88: Change to HP Part No. 2100-2060; RESISTOR:VAR 50Ω 20% CER.

Page 8-13, Figure 8-7,
Change Figure 8-7 partially as shown in Figure 7-1.

Page 8-11, Figure 8-6 (in Table of Active Components),
Delete CR50 and 51; 1902-3059.
Change Q10 to 1854-0071

Page 8-13, Figure 8-7 (in Table of Active Components),
Add Q11; 1853-0051, Q12 and Q13; 1854-0071, U10; 1826-0092, CR29 thru 32; 1901-0040.

Page 6-5, Table 6-2,
A2: Change to HP Part No. 04282-77202; BOARD ASSY:MULTIPLIER.

Page 6-6, Table 6-2,
A2CR15: Change to HP Part No. 1902-0184; DIODE:VREG 16.2V VZ .4W MAX.

Page 6-8, Table 6-2,
A2R74: Change to HP Part No. 0757-0199; RESISTOR:FXD 21.5kΩ 1% .125W F TUBULAR.
A2R76: Change to HP Part No. 0698-3454; RESISTOR:FXD 215kΩ 1% .125W F TUBULAR.

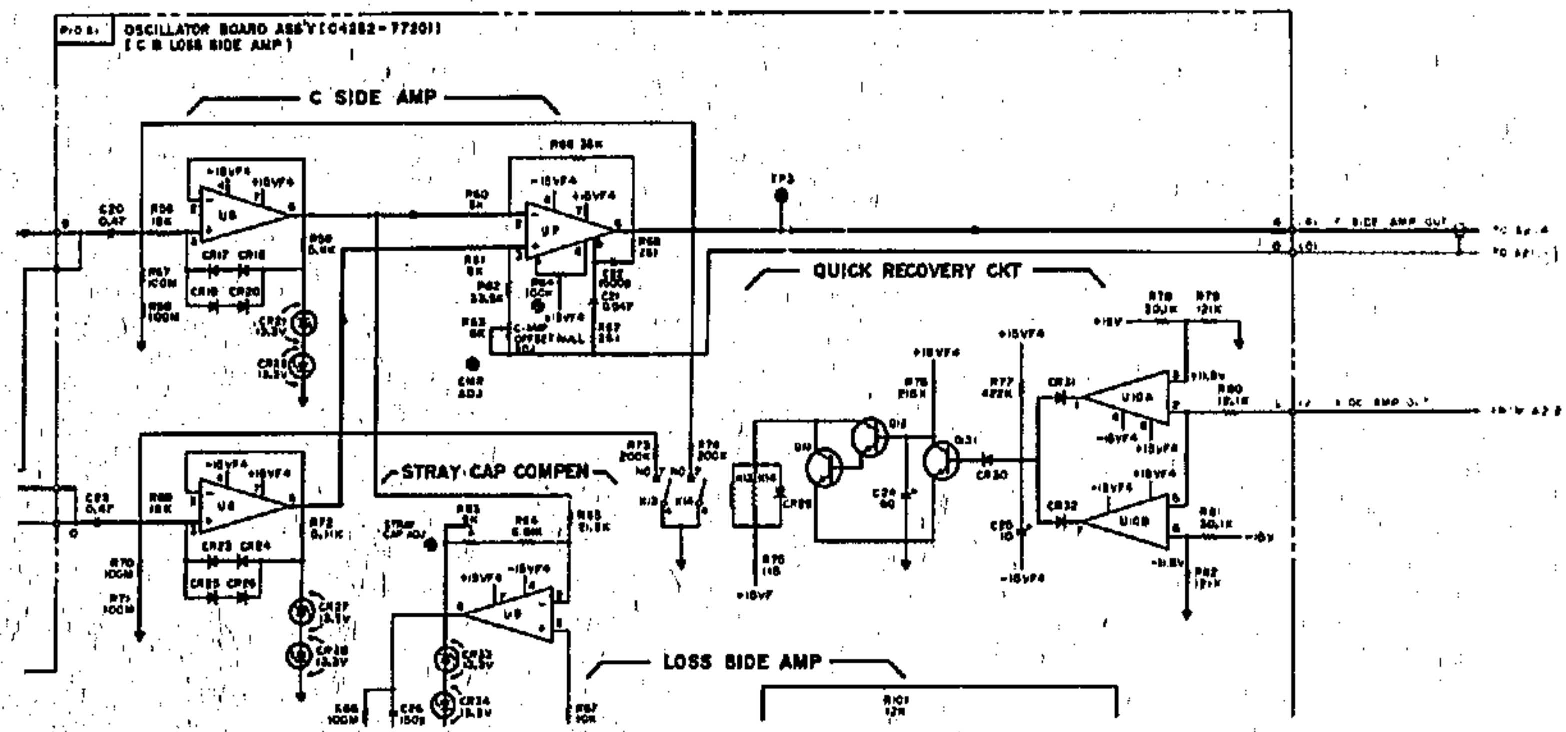
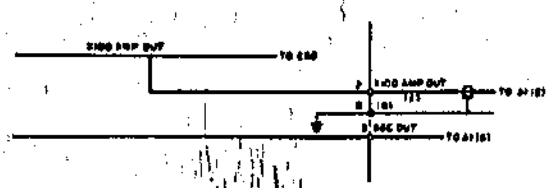

OSCILLATOR BOARD ASS'Y (04282-77201)
(C & LOSS SIDE AMP)
C SIDE AMP
QUICK RECOVERY CKT
STRAY CAP COMPEN
LOSS SIDE AMP

Figure 7-1.

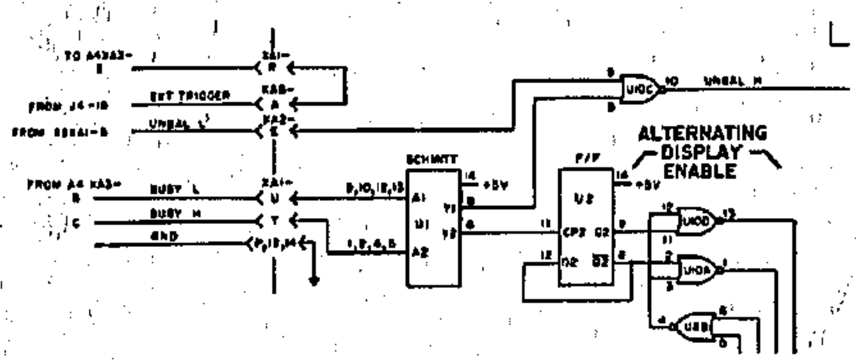
Page 8-15, Figure 8-8,
Change Figure 8-8 partially as follows:



Page 8-15, Figure 8-8 (in Table of Active Components),
CR15: Change to 1902-0184.

Page 6-10, Table 6-2,
A3: Change to HP Part No. 04282-77203; BOARD ASSY:CONTROL.

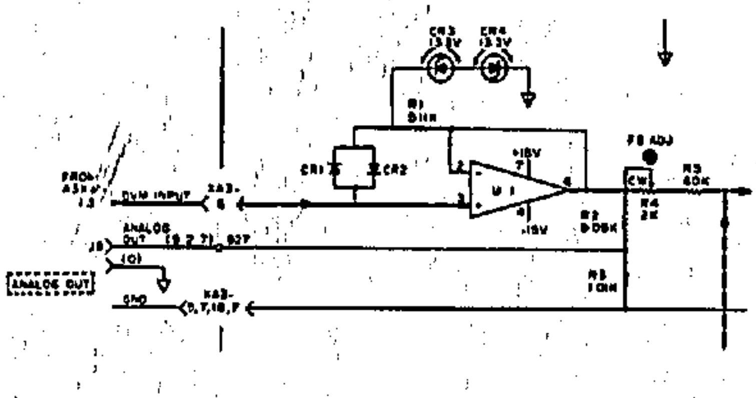
Page 8-21, Figure 8-11,
Change Figure 8-11 partially as follows:



Page 8-21, Figure 8-11 (in Table of Active Components),
Delete CR26.

Pages 6-12 through 6-14, Table 6-2,
A4: Change to HP Part No. 04282-77204; BOARD ASSY:DVM.
A4R58: Change to HP Part No. 0698-4431; RESISTOR:FXD 2.05kΩ 1% .125W F TUBULAR.
Delete following parts,
A4CR11, Q17, R104 and R105.

Page 8-29, Figure 8-15,
Change Figure 8-15 partially as follows:



Page 5-13, paragraph 5-54,
Replace with following paragraphs.

5-54. High Capacitance Ranges Adjustment (A1, A2).

5-55. This adjustment uses a standard capacitor (SOSHIN TM 520-C). Proceed as follows:

a. Set 4282A to same as paragraph 5-31 step a except set C RANGE to 10mF.

b. Set SOSHIN TM 520-C to 10mF.

c. Connect 16035A Test Leads to UNKNOWN connector.

d. Twist two current leads with each other (at lead five times) and also twist the two voltage lead together (see paragraph 3-34) and connect to SOSHIN TM-520-C.

e. Adjust 4282A display for certified 10mF capacitance value with A1R88 (10mF Range Adj.).

f. Set C RANGE and SOSHIN TM 520-C to 1F.

g. Adjust 4282A display for certified 1F capacitance value with A2R10 (1F Full-Scale Adj.).

Page 8-31, Figure 8-16,
Change Figure 8-16 partially as shown in Figure 7-2.

Page 8-31, Figure 8-16 (in Table of Active Components),
Delete CR11 and Q17.

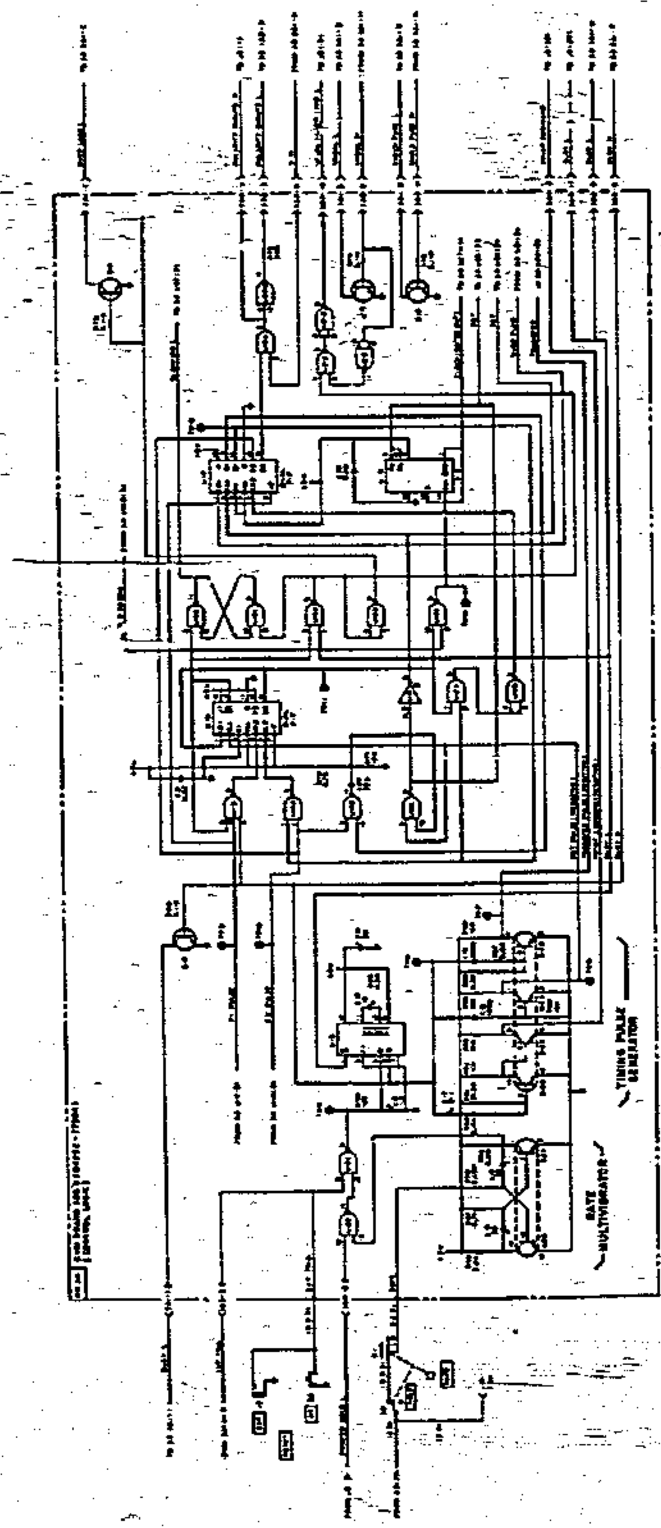


Figure 7-2.

SECTION VIII
CIRCUIT DIAGRAMS

8-1. INTRODUCTION.

8-2. This section includes the following:

a. General Notes for Schematic Diagrams.

b. Block Diagram.

c. Schematic Diagrams and part location illustrations.

d. Circuit Operations.

8-3. The Block Diagram or schematic diagrams can be unfolded and used with any other portion of the manual.

Resistance is in ohms, capacitance is in microfarads and inductance is in microhenries unless otherwise noted.

P/O = part of.

* Asterisk denotes a factory-selected value. Value shown is typical. Capacitors may be omitted or resistors jumpered.

L or H after signal name means the line goes to low or high level, respectively, when the signal is enabled.

R G (RELAY GROUND) or OPEN after signal name means the line is grounded or open, respectively, when the signal is enabled.

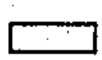
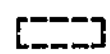
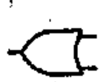
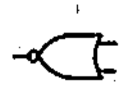
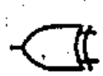
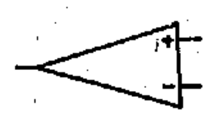
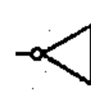
	Screwdriver adjustment.		Panel control.
	Encloses front panel designations.		Encloses rear panel designation.
	AND gate.		NAND gate.
	OR gate.		NOR gate.
	Exclusive OR gate.		Operational amplifier.
	Non-inverting.		Inverting.
	Assembly circuit common.		Floating circuit common.
	Chassis ground.		Protective ground.

Figure 8-1. Schematic Diagram Notes (sheet 1 of 2).

Circuit assembly borderline.

Other assembly borderline.

Heavy line with arrows indicates path and direction of main signal.

Heavy dashed line with arrows indicates path and direction of main feedback.

CW — Wiper moves toward CW with clockwise rotation of control as viewed from shaft or knob.

TP1 — Shows location and number of test point.

(9-4-7) — Encloses wire color code. Code used (MIL-STD-681) is the same as resistor color code. First number identifies the base color, second number the wider stripe, and third number identifies narrower stripe (e.g., 947 denotes white base, yellow wide stripe and violet narrow stripe).

A1 (5) — Shows square pin number used in circuit assembly [e.g., A1(5) denotes pin 5 in A1 assembly].

NC K1 NO — Indicates NC are normally closed contacts and NO are narmally open contacts when relay K1 is not energized.

Voltage regulator (breakdown diode).

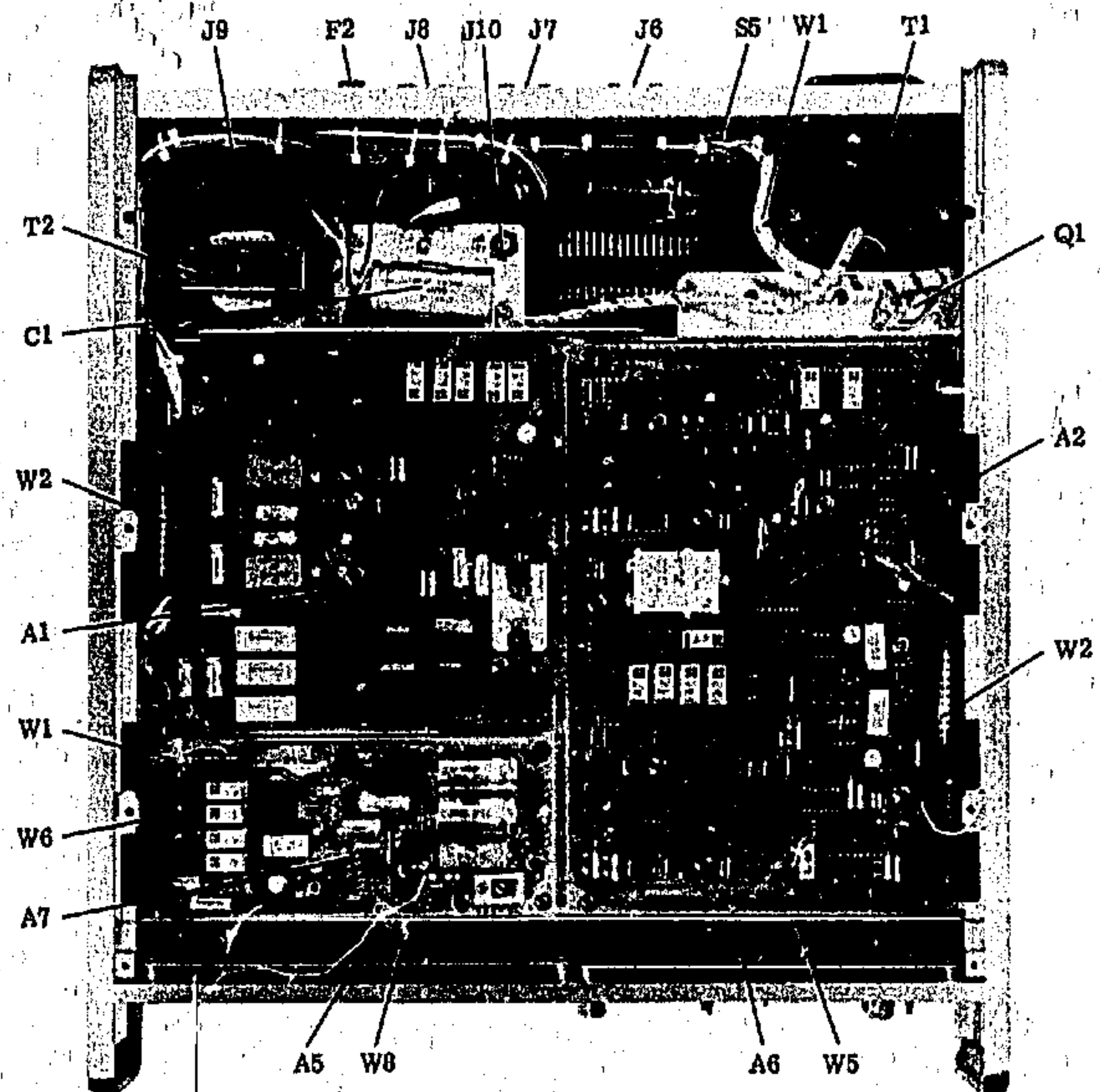
Field Effect transistor (FET) with N-type base.

FET with P-type base.

Tunnel diode.

Light emitting diode (LED).

Figure 8-1. Schematic Diagram Notes (sheet 2 of 2).



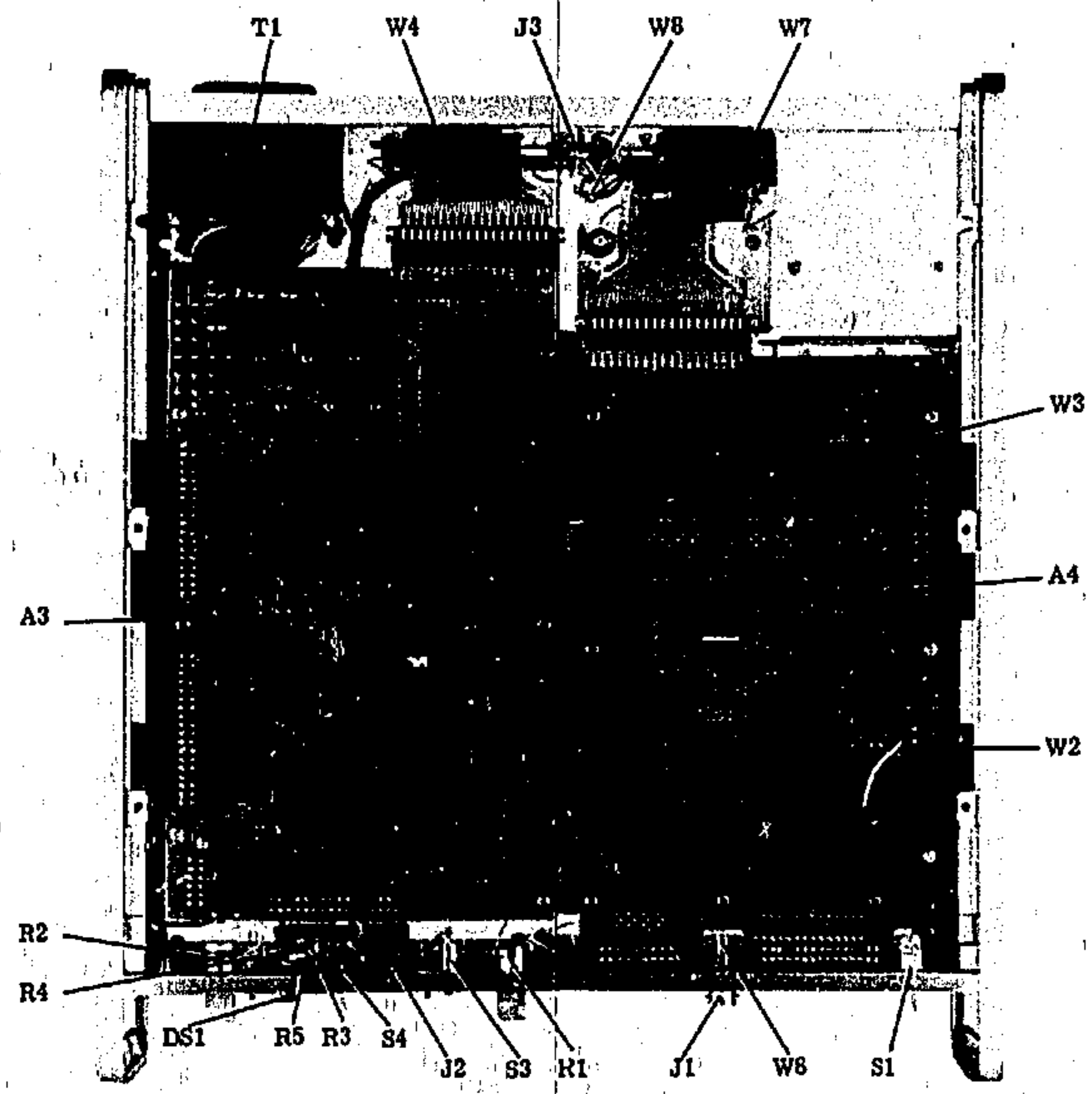


Figure 8-2. Assembly Location.

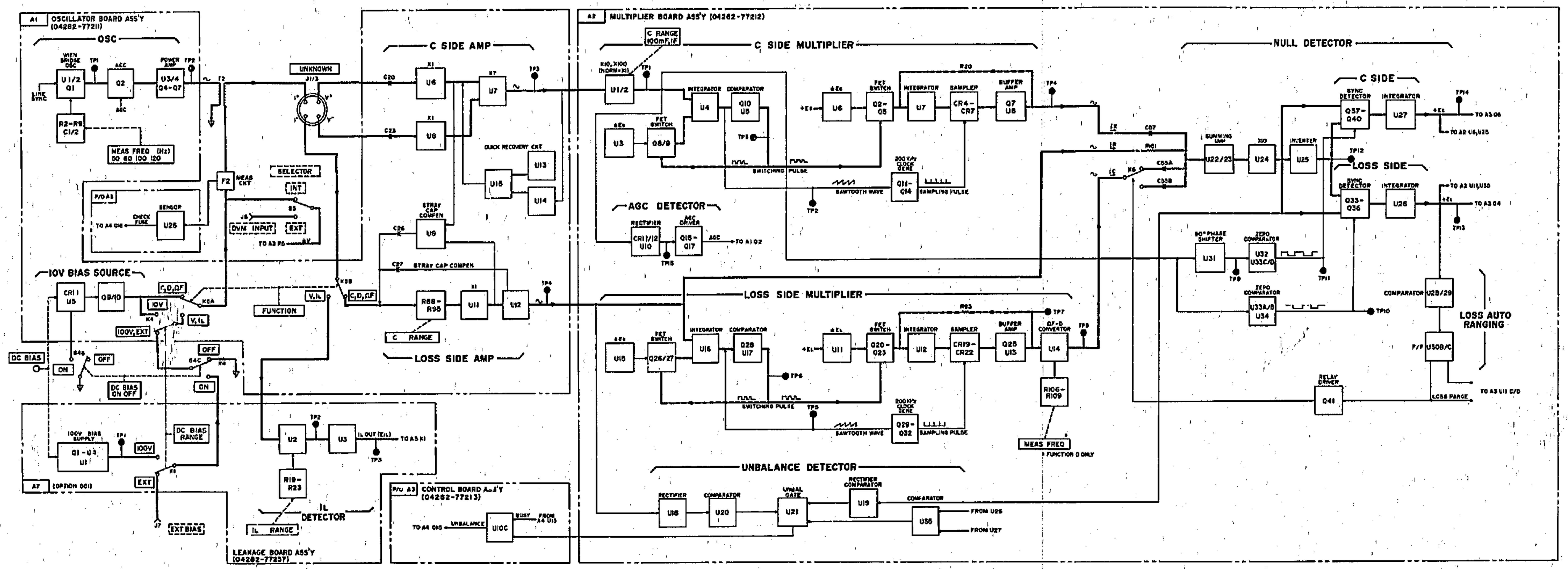


Figure 8-3. Block Diagram - Bridge Section.

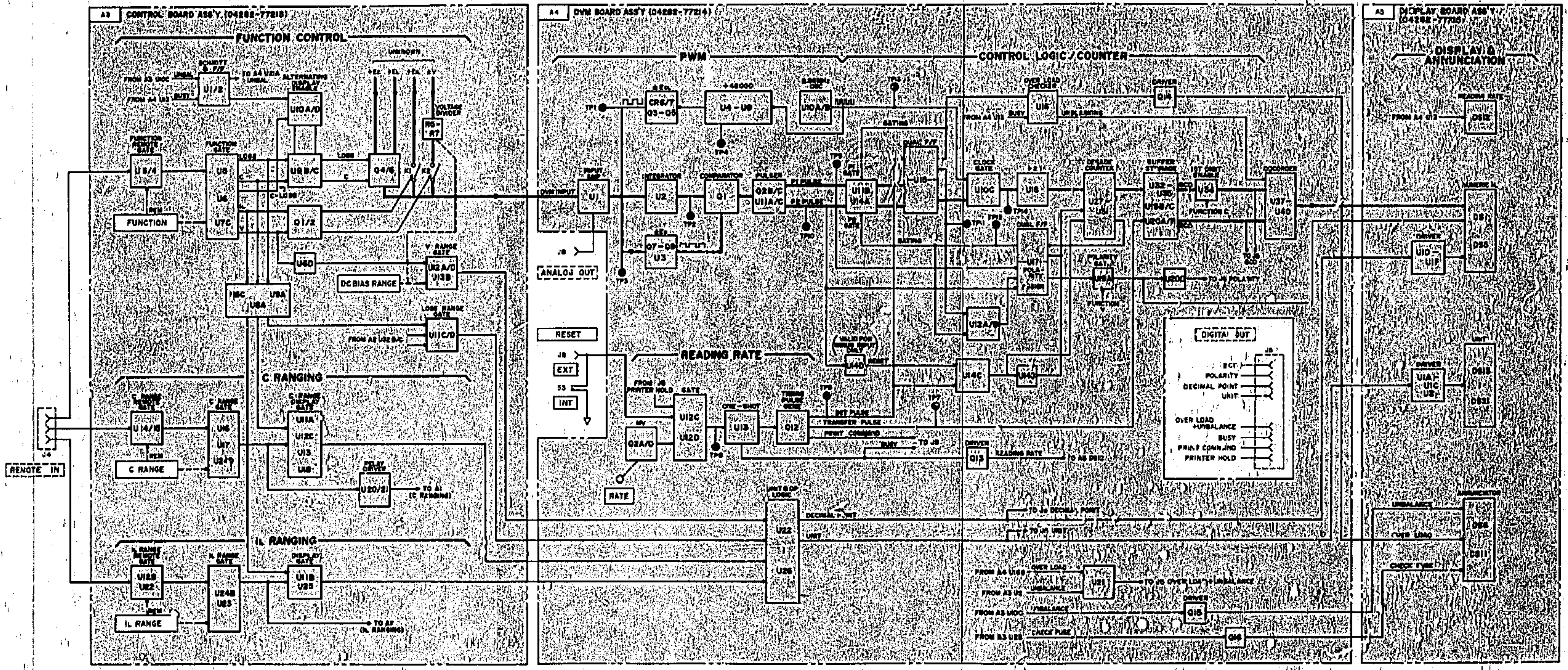


Figure 8-4. Block Diagram - Logic Section.

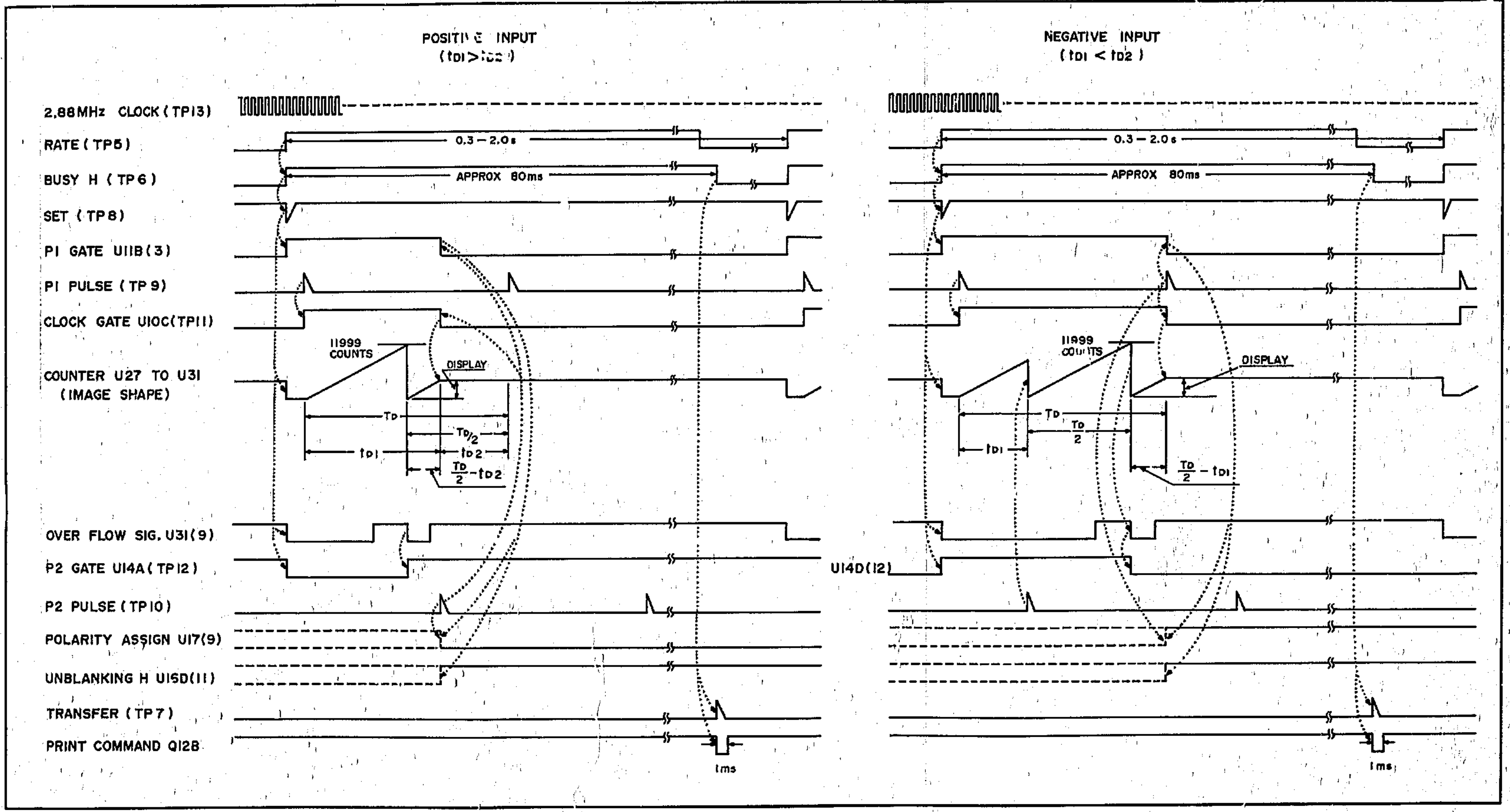
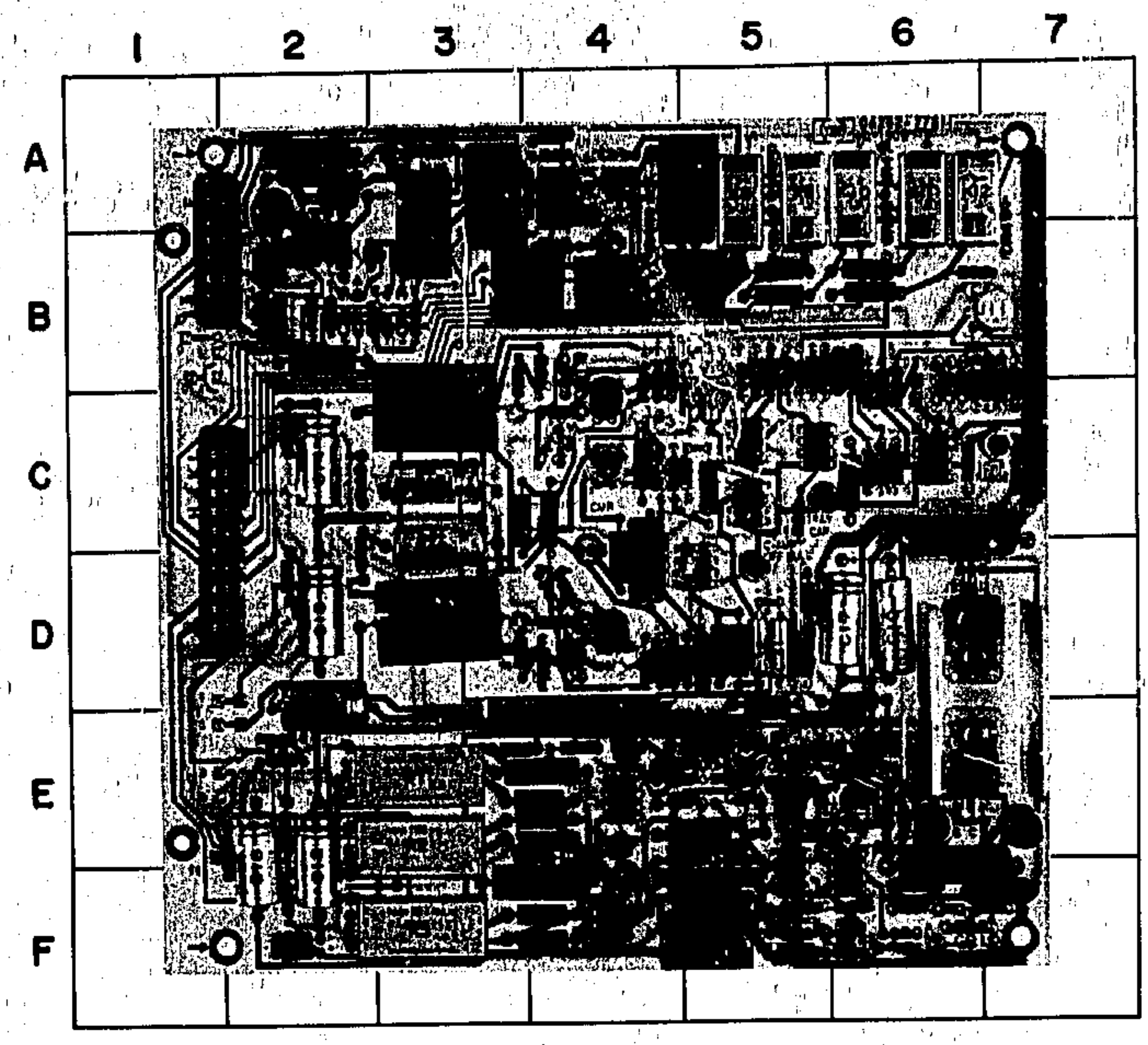


Figure 8-5. DVM Timing Diagram.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	F-5	C14	C-2	CR8	F-6	K3	F-3	Q10	A-2	R12	E-5	R25	E-6	R38	A-2	R51	E-2
C2	F-5	C15	C-3	CR9	F-6	K4	A-3			R13	F-4	R26	E-5	R39	B-2	R52	D-2
C3	E-5	C16	E-2	CR10	F-6	K5	A-3	R1	F-2	R14	E-4	R27	E-6	R40	B-2	R53	D-2
C4	E-5	C17	D-6	CR11	B-2			R2	E-4	R15	E-4	R28	F-6	R41	B-3		
C5	F-5	C18	D-2	CR12	A-2	Q1	E-4	R3	E-4	R16	E-4	R29	E-6	R42	B-2	U1	F-4
C6	E-5	C19	C-3	CR13	B-3	Q2	E-5	R4	F-4	R17	E-5	R30	E-6	R43	B-3	U2	E-4
C7	E-5	CR1	E-2	CR14	B-3	Q3	F-6	R5	F-5	R18	E-4	R31	F-6	R44	E-5	U3	F-5
C8	F-7	CR2	E-2	CR15	B-2	Q4	E-6	R6	E-4	R19	E-4	R32	F-6	R45	E-6	U4	F-6
C9	B-2	CR3	F-2	CR16	B-2	Q5	E-7	R7	E-4	R20	F-6	R33	F-6	R46	E-2	U5	B-2
C10	D-6	CR4	E-5	CR50	F-2	Q6	E-6	R8	F-4	R21	F-6	R34	D-6	R47	E-2		
C11	E-5	CR5	E-3	CR51	F-2	Q7	D-6	R9	F-4	R22	F-5	R35	B-2	R48	C-2	XA1	B-1
C12	E-2	CR6	E-5			Q8	B-2	R10	E-4	R23	F-5	R36	B-2	R49	C-2	XA2	C-1
C13	E-2	CR7	F-6	K1	E-3	Q9	B-2	R11	E-4	R24	F-6	R37	A-2	R50	E-1		
				K2	E-3												

SEE INSIDE

Figure 8-5
DVM Timing Diagram

A1 OSCILLATOR BOARD OPERATION

Measuring Signal Generator.

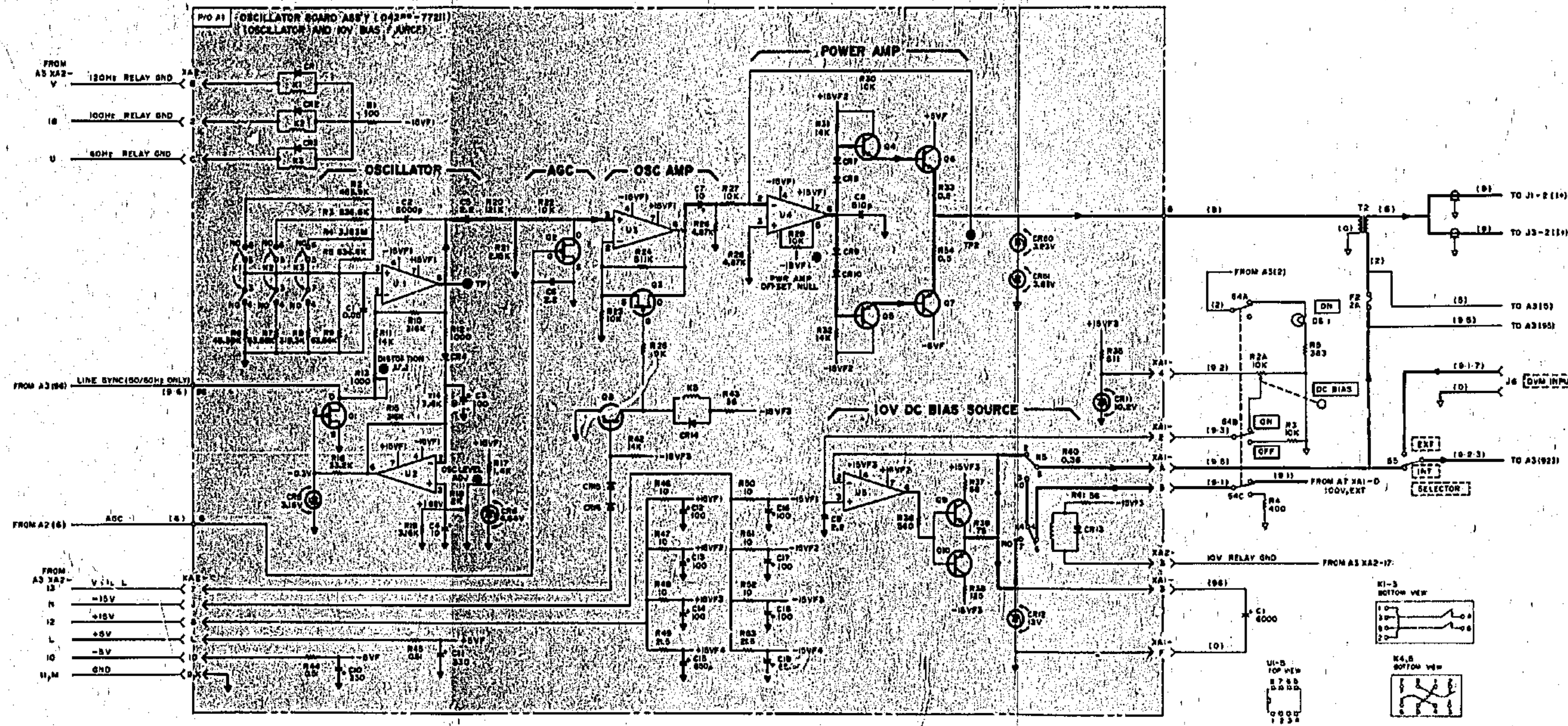
This section is the signal source of Bridge and consists of an oscillator, amplifier and power amplifier. The oscillator employs the Wien Bridge technique and provides four measuring frequencies of 50, 60, 100 and 120Hz. Selection and determination of frequency are done by relays K1, K2 and K3 which select R2 through R9 in combination with C1 and C2. FET Q1 is driven by U2 whose input is difference between Peak Detector CR4 output and reference voltage established by CR6. Q1 operates to maintain voltage ratio at U1(2) at one twenty first of voltage at U1(6) (because, for example, C1 is ten times of C2, R9 is one tenth of R5 at 50Hz setting, and so on). Output at U1(6) can be changed or maintained by potentiometer R18. When MEAS FREQ switch is set to 50 or 60Hz, line synchronous signal is applied to Q1 drain to synchronize frequency to line frequency.

AGC(Q2) only operates when C range is set to 100mF or 1F. On these two ranges, range is determined not by changing range resistances but by increasing amplifier A2U1, U2 gain from 1 to 10 or to 100. Amplifiers could be saturated depending upon unknown values. To prevent this, appropriate AGC signals reduce measuring signal level. Amplifier U3 amplifies oscillator signal to furnish sufficient drive to Power Amplifier. Both Q2 and Q3 turn on when function is set to V or I_L (option 001) which operate to extinguish oscillator signal. The Power Amplifier, which is comprised of U4 and Q4 through Q7, has unity gain and the capability to feed maximum signal current of about 660mA (equivalent to 1A) through transformer T2 which has a turns ratio of three to two. Q4, Q6 and Q5, A7 form a complementary push-pull circuit.

10V DC Bias Source.

A 10 volts DC Bias Source is provided by reference diode CR11, differential amplifier U5 and power amplifier Q9 and Q10. Bias voltage is controlled by DC BIAS control R2A. Maximum current is about 100mA.

A1 Parts Locations under Fold



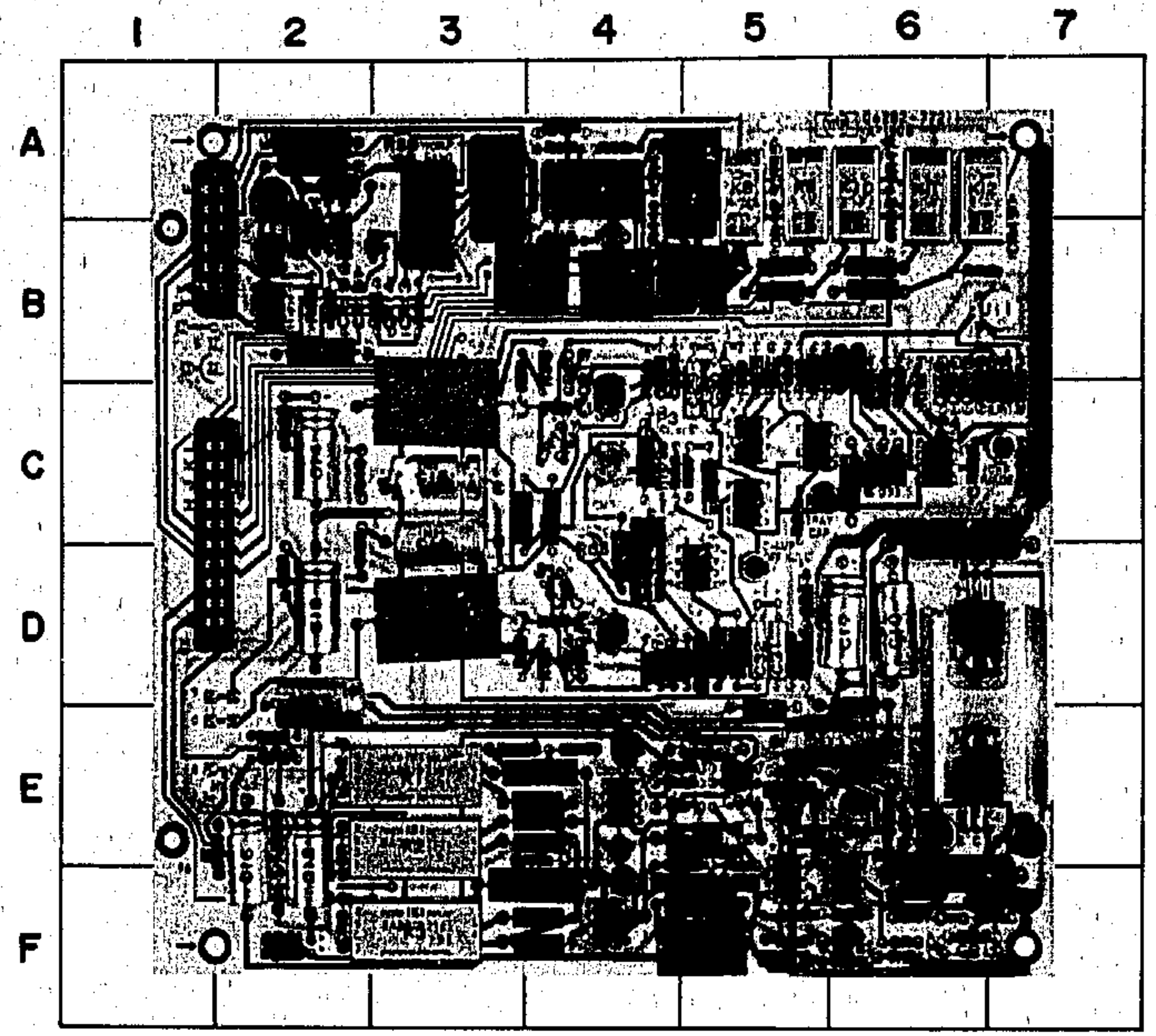
Reference Designations

NO PREFIX	A1
C1	C1 - 16 CR1 - 16, 50, 51
DS1 F2 J6	K1 - 6 Q1 - 10 R1 - 53
R2 - 3 S4, 5 T2	U1 - 5 XA1, 2

Table of Active Components

Reference Designations	HP Part Number
A1	
CR1 - 4, 7 - 10	1901-0040
CR13 - 16	1901-0040
CR5	1902-3036
CR50, 51	1902-3059
CR6	1902-3082
CR11	1902-3193
CR12	1902-0612
Q1	1855-0087
Q2, 3	1856-0091
Q4, 9	1854-0090
Q5	1853-0061
Q6	1854-0127
Q7	1853-0106
Q8	1853-0020
Q10	1853-0051
U1 - 5	1820-0314

Figure 8-6. A1 Oscillator Board Ass'y, (Oscillator and 10V Bias Source)



PARTS LOCATOR

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C20	C-3	CR20	B-4	CR34	D-5	CR48	A-6	Q11	D-5	R63	D-5	R78	B-5	R92	B-5	R107	B-5
C21	D-5	CR21	C-4	CR35	B-6	CR49	B-7	Q12	D-5	R64	B-4	R79	B-5	R93	B-5	R108	A-3
C22	C-5	CR22	C-4	CR36	B-7			Q13	D-5	R66	C-4	R80	B-5	R94	B-6		
C23	D-3	CR23	D-4	CR37	B-6	K5	A-2			R67	D-5	R81	B-5	R95	B-6	U6	C-4
C24	D-5	CR24	D-4	CR38	B-6	K6	A-4	R43	B-3	R68	C-5	R82	B-5	R96	B-7	U7	C-5
C25	D-5	CR25	D-4	CR39	B-7	K7	A-5	R54	A-4	R69	D-4	R83	C-5	R97	B-7	U8	D-4
C26	B-6	CR26	D-4	CR40	B-7	K8	A-5	R55	A-4	R70	D-3	R84	C-5	R98	B-6	U9	C-5
C27	B-6	CR27	D-4	CR41	C-6	K9	A-5	R56	C-4	R71	D-4	R85	B-5	R99	B-6	U10	C-5
C28	C-6	CR28	D-4	CR42	C-6	K10	A-6	R57	C-3	R72	D-4	R86	B-5	R100	B-6	U11	B-7
		CR29	D-4	CR43	A-4	K11	A-6	R58	B-4	R73	D-3	R87	B-5	R101	B-6	U12	C-6
CR14	B-3	CR30	D-5	CR44	B-4	K12	A-7	R59	B-4	R74	C-3	R88	A-3	R103	C-6		
CR17	C-4	CR31	C-5	CR45	A-5	K13	C-4	R60	C-5	R75	D-4	R89	D-4	R104	C-7	XA1	B-1
CR18	C-4	CR32	C-5	CR46	A-5	K14	C-4	R61	D-5	R76	C-5	R90	B-4	R105	C-7		
CR19	B-4	CR33	D-5	CR47	A-6			R62	D-5	R77	C-5	R91	B-5	R106	C-6		

MEASURING CIRCUIT OPERATION

C, D, and ΩF Measurements.

Both UNKNOWN connectors J1 (front) and J3 (rear) each have the two current terminals and the two voltage terminals required for Four-Terminal operation. Measuring current from T2 appears at current terminal I^+ and flows through unknown to current terminal I^- into the range resistors in A1. Voltage terminals detect voltage across unknown and send it to C Side Amplifier in A1. When dc bias is superimposed, dc bias is fed from A1XA1-A and applied to unknown through T2. Quick action fuse F2 (2A) works to protect measuring circuit from excessive current. If fuse blows, measuring signal becomes input of Check Fuse Sensor in A3.

V (Voltage) Measurement.

When FUNCTION is set to V, voltage across unknown is connected to DVM Board (A4) through Control Board (A3). Both external input voltage and biasing voltages up to 600V are measureable. Selection is made with DVM INPUT SELECTOR switch S5.

I_L Measurement (Option 001).

When FUNCTION is set to I_L or V and DC BIAS ON-OFF switch S4 to ON, dc bias is fed from A1XA1-A and applied to unknown through current lead I^+. Leakage current through unknown is connected to A1XA1-6 and fed to Leakage Current Board (A7) through current lead I^-. A7 assembly converts this current to voltage. When S4 is set to OFF, discharge resistor R4 is connected to unknown.

SEE INSIDE

Figure 8-6

A1 Oscillator Board Ass'y (Oscillator and 10V Bias Source)

A1 OSCILLATOR BOARD OPERATION (C and Loss Side Amplifier Section).

C Side Amplifier.

The C side Amplifier contains two Impedance Converters U6 and U8 plus Amplifier U7. The impedance converters, whose inputs are connected to voltage terminals V^+ or V^-, provide high input impedance so as not to affect unknown. Amplifier U7 amplifies voltage across unknown seven times and sends an output opposite in phase to Multiplier Board A2. CR17 to CR22 and CR23 to CR28 form a protective circuit for large changes of dc bias. U13 to U15 provides negative feed back loop for stable dc offset nulling.

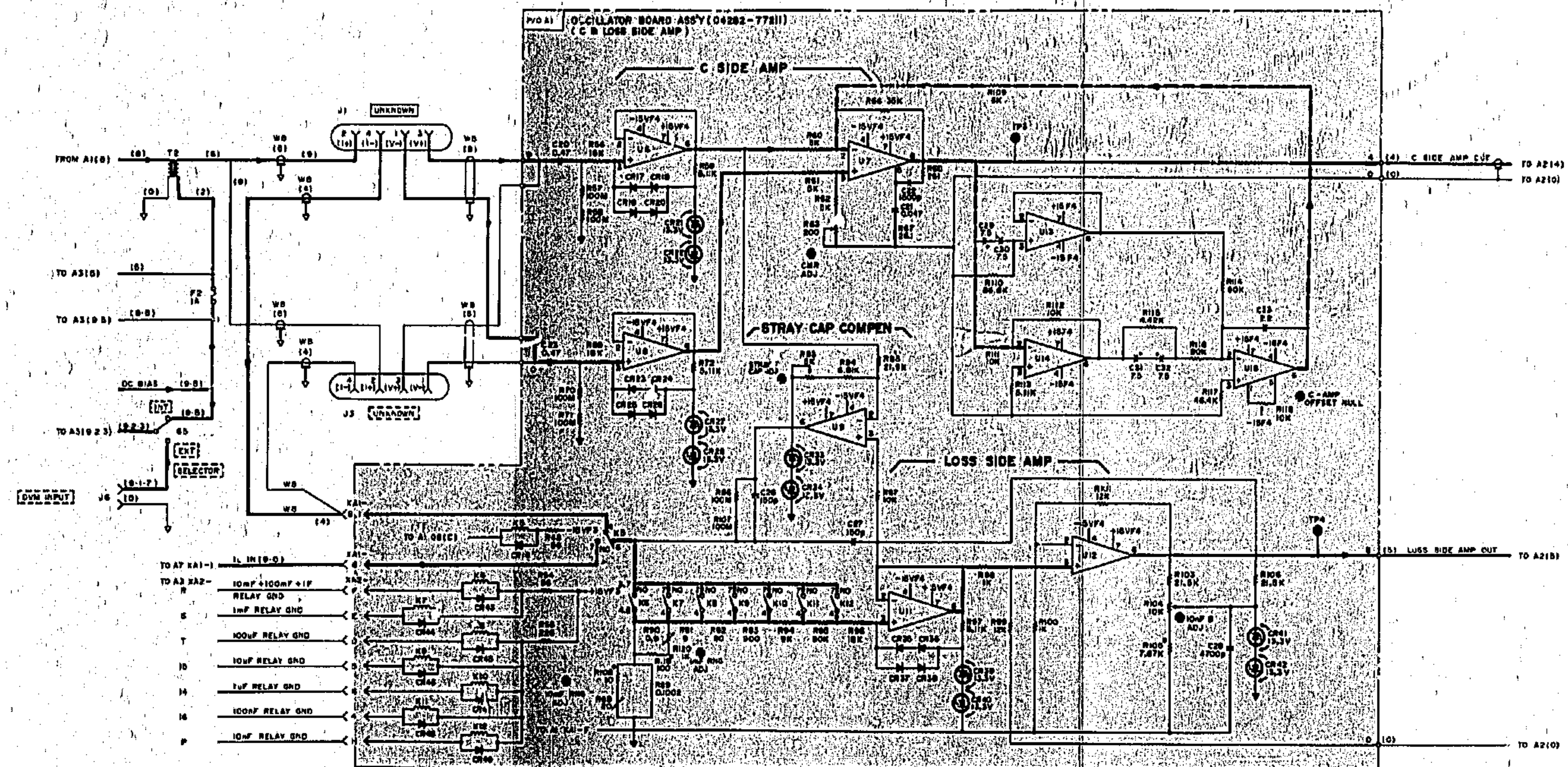
Loss Side Amplifier.

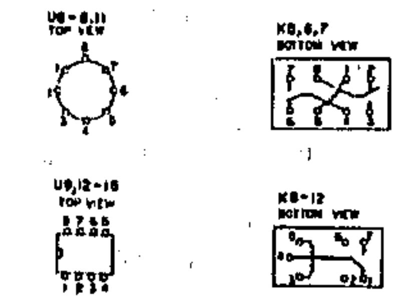
The Loss Side Amplifier includes C Range resistors R88 to R95, Impedance Converter U11 and Amplifier U12. Measuring signal goes to ground through current lead I^- and selected C Range Resistor. Impedance Converter U11 sends voltage across C Range resistor to Amplifier U12. U12 amplifies U11 output and provides an output in phase with measuring current which is sent to Multiplier Board A2.

Stray Capacitance Compensation Circuit.

Differential amplifier U9 and C26 compensate for stray capacitance between measuring leads and C27 compensates for stray capacitance of C Range Resistors.

A1 Part Locations under Fold





Reference Designations

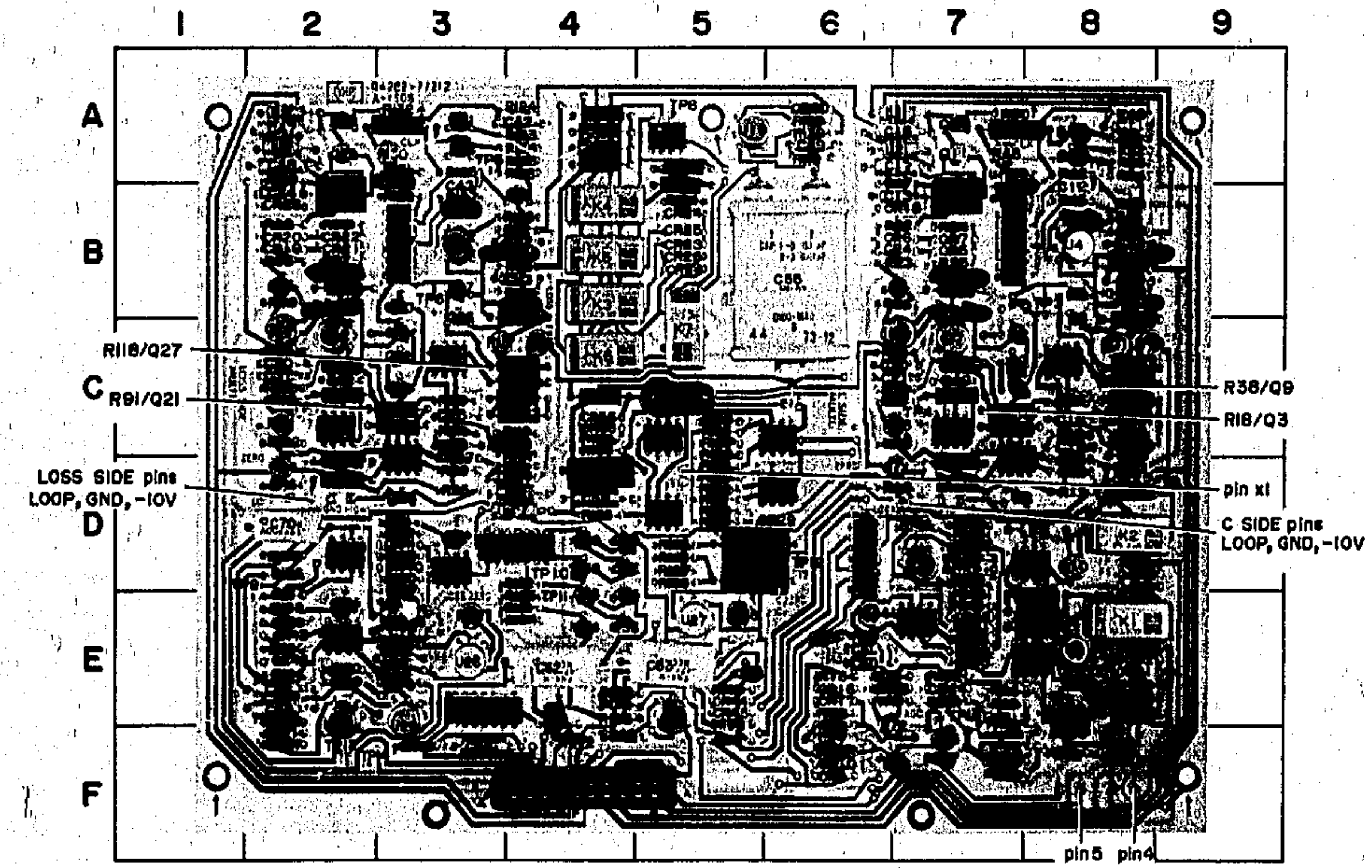
NO PREFIX	A1
	C20 - 23, 26 - 33
	CR14, 17 - 20, 23 - 40
F2	
J1, 3, 6	
	K5 - 12
	R49, 54 - 63, 68 - 72, 83 - 101, 103 - 120
S1	
T2	
	U6 - 9, 11 - 15
W8	
	XA1

R64, 65 (not assigned)
R73 - 82
R102
CR24, 25
CR29 - 32
U10

Table of Active Components

Reference Designations	HP Part Number
A1	
CR14, 43 - 45	1901-0040
CR17 - 20, 23 - 26	1901-0376
CR35 - 36	1901-0376
CR21, 22, 27, 28	1902-3183
CR33, 34, 39 - 42	1902-3103
U6, 8	1826-0121
U7	1826-0009
U9, 12 - 15	1820-0216
U11	1826-0036

Figure 8-7. A1 Oscillator Board Ass'y. (C & Loss Side Amp)



SEE INSIDE

PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	E-8	Q4	C-7	R39	C-8
C2	D-7	Q5	C-7	R40	B-8
C3	B-7	Q6	C-6	R41	B-8
C4	C-7	Q7	B-6	R42	B-8
C5	B-7	Q8	B-8	R43	A-8
C6	D-8	Q9	B-8	R44	B-8
C7	D-8	Q10	B-8	R45	B-8
C8	C-2	Q11	A-7	R46	B-7
C9	B-8	Q12	A-7	R47	B-6
C10	B-8	Q13	A-8	R48	A-7
C11	A-8	Q14	A-8	R49	B-7
C12	B-8	Q15	E-7	R50	A-7
C13	B-6	Q16	F-6	R51	A-8
C14	B-7	Q17	F-7	R52	A-8
C15	A-7			R53	A-8
C16	A-6	R1	E-8	R54	C-8
C17	A-6	R2	D-8	R55	C-6
C18	C-8	R3	E-8	R56	B-8
C19	C-8	R4	E-8	R57	C-8
C20	C-6	R5	E-8	R58	C-6
C21	C-6	R6	E-8	R59	B-8
C22	B-8	R7	D-8	R60	F-8
C23	B-8	R8	E-8	R61	E-8
C24	D-8	R9	D-7	R62	F-8
C25	E-7	R10	D-8	R63	F-8
C26	F-7	R11	D-6	R64	E-7
C27	E-6	R12	D-6	R65	E-7
		R13	D-7	R66	F-7
CR1	E-8	R14	D-7	R67	E-7
CR2	E-8	R15	D-8	R68	F-7
CR3	D-8	R16	D-8	R69	E-7
CR4	B-6	R17	C-7	R70	E-6
CR5	B-7	R18	C-7	R71	E-6
CR6	B-6	R19	C-7	R72	E-6
CR7	B-7	R20	C-7	R73	E-6
CR8	C-8	R21	B-7	R74	E-6
CR9	F-6	R22	B-6	R75	E-6
CR10	F-6	R23	B-6	R76	F-6
CR11	E-8	R24	B-6		
CR12	E-8	R25	B-7	T1	B-7
CR13	E-7	R26	B-6		
CR14	E-7	R27	C-6	U1	E-7
CR15	E-6	R28	C-6	U2	D-7
CR16	E-6	R29	C-6	U3	C-8
CR17	E-6	R30	C-8	U4	B-8
CR18	B-6	R31	C-8	U5	B-7
		R32	C-8	U6	C-7
K1	E-8	R33	D-8	U7	C-7
K2	D-8	R34	C-8	U8	C-7
		R35	D-8	U10	E-8
Q1	D-7	R36	C-8		
Q2	B-7	R37	C-8	XA1	F-4
Q3	C-7	R38	C-8		

Figure 8-7

A1 Oscillator Board Ass'y
(C & Loss Side Amp)

A2 MULTIPLIER BOARD OPERATION
(C Side Multiplier and AGC Detector Section).

C Side Multiplier.

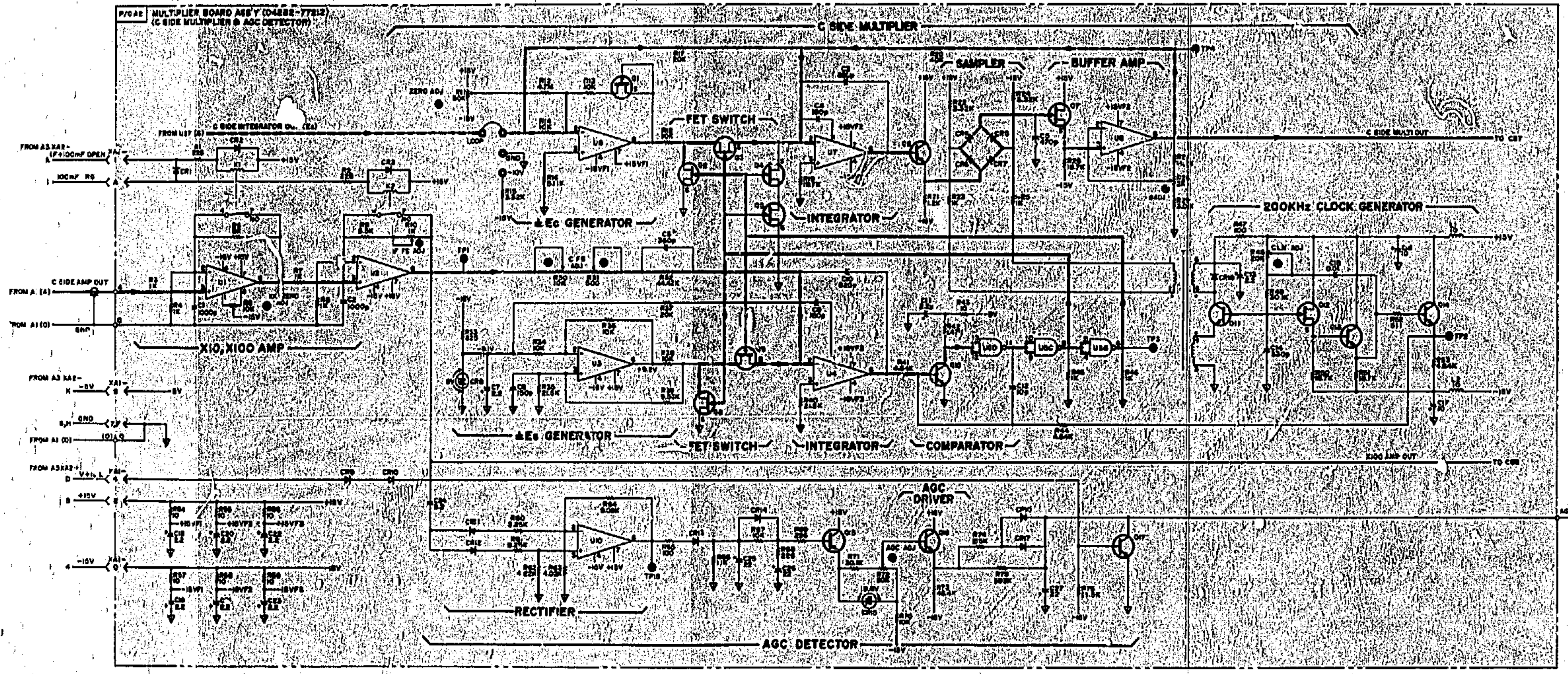
The C Side Multiplier, shown in top section of schematic Figure 8-8, produces the product of C Side Amplifier output in A1 and C Side Integrator output (E_C) in A2. Amplifiers U1 and U2 (x10 and x100) have a gains of 1 below a C Range 10mF and increase their gains to 10 on 100mF range and to 100 on 1F range. U2 output is applied to integrator U4. The $\pm E_S$ Generator CR8 and U3 provide plus and minus references through R38 and R37, respectively. The $+E_S$ is switched by FET Switch Q8 and Q9 as U4 input goes to zero during one period of 200kHz clock. U4 output produces both positive and negative going ramps during one clock period. Changing of ramp polarity occurs at the same level of U4 output and sawtooth waveform of Q14 in 200kHz Clock Generator. This is sensed by Comparator Q10, which changes state of U5C and U5B whose output is connected to FET Switch Q8 and Q9 (to complete negative feedback loop) and also to FET switch Q2 to Q5. U5 is driven in negative domain to match action of FET Switches and provides a waveform modulated to pulse width by U2 output.

The $\pm E_C$ Generator U6 accepts C Side Integrator output ($+E_C$) and develops $-E_C$. Q1 is temperature compensator for U6. The $+E_C$ is connected to Integrator U7 through R17 and the $-E_C$ is connected to U7 through R18 and FET Switch Q2 to Q5 which is switched by timing from U5. U7 integrates the sum of these two inputs. U7 output through Q6 is sampled by applying sampling pulse issued at each end of sawtooth from T1 in 200kHz Clock Generator to Sampler (CR4 to CR7) and is stored in C5. Charge stored in C5 maintains input to Buffer Amplifier Q7 and U8. Therefore, U8 output forms staircase which is similar to and in phase with C Side Amp output in A1. Negative feedback loop through R20 operates to cancel result of previous integration. The heart of 200kHz Clock Generator is the Blocking Oscillator (Q11, T1 and CR18). This provides two outputs, one is sampling pulse of 10V peak at T1 (1-2) and the other is sawtooth at Q14 emitter.

AGC Detector.

AGC Detector, shown on bottom section of schematic Figure 8-8, provides a valid signal only when C Range is 100mF or 1F to reduce Oscillator signal level in A1 according to conditions of U1 and U2. On the other ranges, U2 output never exceeds about 7Vrms but on two ranges the 7Vrms may be exceeded which saturates U1 and U2 due to increased gain. Rectifier CR11 and CR12 and U10 rectifies U2 output and sends it to Smoothing Circuit and again to AGC Driver Q16. Q16 emitter level is normally negative and goes towards positive when U2 output increases. Q17 is on when Function is V or I_L to break out Oscillator signal in A1.

A2 Parts Locations under Fold



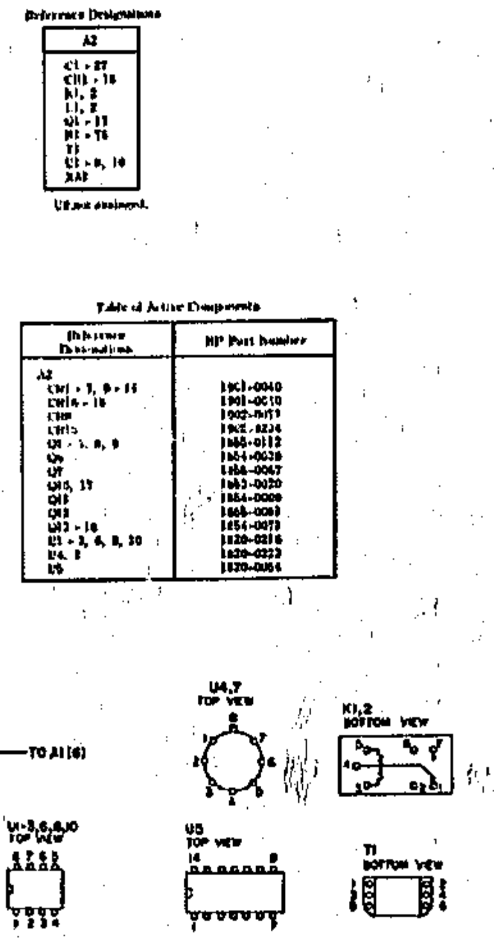
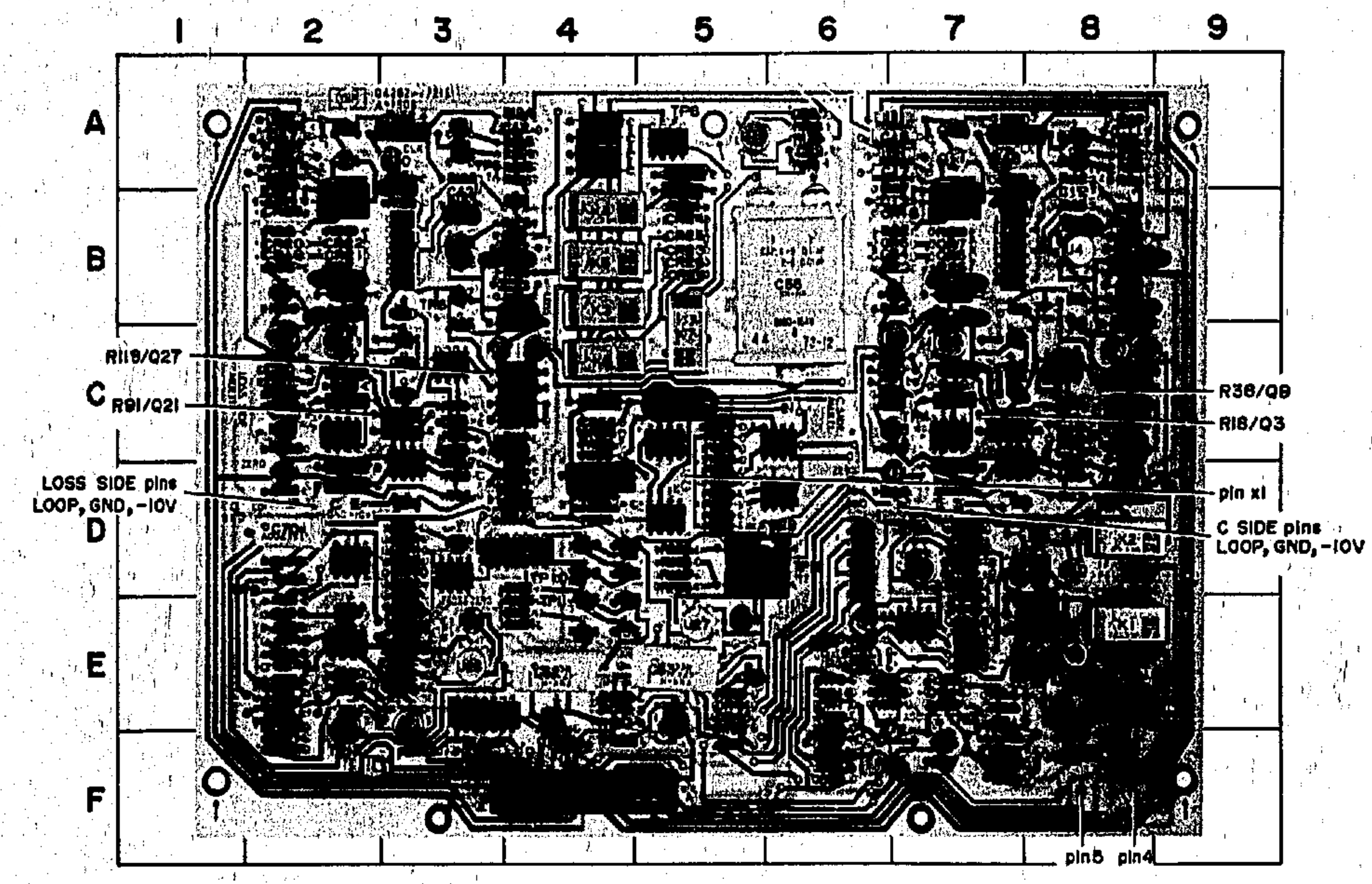


Figure 8-8. A2 Multiplier Board Ass'y.
(C Side Multiplier & AGC Detector)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C28	C-3	Q19	D-3	R115	C-4
C29	C-3	Q20	B-3	R116	C-4
C30	C-2	Q21	C-3	R117	C-3
C31	C-2	Q22	C-3	R118	C-4
C32	B-4	Q23	C-3	R119	C-4
C33	B-4	Q24	C-2	R120	B-4
C34	C-2	Q25	B-2	R121	C-4
C35	B-2	Q26	B-3	R122	B-4
C36	B-2	Q27	B-3	R123	B-4
C37	D-4	Q28	B-4	R124	A-4
C38	C-4	Q29	A-2	R125	A-3
C39	B-4	Q30	A-2	R126	A-4
C40	B-3	Q31	A-3	R127	B-3
C41	B-4	Q32	A-3	R128	B-3
C42	A-4			R129	B-2
C43	B-3	R77	E-5	R130	A-3
C44	B-2	R78	C-3	R131	A-3
C45	B-3	R79	C-3	R132	A-3
C46	A-3	R80	C-2	R133	A-4
C47	A-2	R81	C-2	R134	A-4
C48	A-2	R82	B-4	R135	A-4
C49	A-6	R83	B-4	R136	D-5
C50	E-6	R84	D-2	R137	D-5
C51	E-6	R85	D-3	R138	A-6
C52	D-7	R86	D-2	R139	A-6
C53	D-7	R87	D-2	R140	E-7
C54	E-6	R88	C-2	R141	E-6
		R89	D-3	R142	E-7
CR19	B-2	R90	C-3	R143	E-7
CR20	B-2	R91	C-3	R144	E-6
CR21	B-2	R92	C-2	R145	E-7
CR22	B-2	R93	C-2	R146	D-7
CR23	B-5	R94	B-2	R147	D-7
CR24	B-5	R95	B-2	R148	D-7
CR25	B-5	R96	B-2	R149	D-7
CR26	B-5	R97	B-2	R150	D-7
CR27	C-3	R98	B-2		
CR28	B-2	R99	B-2	T2	B-2
CR29	D-5	R100	C-2		
CR30	A-6	R101	C-2	U11	C-3
CR31	E-7	R102	C-2	U12	C-2
CR32	E-7	R103	E-5	U13	C-2
CR33	D-7	R104	B-5	U14	A-5
		R105	A-4	U15	C-3
K3	B-4	R106	A-4	U16	B-3
K4	B-4	R107	A-4	U17	B-3
K5	B-4	R108	A-4	U18	E-7
K6	C-4	R109	B-5	U19	A-5
		R110	A-6	U20	D-7
L3	A-2	R111	A-5	U21	D-6
L4	A-2	R112	C-4		
		R113	C-4	XA1	F-4
Q18	E-5	R114	C-4		

SEE INSIDE

Figure 8-8
A2 Multiplier Board Ass'y
(C Side Multiplier & AGC Detector)

A2 MULTIPLIER BO. UPERATION
(Loss Side Multiplier ano Unbalance Detector Section).

Loss Side Multiplier.

Loss Side Multiplier produces the product of Loss Side Integrator output (E_L) in A2 and Loss Side Amplifier output in A1. This operation is very similar to C Side Multiplier. Loss Side Amplifier output is sent to Integrator U16 and reference resistor R151. The $\pm E_s$ Generator CR27 and U15 provides plus and minus references through R118 and R121, respectively. The $+E_s$ is switched by FET Switch Q26 and Q27 as U16 input goes to zero during one period of 200kHz Clock. U16 output produces positive and negative going ramps in one clock period. Changing of ramp polarity occurs at the same level of U16 output and sawtooth waveform of Q32 in 200kHz Clock Generator. This is sensed by Comparator Q28, which changes state of U17C and U17B whose output is connected to FET Switch Q26 and Q27 to complete negative feedback loop and also to FET switch Q20 to Q23. U17 is driven in negative domain to match operation of FET Switches and provides waveform modulated to pulse width by Loss Side Amp output in A1.

The $\pm E_L$ Generator U11 accepts Loss Side Integrator output ($+E_L$) and provides $-E_L$. Q19 is temperature compensator for U11. The $+E_L$ is connected to Integrator U12 through R90 and $-E_L$ is connected to U12 through R91 and FET Switch Q20 to Q23 which is switched by timing from U17. U12 integrates the sum of these two inputs. U12 output through Q24 is sampled by applying sampling pulse, issued at each end of sawtooth from T2 in 200kHz Clock Generator, to Sampler (CR19 to CR22) and is stored in C36. Charge stored in C36 maintains input of Buffer Amplifier Q25 and U13. Therefore, U13 output forms staircase which is similar to and 180° out of phase with Loss Side Amp output in A1. Negative feedback loop through R93 operates to cancel result of previous integration. Following stage, U14, is ΩF-D Converter. The gain is one for Function ΩF and is $1000/2\pi f$ for Function D (f is measuring frequency in Hz). The heart of 200kHz Clock Generator is the Blocking Oscillator (Q29, T2 and CR28). This provides two outputs, one is a sampling pulse of 10V peak at T2(1-2) and the other is sawtooth at Q32 emitter.

Unbalance Detector.

Unbalance Detector judges unbalance condition from three sources of information. The first is sensed by U18 and U20 when unknown capacitance is too low compared to C Range setting. The second is by U19 when an error signal always exists on Null Detector. The third is by A2U35 when E_C or E_L exceeds +12V. U18 and CR31 plus CR32 form a Rectifier and the smoothed output is applied to Comparator U20. U20 output goes to L (low level) when the level at U20(3) goes lower than at U20(2), which means that Loss Side Amp output is too small. If an error signal exists, it is rectified by CR29 and fed to Comparator U19. U19(6) goes L when the level at U19(2) exceeds that at U19(3). Either one, when conditioned, drives Gate U21D(11) to H (high level) and also U21B(6) L. Finally, A2U35 output goes to L when E_C or E_L exceed +12V and similarly makes U21A(3) H, and U21B (6) L. Gate U21B is disabled when Function is V or I_L.

A2 Parts Locations under Fold

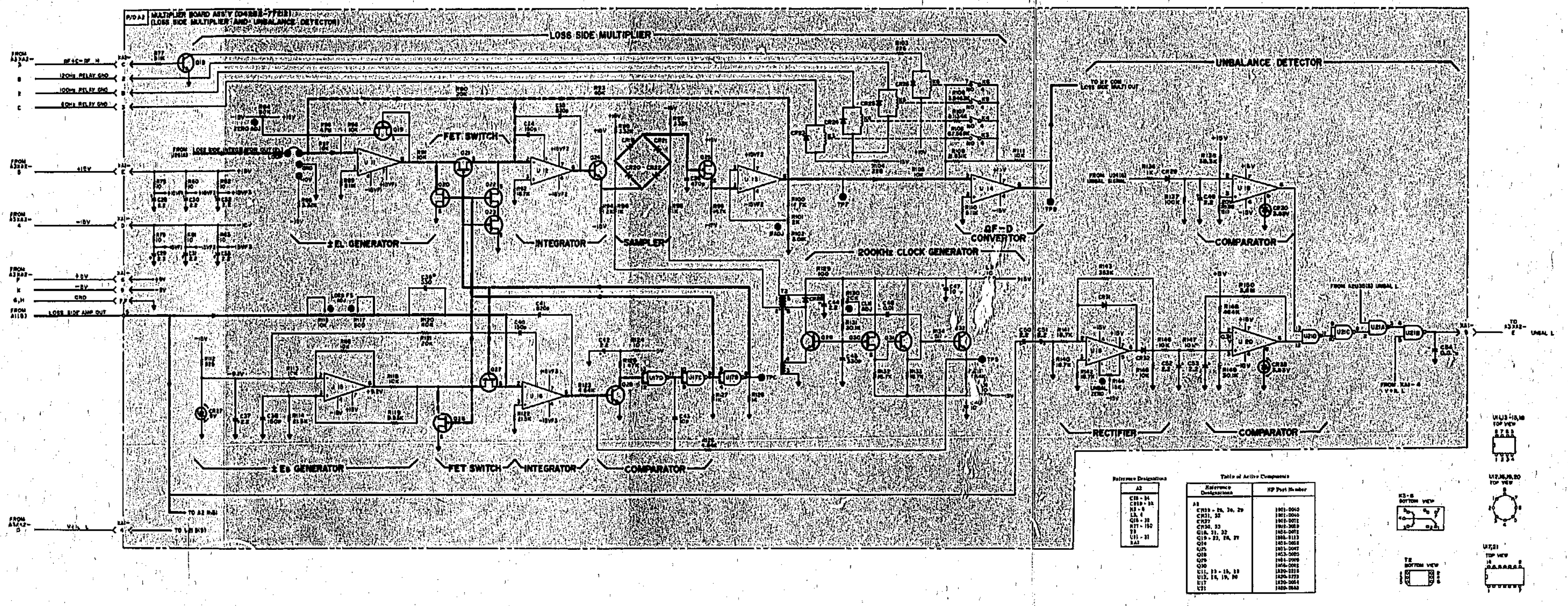
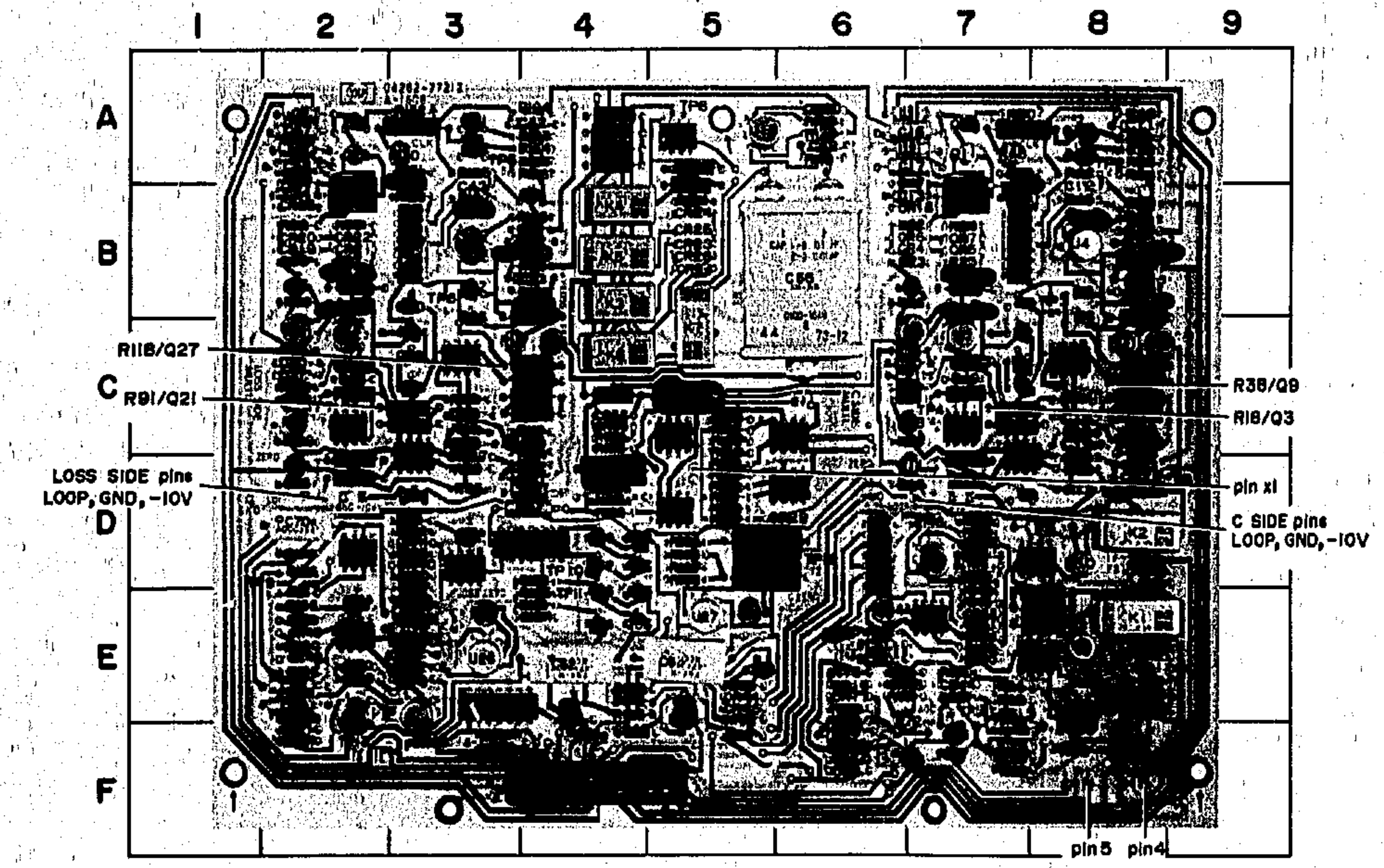


Figure 8-9. A2 Multiplier Board Ass'y.
(Loss Side Multiplier and Unbalance Detector)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C55	B-6	Q35	D-4	R179	E-3
C57	C-5	Q36	D-4	R180	D-3
C58	D-4	Q37	D-4	R181	D-3
C59	D-4	Q38	D-4	R182	D-3
C60	D-5	Q39	D-4	R183	D-3
C61	D-5	Q40	D-4	R184	E-4
C62	E-4	Q41	E-4	R185	D-4
C63	E-5	Q42	D-3	R186	E-2
C64	E-3	Q43	E-2	R187	D-3
C65	E-3			R188	E-2
C66	E-3	R151	C-4	R189	E-2
C67	D-4	R152	C-4	R190	E-2
C68	E-2	R153	C-4	R191	E-4
C69	E-2	R154	C-5	R192	D-4
C70	D-2	R155	D-4	R193	E-5
C71	D-3	R156	C-5	R194	E-4
C72	D-3	R157	C-5	R195	E-4
		R158	C-5	R196	E-4
CR34	B-5	R159	D-5		
CR35	C-4	R160	D-5	U22	C-5
CR36	C-4	R161	D-5	U23	D-5
CR37	E-2	R162	D-5	U24	C-6
CR38	E-2	R163	D-5	U25	D-6
CR39	E-3	R164	D-5	U26	E-3
CR40	D-3	R165	D-5	U27	E-5
CR41	D-3	R166	D-5	U28	E-2
CR42	E-2	R167	E-3	U29	E-3
CR43	E-2	R168	E-5	U30	E-3
CR44	E-5	R169	E-2	U31	D-2
CR45	E-5	R170	E-2	U32	D-3
CR46	E-4	R171	E-2	U33	D-4
		R172	E-4	U34	E-2
K7	C-5	R173	E-4	U35	E-5
		R174	E-3		
L5	D-4	R175	E-3	XA1	F-4
		R176	D-2		
Q33	E-4	R177	D-2		
Q34	E-4	R178	D-2		

SEE INSIDE

Figure 8-9
A2 Multiplier Board Ass'y
(Loss Side Multiplier and Unbalance Detector)

A2 MULTIPLIER BOARD OPERATION

Null Detector Section.

This section contains Summing Amplifier U22 to U24, Synchronous Detectors Q33 to Q40 and Integrators U26 and U27. Also included are Loss Auto Ranging Circuit U28 to U30 and Synchronous Detector Driver U31 to U34.

The three outputs, C Side Multiplier, Loss Side Multiplier and Loss Side Amplifier, are fed to Standard Capacitors C57 and C55 and Standard Resistor R151, respectively. They are summed at summing node of U22(2). U22 detects the summed difference as error and feeds it to U24. CR35 and CR36 work to reduce gain of U22 to prevent saturation during balancing process. U23 is employed to verify zero of dc level at U22(6). U24, which has a gain of 10, amplifies error signal and feeds it to Sync Detectors. One input is fed directly and the other is fed through Inverter U25. The two Sync Detector (FET Switches) are driven by pulses having a 90° phase difference with each other. Therefore, the two Detectors detect in phase and 90° phase different components and feed them to Integrators U26 (Loss Side) and U27 (C Side), respectively. U26 and U27 integrate error signals detected and provide outputs as E_L and E_C.

Loss Auto ranging Circuit selects proper Loss Range from two available ranges. This information is received from Comparators U28 and U29. U28(6) is L when U28(2) is above about +12V. Since U29(6) is H, F/F U30B/C is H at U30(8) and L at U30(6). This means up-ranging is required so Q41 is turned on to energize K7 to connect Standard Capacitor C55B. This operates to reduce U26 output E_L to one-tenth. Additionally, CR39 is turned off and U28A(1) is maintained L which prevents frequent range changing until charge of C64 reaches H. On the other hand, when E_L is below about +1V, U29(6) goes to L. This makes U30B(5) L. Since U30C(10) is H, F/F changes state as U30C(8) is L and U30B(6) is H. This means down-ranging is required so Q41 is turned off to connect C55A. Synchronous Detector Driver circuitry includes 90° Phase Shifter U31 and two comparators U32 and U34. U31 provides a sine wave 90° out of phase with input. U32 produces a square wave output in phase with U31 output. U33D/C is driven in negative domain to match operation of FET Switches. U34 also produces square wave in phase with input. U33A/B are similar to U33C/D.

A2 Parts Locations under Fold

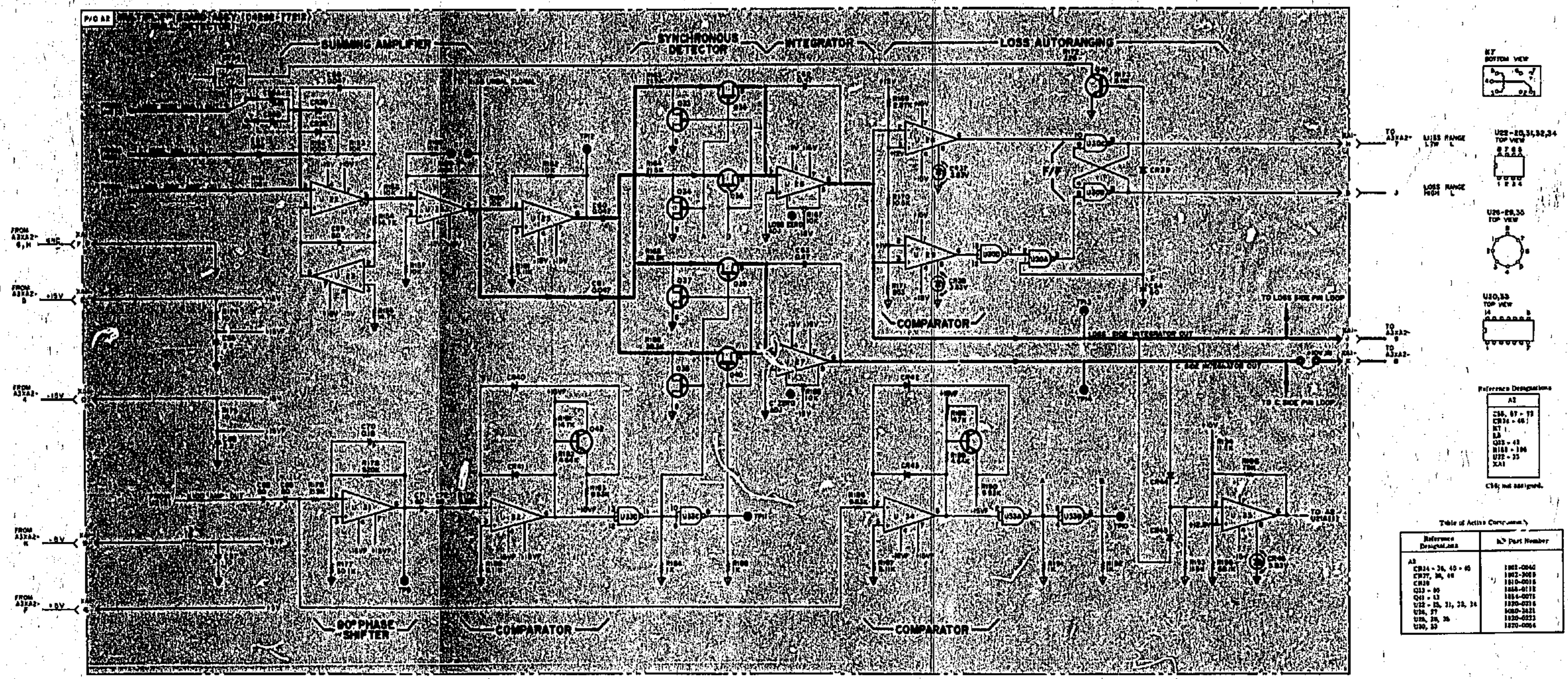
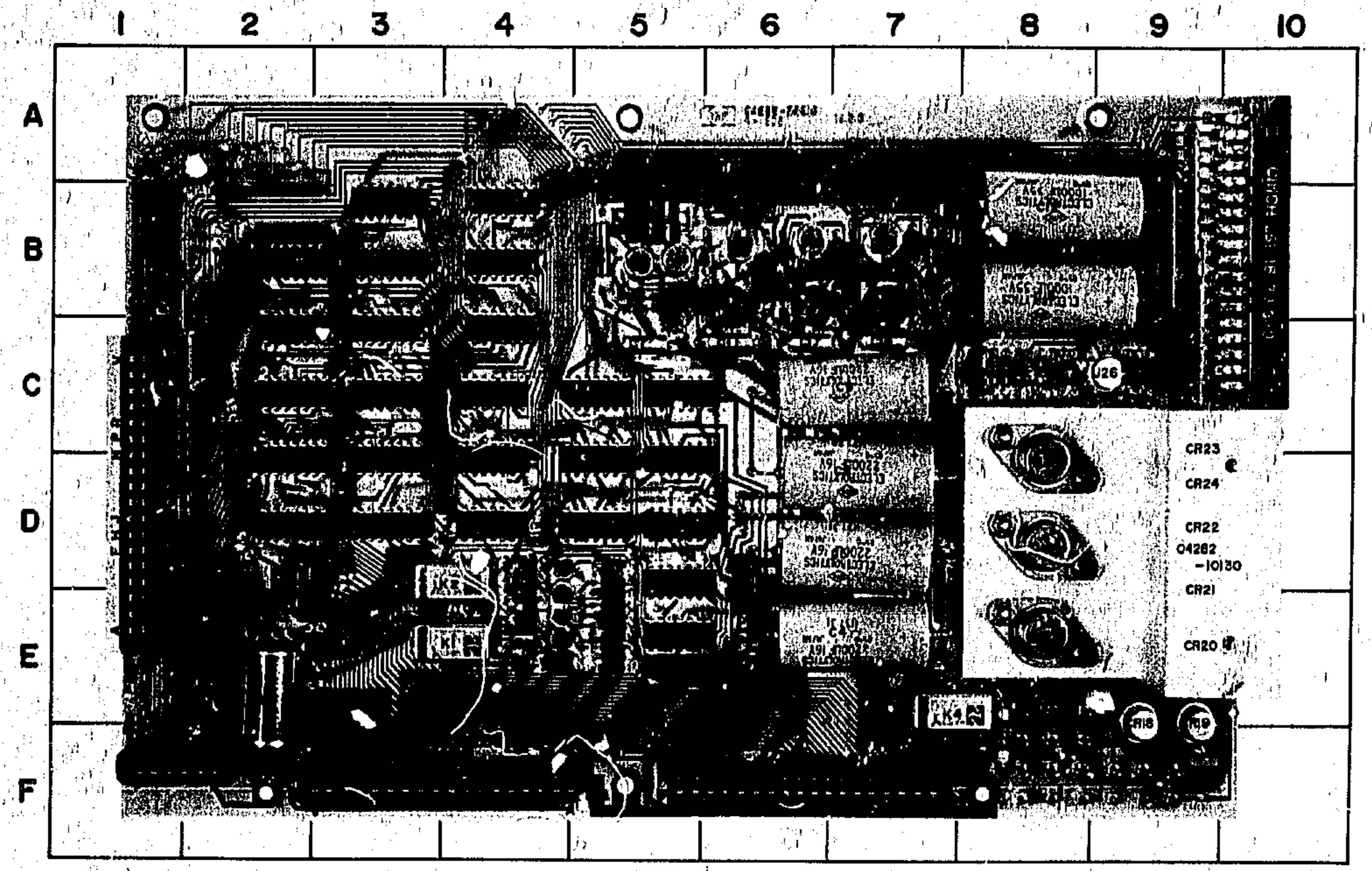
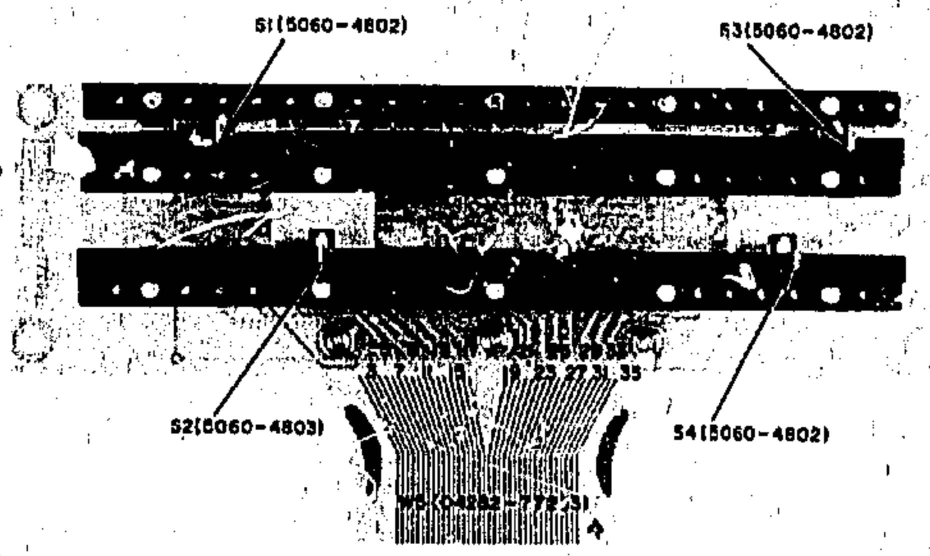


Figure 8-10. A2 Multiplier Board Ass'y, (Null Detector)





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C20	D-5	R1	E-4	U1	E-5
		R2	E-4	U2	D-5
CR1	E-4	R3	D-4	U3	C-5
CR2	E-3	R4	E-4	U4	D-4
CR3	E-2	R5	D-2	U5	D-5
CR4	D-4	R6	D-2	U6	D-4
CR5	D-5	R7	D-2	U7	C-5
CR6	E-5	R8	E-3	U8	D-5
CR7	D-5	R9	D-4	U9	D-5
CR8	E-5	R10	D-4	U10	D-5
CR9	E-4	R11	D-5	U11	C-2
CR26	D-5	R12	D-5	U12	D-2
		R13	E-5	U13	D-3
K1	E-4	R14	E-5		
K2	D-4	R15	E-5	XA1	F-6
K3	E-2	R16	E-5	XA2	F-3
		R17	E-5	XA3	F-1
Q1	E-4	R18	E-4	XA4	D-1
Q2	E-4	R19	C-9	XA5	B-10
Q3	D-4	R20	B-9		
Q4	D-4	R21	B-2		
Q5	E-4	R52	E-5		
Q6	E-4	R53	D-6		

SEE INSIDE

Figure 8-10
A2 Multiplier Board Ass'y
(Null Detector)

A3 CONTROL BOARD OPERATION

Function Control Section.

This section contains the various logic circuits. For explanatory purposes (in text and in diagrams), H or L after function letter abbreviation shows TTL logic level when that function is enabled, e.g., C H shows that C signal line is at TTL high level when Function C is selected.

Function Remote Gate is enabled to allow Function to be remotely programmed when FUNCTION switch is set to REM. Function Gate provides H (high level) when either one input goes L (low level). When C Function is selected, U5B(4) or U5B(5) go to L and U5B(6) is H. This makes U9C (8) L and C Enable Switch Q6 turns on. Q6 on means that C Side Integrator A2U27 output E_C is connected to DVM input in A4. U5B(6) H also makes U8A(1) L to enable transfer of C Range information.

Similarly, when D or ΩF Function is selected, Q4 is turned on to Loss Side Integrator A2U26 whose output E_L is connected to DVM input. Then U9A(12) becomes L to enable transfer of Loss (D or ΩF) range and units information.

When Functions C-D or C-ΩF are selected, U8B(4) goes to L to enable U10A/D. On the other hand, each negative transition of Busy H signal which comes from A4U13 causes a positive transition is Schmitt U1(6). This positive transition, which occurs at the same time as data transfer pulse, alternately changes F/F U2 state. Assuming U10D(13) is H (U2(9) = L) is equivalent to assuming an independent selection of Function C. The difference is that U10D(13)H makes U9A(12) L. This is required to enable transmission of information of range and unit of Loss (D or ΩF) because the display is Loss while DVM is measuring E_C (capacitance value) and vice versa.

When Function is V, U6A(3) H turns relay driver Q2 on which turns K2 on to connect voltage (V) to DVM input and makes U10B(4) L which completes voltage measurement circuit and also U6D(11) L which enables V Range Gate. Input voltage is attenuated by Voltage Divider R5 to R7 determined by DC BIAS RANGE switch A6S4 setting.

When Function is I_L, U6B(6) H turns relay driver Q1 on which turns K1 on to connect I_L Detector output (E_{IL}) to DVM input and makes U10B(4) L which completed I_L measurement circuit and also U6C(8) L which enables transfer of I_L Range and unit information.

A3 & A6 Parts Locations under Fold

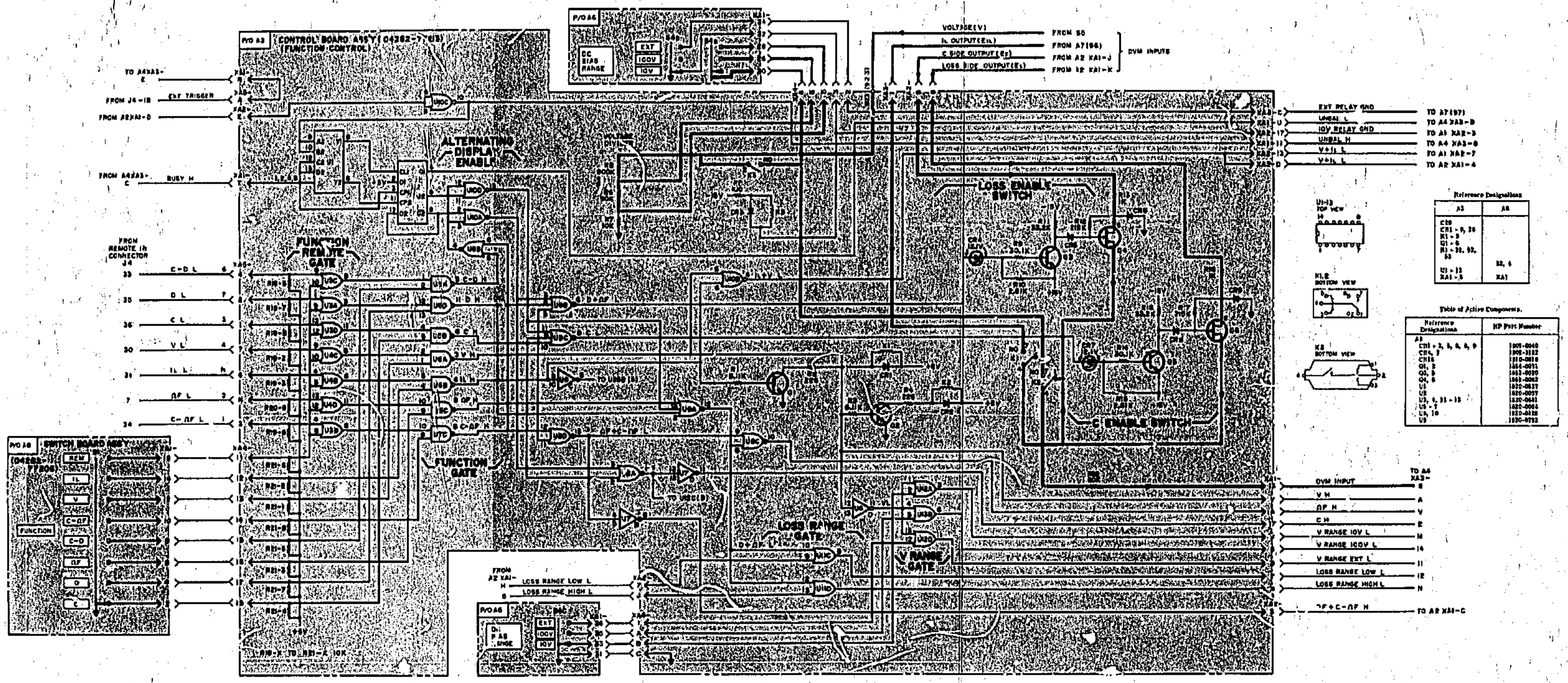
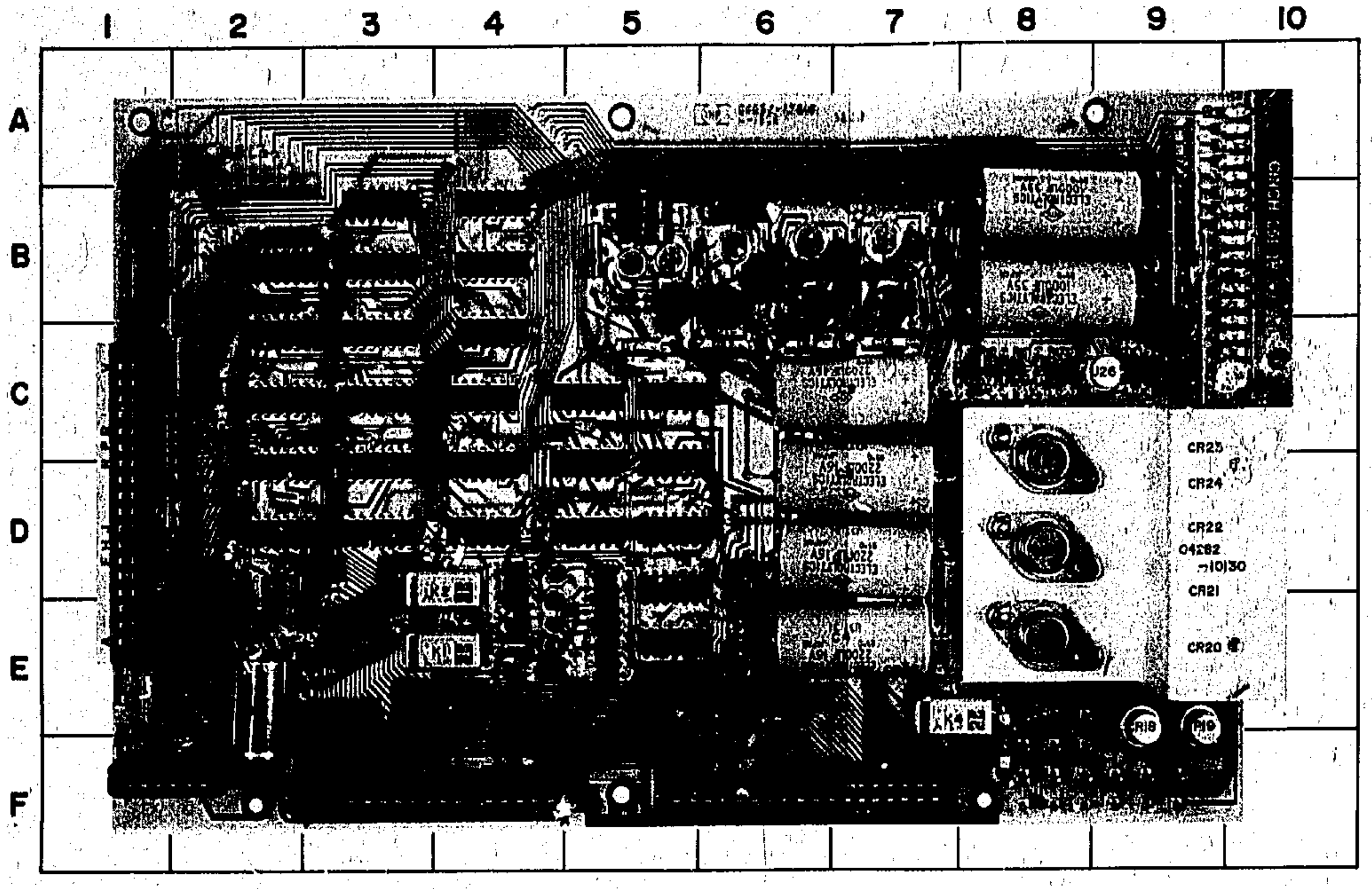
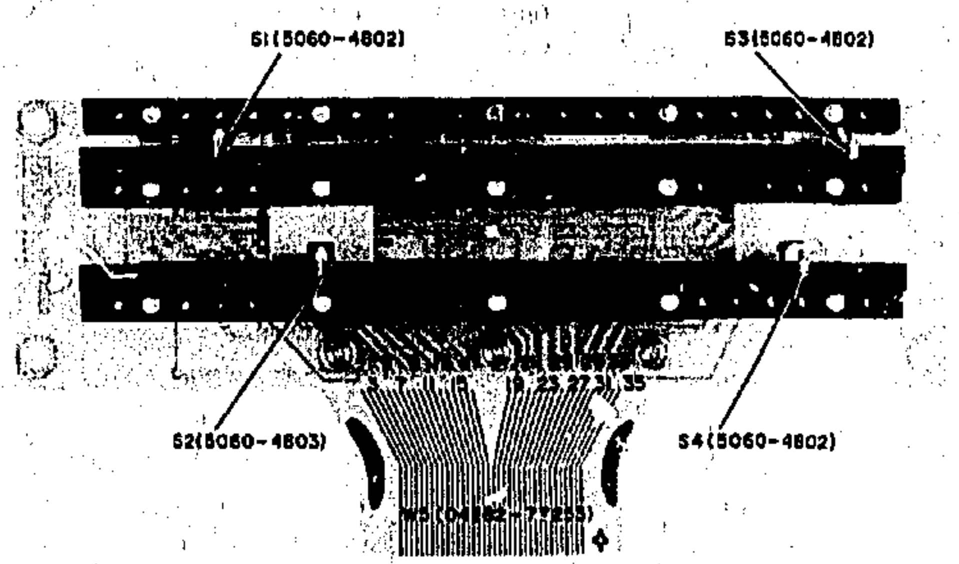


Figure 8-11. A3 Control Board Ass'y. (Function Control)
A6 Switch Board Ass'y.





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
R19	C-9	U12	D-2	U20	B-2
R20	B-9	U13	D-3	U21	B-3
R22	B-9	U14	B-4		
R23	C-1	U15	B-4	XA1	F-6
R24	B-1	U16	C-4	XA2	F-3
		U17	C-4	XA4	D-1
U4	D-4	U18	D-3	XA5	B-10
U11	C-2	U19	B-3		

Figure 8-11
A3 Control Board Ass'y
(Function Control)
A6 Switch Board Ass'y

SEE INSIDE

A3 CONTROL BOARD OPERATION

C Range Control Section.

This section contains C Range Remote Gate, C Range Gate, C Range Display Gate and Open Collector Relay Driver. The Remote Gate is enabled to allow C Range remote program when C RANGE switch is set to REM. C Range Gate is at L (low level) when either input goes L. This drives Open Collector Relay Driver to select a C range. Display Gate is enabled to display appropriate unit and decimal point when Function C is selected.

A3 & A6 Parts Locations under Fold

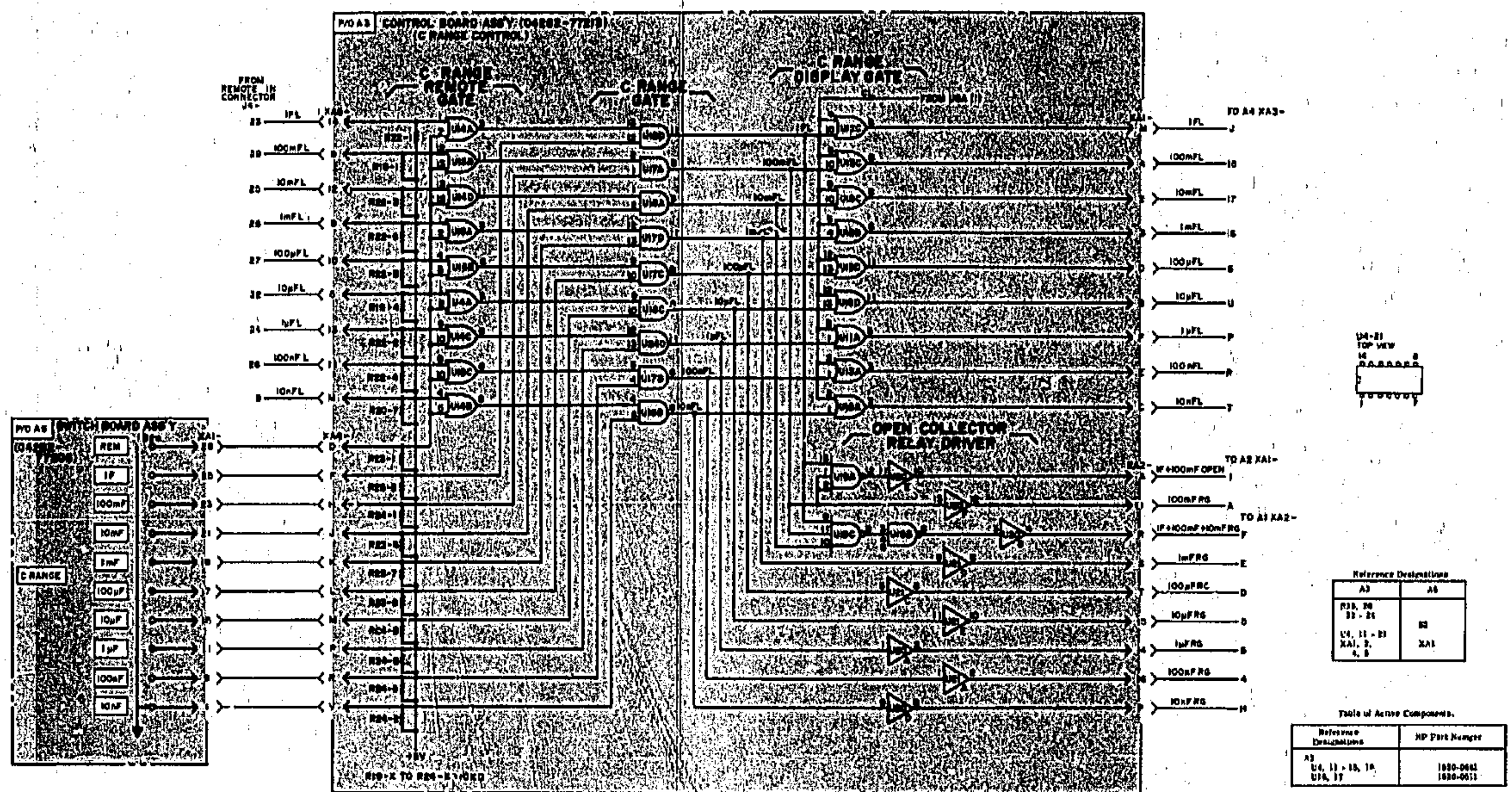
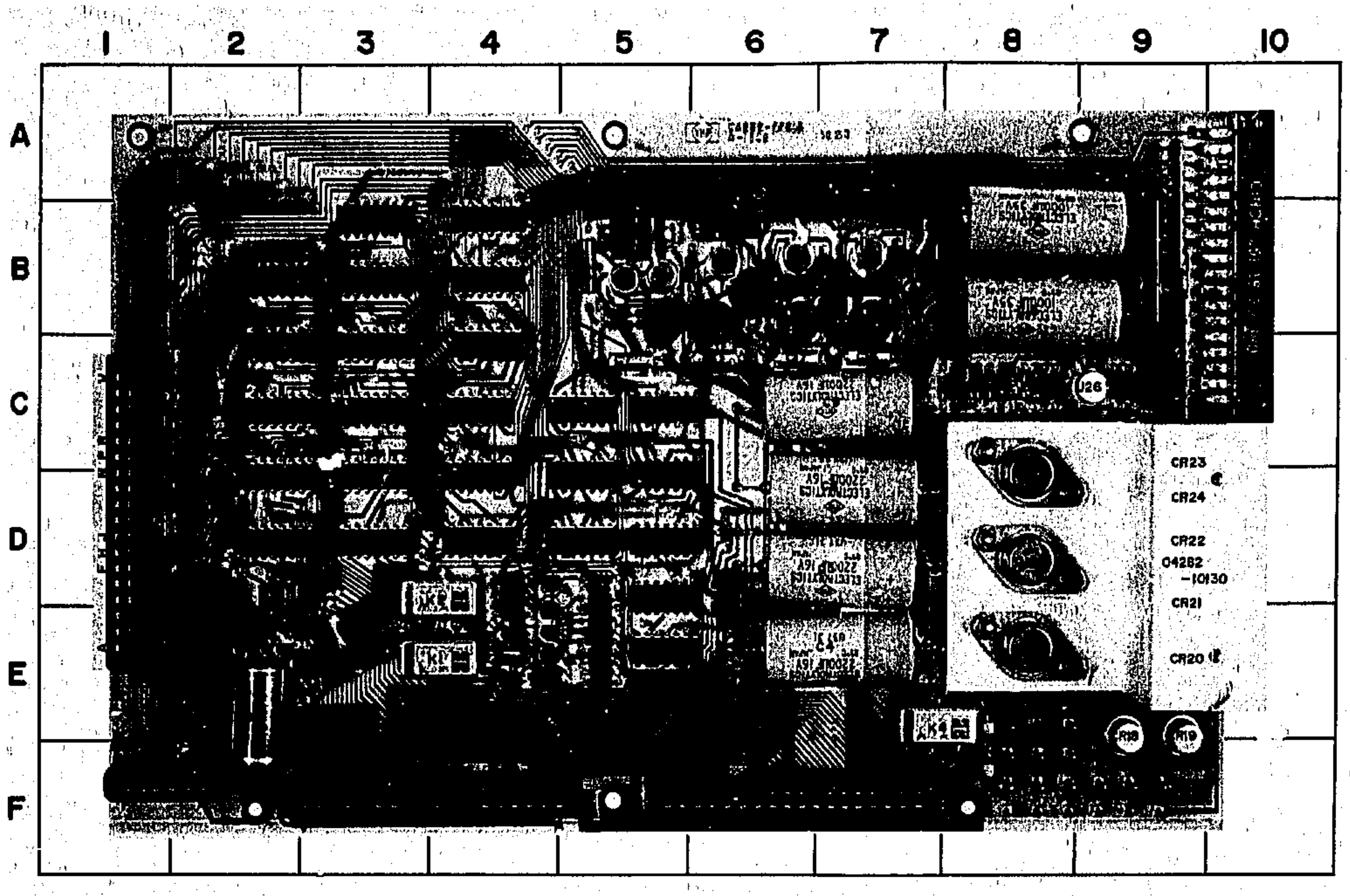
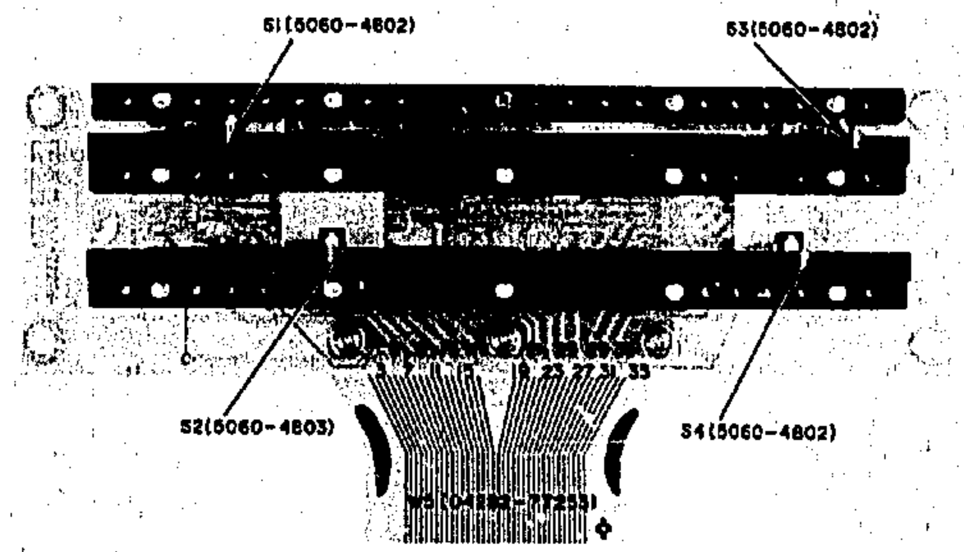


Figure 8-12. A3 Control Board Ass'y. (C Range Control)
A6 Switch Board Ass'y.





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Lod.	Ref. Desig.	Grid. Loc.
C1	B-7	R20	B-9	U11	C-2
C2	B-7	R23	C-1	U12	D-2
C3	C-8	R24	B-1	U22	C-3
		R25	E-8	U23	C-2
		R26	B-7	U24	C-3
CR10	C-8	R27	B-7	U25	D-2
CR11	C-8	R28	C-8	U26	C-9
CR12	C-8	R29	C-8		
CR13	C-8	R30	C-8	XA1	F-6
CR14	C-8	R31	C-8	XA2	F-3
CR15	C-8	R32	C-8	XA3	F-1
CR16	C-9			XA4	D-1
CR17	C-9			XA5	B-10

SEE INSIDE

Figure 8-12
A3 Control Board Ass'y
(C Range Control)
A6 Switch Board Ass'y

A3 CONTROL BOARD OPERATION

I_L Range Control Section.

This section contains I_L Range Remote Gate, I_L Range Gate and I_L Range Display Gate. Remote Gate is enabled to allow I_L Range remote programming when I_L RANGE switch set to REM. I_L Range Gate is at L (low level) when either input goes L. This is used for I_L Range selection in A7. Display Gate is enabled to display appropriate unit and decimal point when Function I_L is selected.

Check Fuse Sensor.

This circuit annunciates when measuring circuit fuse F2 is blown. When F2 blows, measuring signal is applied across R24. This signal is rectified by CR10, CR11 and fed to Comparator U26. U26 provides positive output and CR17 limits it to TTL high level.

A3 & A6 Parts Locations under Fold

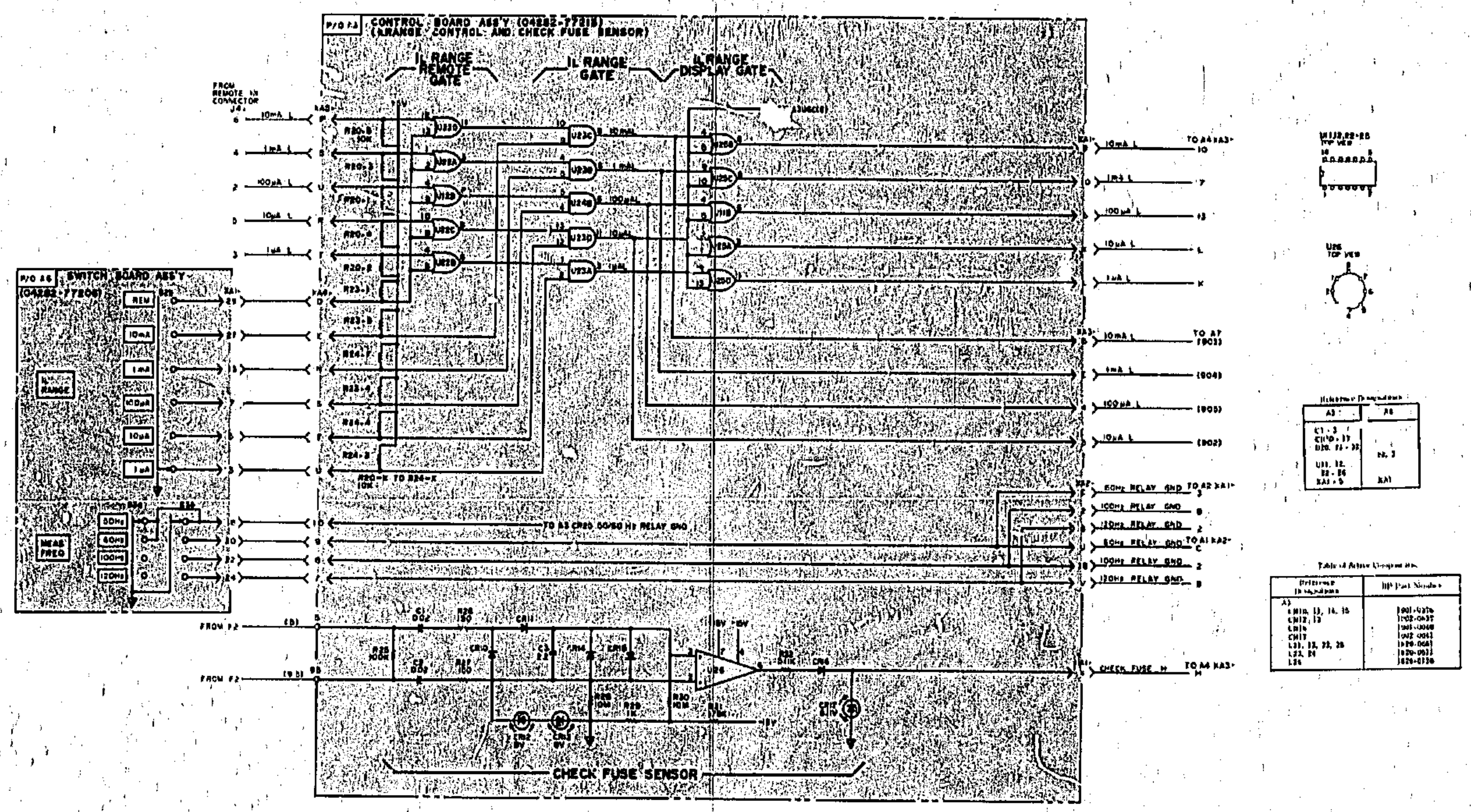
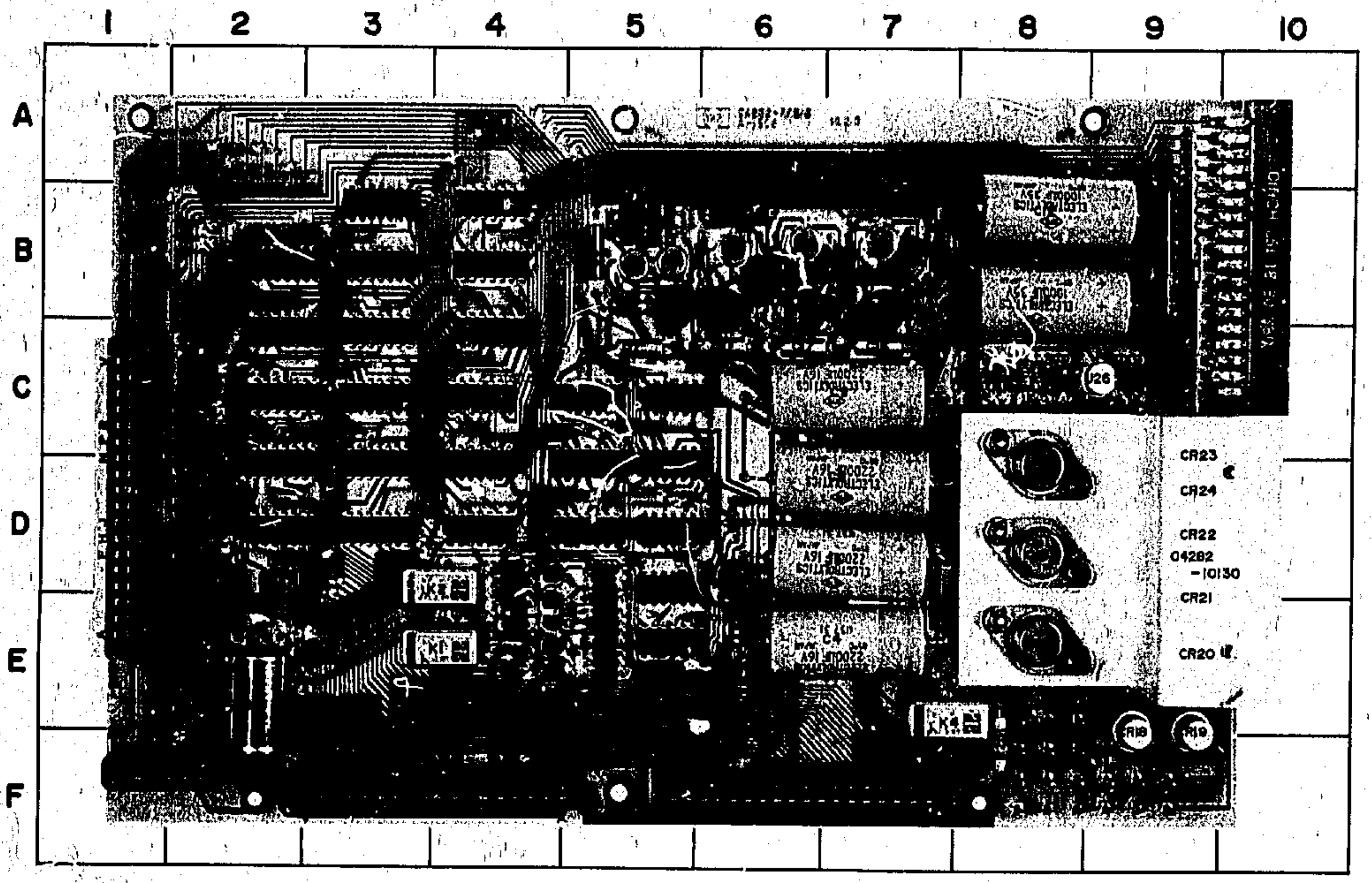


Figure 8-13. A3 Control Board Ass'y. (I_L Range Control and Check Fuse Sensor)
A6 Switch Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C4	E-7	CR22	D-10	R42	B-7
C5	D-7	CR23	C-10	R43	B-7
C6	B-5	CR24	D-10	R44	B-7
C7	C-5	CR25	E-7	R45	B-7
C8	D-7			R46	B-6
C9	C-7	K4	E-[illegible]	R47	B-7
C10	B-6			R48	D-6
C11	C-6	Q7	B-5	R49	B-7
C12	B-8	Q8	E-8	R50	E-8
C13	B-7	Q9	C-8	R51	E-7
C14	C-7	Q10	D-8		
C15	B-8			U27	B-5
C16	B-6	R33	B-5	U28	B-6
C17	C-6	R34	B-5	U29	B-7
C18	F-8	R35	B-5	U30	B-6
C19	F-8	R36	B-5		
		R37	B-5	XA1	F-6
CR18	E-9	R38	B-6	XA2	F-3
CR19	E-9	R39	B-6	XA3	F-1
CR20	E-9	R40	B-6	XA4	D-1
CR21	D-9	R41	B-6	XA5	B-10

Figure 8-13
A3 Control Board Ass'y
(I_L Range Control and Check Fuse Sensor)
A6 Switch Board Ass'y

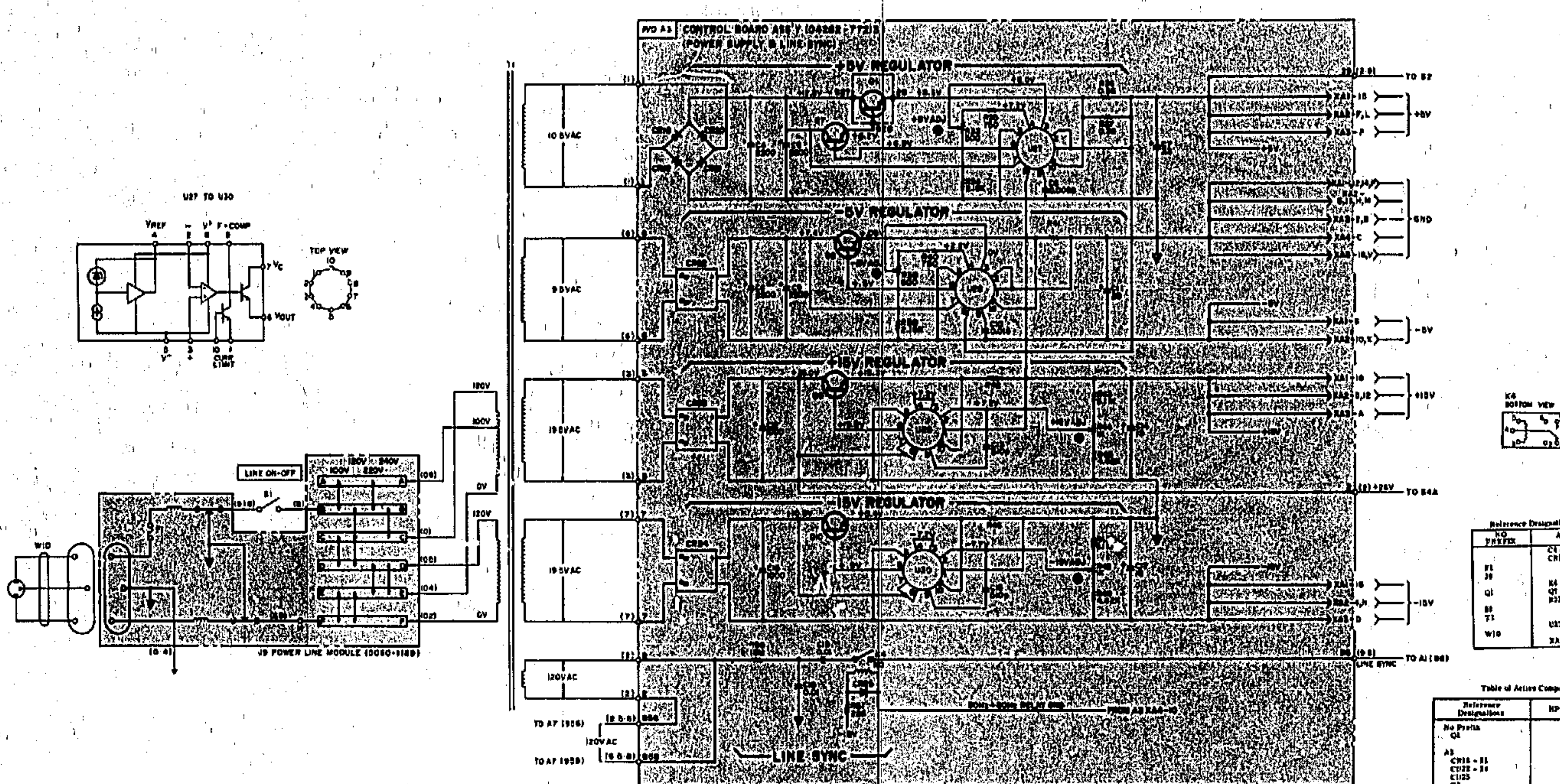
SEE INSIDE

A3 CONTROL BOARD OPERATION

Power Supply Section.

This section contains four regulated dc sources, +5V, -5V, +15V and -15V and one non-regulated dc source, +26V. Also included is an ac 120V source sent to Leakage Current Board A7 (Option 001). The +15V regulator output is used in +5V regulator and the +5V output is used in -5V regulator. A3 also furnishes the Line Synchronous signal which is taken from Relay K4. The four dc regulators are very similar. Only +5V Regulator is described. Rectifier CR18 to CR21 is bridge type rectifier. Series Regulator Q1 is placed on main chassis to enhance radiation of heat. Voltage Controller U27 has a reference and current limiter in itself. Its equivalent circuit is shown as an inset on the schematic (Figure 8-14). Control signals appear at U27(6) and ar[illegible]ed to Q1 through Q7. Current limiting signal is taken from R36 and R37.

A3 Parts Locator under Fold



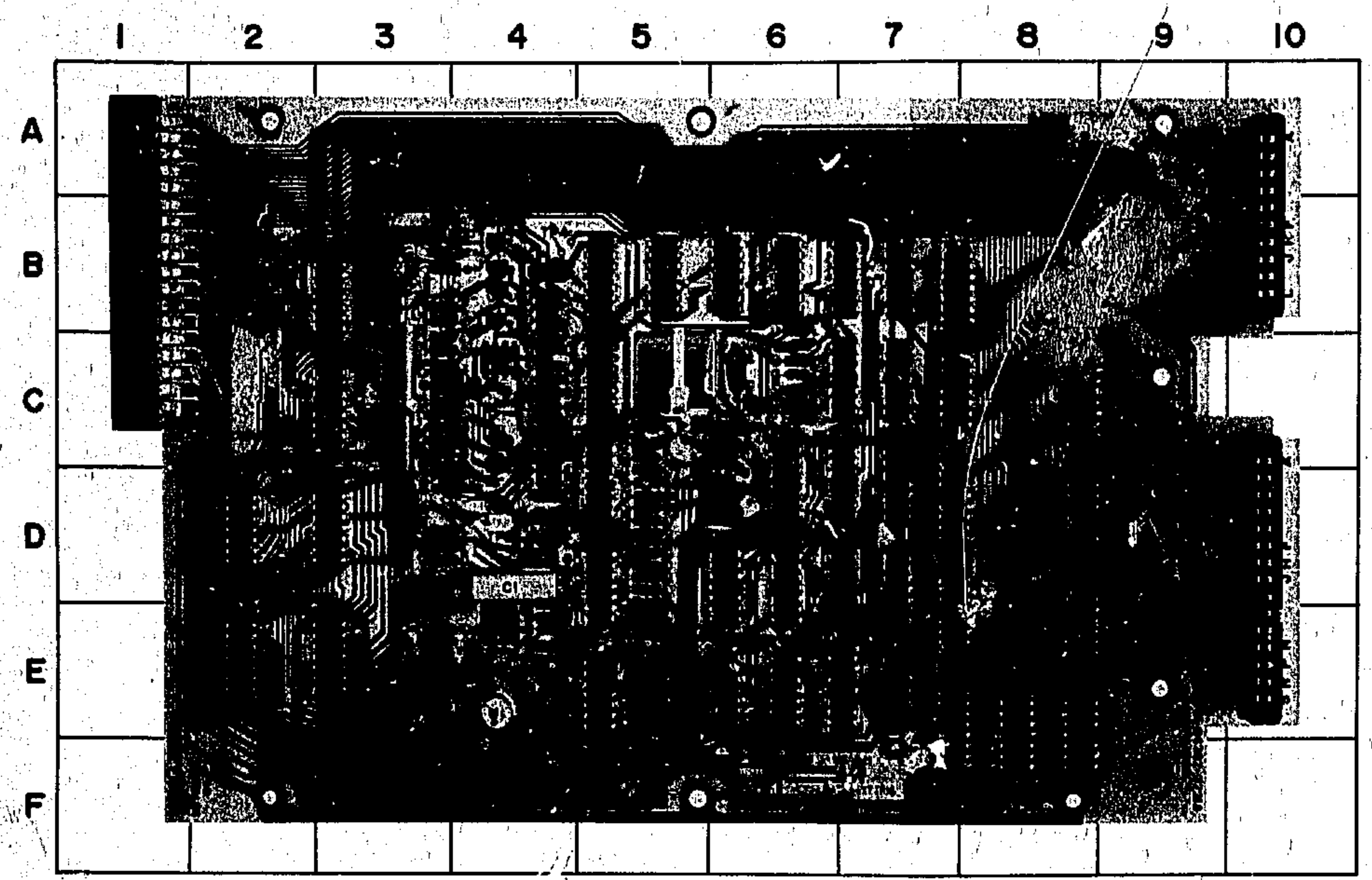
Reference Designations

NO PREFIX	A3
	C1 - 19 CR10 - 35
F1 J9	
	K4
Q1	Q7 - 10 R33 - 88
S1 T1	
	U27 - 30
W10	XA1 - 5

Table of Active Components.

Reference Designations	HP Part Number
No Prefix	
Q1	1854-0063
A3	
CR18 - 33	[illegible]
CR22 - 34	[illegible]
CR25	1901-0050
Q7	1854-0039
Q8 - 10	1854-0072
U27 - 30	1820-0196

Figure 8-14. A3 Control Board Ass'y. (Power Supply & Line Sync)
J9 Power Line Module.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	D-4	R1	E-4	R34	C-6
C2	D-4	R2	E-4	R35	C-6
C3	E-5	R3	E-4	R36	C-6
C4	E-5	R4	E-3	R37	C-6
C5	C-6	R5	E-4	R38	D-4
C6	C-6	R6	E-4	R39	E-[illegible]
C7	B-4	R7	D-4	R40	[illegible]
C8	D-4	R8	D-4	R41	D-3
C9	D-4	R9	D-5	R42	E-4
C10	C-4	R10	D-5	R43	D-4
C11	C-4	R11	D-[illegible]	R44	C-4
		R12	E-5	R45	C-4
CR1	E-4	R13	E-5	R46	C-4
CR2	E-4	R14	D-5	R47	C-4
CR3	E-4	R15	E-5	R48	C-4
CR4	E-4	R16	D-5	R49	C-4
CR5	D-4	R17	E-5	R50	C-4
CR6	B-4	R18	E-5	R51	C-4
CR7	B-4	R19	E-4	R52	D-4
CR8	C-4	R20	E-4	R53	D-4
CR9	C-4	R21	C-4		
CR10	D-4	R22	C-4	U1	E-4
CR11	E-4	R23	B-4	U2	E-4
		R24	C-4	U3	C-4
Q1	D-5	R25	D-4	U4	C-5
Q2	E-5	[illegible]	C-4	U5	B-5
Q3	B-4	R27	C-4	U6	B-5
Q4	B-4	R28	C-4	U7	B-6
[illegible]	B-4	R29	C-4	U8	B-6
Q6	B-4	R31	C-4	U9	B-7
Q7	C-4	R32	B-4	U10	C-7
Q8	C-4	R33	B-4		
Q9	D-4			XA3	F-3
				Y1	C-5

Figure 8-14
A3 Control Board Ass'y
(Power Supply & Line Sync)
J9 Power Line Module

SEE INSIDE

A4 DVM BOARD OPERATION

Pulse Width Modulation (PWM) Section.

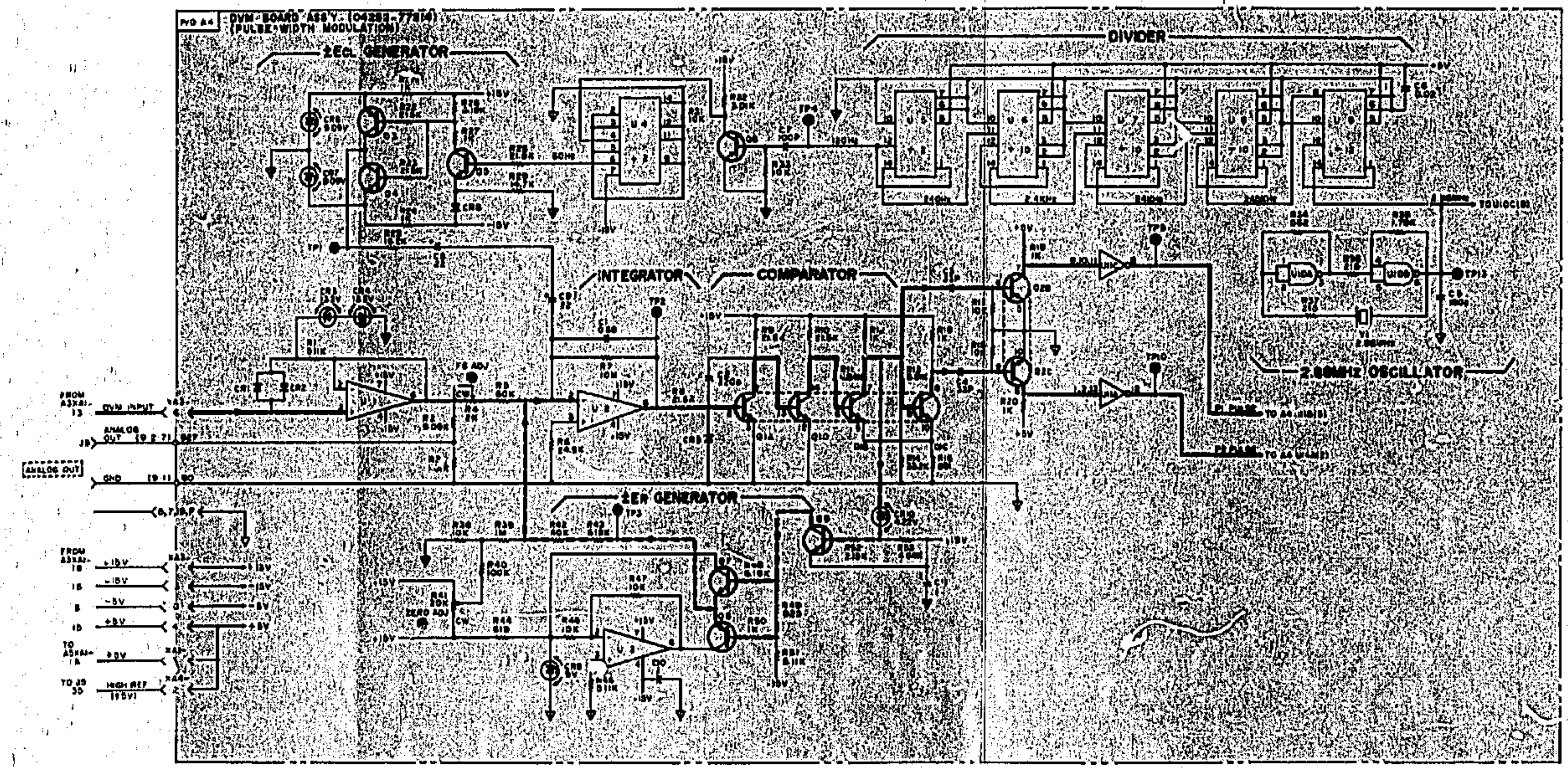
This section is employed to convert input voltage to time interval, which is accomplished by an $\pm E_{CL}$ Generator, an E_R Generator, an Integrator and a Comparator.

The $\pm E_{CL}$ Generator Q3 to Q5 and CR6/7 provide a 60Hz clock signal to determine the period of integration. The clock signal is obtained by dividing a 2.88MHz Crystal Oscillator output by 48,000 through Dividers U4 to U9. Q6 converts TTL level to negative level to fit Q5 drive requirements. Q3 and Q4 are switched alternately by Q5 and provide a symmetrical square wave whose frequency is 60Hz and whose amplitude is ±9.09V referred to CR6/7. The $\pm E_R$ Generator, whose duty cycle is determined by input voltage and whose frequency is [illegible], provides ±9V referred to CR9 by alternately switching Q7 and Q8. Integrator U2 receives two inputs $\pm E_{CL}$ and $\pm E_R$ plus another input which is either E_C, E_L, V or E_{IL} (unknowns).

When E_{CL} and E_R are positive, the most rapid negative going ramp is produced at U2(6). When this ramp reaches zero, Comparator Q1A is turned off and a positive pulse (called P1) occurs at U11C(8). This also turns Q9 off to connect minus reference ($-E_R$) to U2(2) through Q8. Since the sum of three inputs is still positive, U2(6) continues to produce a slowed down negative going ramp until 60Hz clock changes to $-E_{CL}$. Then U(6) changes to the most rapid positive going ramp and, when crossing zero point, turns Q1A on. At this point a positive pulse (called P2) is produced at U11A(12). Q9 is also turned on to connect positive reference ($+E_R$) through Q7 to U2(2). The slowed down negative going ramp continues until 60Hz clock changes to $+E_{CL}$. This completes one cycle which has created P1 and P2 Pulses whose interval represents unknown input voltage.

Analog output is Impedance Converter U1 output divided by 10 and produces 1V output for a 10V input.

A4 Parts Locations under Fold



Reference Designations

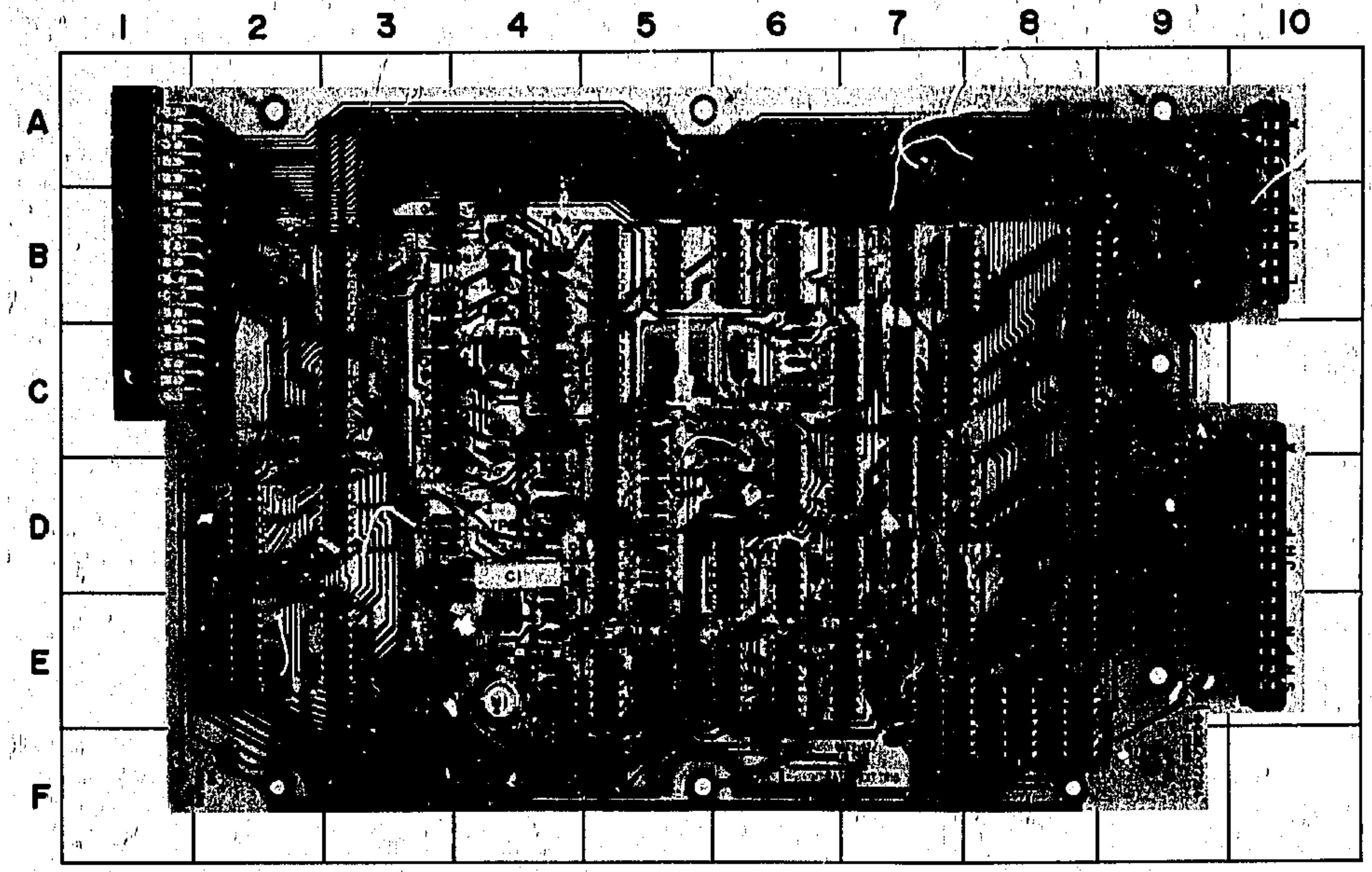
A4
C1 - 11 CR1 - 10 Q1 - 9 R1 - 53 U1 - 10 XA3 Y1

R30, not assigned.

Table of Active Components.

Reference Designations	HP Part Number
A4	
CR1, 2	1901-0376
CR3, 4	1902-3193
CR5, 6	1901-0040
CR6, 7, 9	1902-3150
CR10	1902-3070
Q1, 2	1850-0033
Q3, 8, 9	1853-0016
Q4, 5, 7	1854-0215
Q6	1853-0020
U1	5060-3621
U2, 3	1820-0493
U4	1820-1104
U5, 9	1820-0066
U6 - 8	1820-0600
U10	1820-0054
Y1	0410-0307

Figure 8-15. A4 DVM Board Ass'y, (Pulse Width Modulation)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C12	C-6	R54	D-6	R74	B-9
C13	C-6	R55	C-6	R75	B-9
C14	C-6	R56	E-4	R104	F-6
C15	E-5	R57	E-4	R105	B-9
C16	E-4	R58	E-4	U10	C-7
C17	D-6	R59	E-4	U11	E-6
C18	D-6	R60	D-5	U12	D-6
C19	D-6	R61	C-5	U13	D-6
C20	E-7	R62	C-5	U14	E-7
C21	E-6	R63	D-5	U15	E-6
C22	D-7	R64	D-5	U16	D-6
		R65	C-5	U17	D-7
CR11	F-4	R66	D-5	U18	D-7
		R67	D-5	U19	E-8
Q2	E-5	R68	D-5	U20	E-8
Q12	D-5	R69	C-6	U21	B-3
Q13	A-9	R70	E-7		
Q14	B-9	R71	E-6	XA1	B-10
Q15	B-9	R72	B-4	XA2	D-10
Q16	B-9	R73	E-9	XA3	F-3
Q17	B-9			XA4	B-1

SEE INSIDE

Figure 8-15
A4 DVM Board Ass'y
(Pulse Width Modulation)

A4 DVM BOARD OPERATION

Control Logic Section.

This section includes Rate Generator, Timing Pulse Generator and various Gates. Rate Generator Q2A/D is astable MV whose period is variable from 0.3 to 2.0 seconds with RATE control.

The positive transition at U12(8) driven internally or externally causes positive transition at U13(6) or negative transition at U13(1) which holds H (high level) or L (low level) for about 80ms, respectively. They are Busy H or L and indicate busy period for one reading. Timing Pulse Generator Q12 provides negative Set Pulse at the beginning of busy period and positive Transfer Pulse and negative Print Command at the end of busy period.

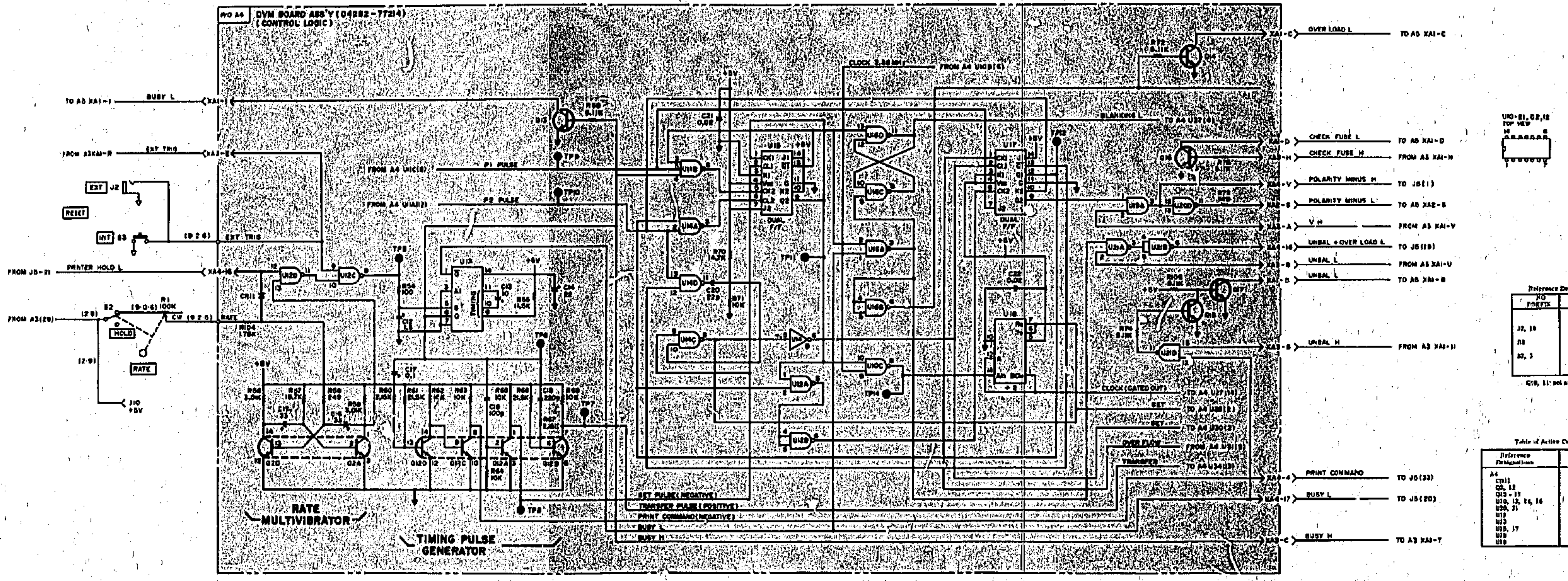
When Set Pulse is issued, Dual F/F U15(13) and U17(13) are set to H and Counter U27 to U31 are set to zero. P1 Pulse Gate U11B enabled by U11B(3, 4) H allows acceptance of P1 Pulse. P2 Pulse Gate U14A is closed by U17 (12) L. P1 Pulse makes U15(9) H and opens Clock Gate U10C. At this point, the 2.88MHz Clock passes through U10C and goes into ÷2 Counter U18 whose output is applied to Counter U27. When Counters U27 to U31 count 6,000, U17(1) goes H and 12,000 counts of Counters returns U17(1) to L (Counter is reset to zero by itself). This negative transition makes U17(12) H and opens P2 Pulse Gate U14A. Then P2 Pulse appears at U14A(2) and makes U15(9) L to close U10C. Counters hold result which represents input voltage of PWM (Pulse Width Modulation) section. Negative transition of U15(9) also makes U15(13) L to close U11B. Above description is for positive input.

For negative input, since P2 Pulse occurs before the completion of half a period of 60Hz clock signal (before Counters count 12,000), P2 Pulse Gate U14A is closed but Gate U14D is opened. P2 Pulse passing through Gates U14D/C resets Counters.Counter again begin to count and is reset to zero by itself at 12,000 counts (after half period of 60Hz Clock from P2 Pulse). Under above conditions, next P1 Pulse is applied to U15(5). This makes U15(9) L and closes Clock Gate U10C and also P1 Pulse Gate U11B. Counters hold result which represents input voltage.

Bottom half of Dual F/F U17 provides polarity assignment. This is accomplished by checking which pulses (P1 or P2) are coincident with negative transition at U15(9) which is applied to U17(5). When P1 Pulse occurs, a negative transition at U17(5) transfers momentary H at U17(7) to U17(9) L. U17(9) L means positive input. Similarly, if a P2 Pulse occurs, it makes U17(9) H which means negative input.

U16 which forms F/F and Gates is Overload Detector. In an overload condition, P1 and P2 Pulses are not issued because of saturation of PWM section. Therefore, U15(13) remains H for one reading period after Set Pulse. When Busy L changes to H at the end of busy period, Gate U16(3) goes to L whose signal is Overload, F/F U16C/D stores this signal and U16D(11) provides Blanking L signal to blank display. This F/F is employed to keep display blanked until end of next busy period.

A4 Parts Locations under Fold



Reference Designations

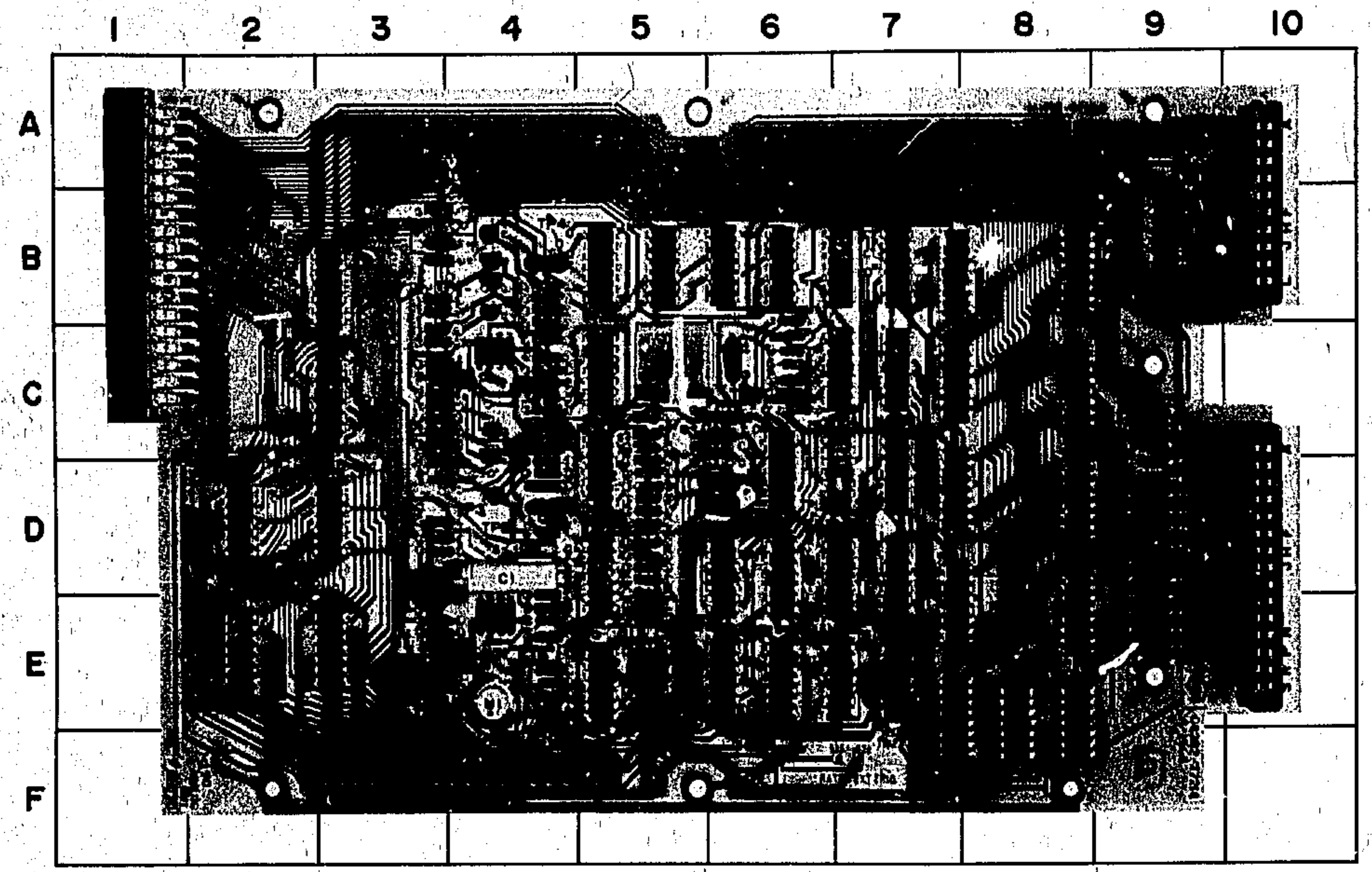
NO PREFIX	A4
J2, 10	C12 - 32
R1	CR11
S2, 3	Q2, 12 - 17
	R54 - 79, 104, 105
	U10 - 21
	XA1 - 4

Q10, 11: not assigned

Table of Active Components.

Reference Designation	HP Part Number
A4	
CR11	1910-0016
Q2, 12	1854-0039
Q13 - 17	1854-0071
U10, 12, 14, 16	1820-0054
U20, 21	1820-0054
U11	1820-0068
U13	1820-0301
U15, 17	1820-0075
U18	1820-0094
U19	1820-0511

Figure 8-16. A4 DVM Board Ass'y. (Control Logic)



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
U21	B-3	U24	C-3	XA1	B-10
U22	E-2	U25	D-2	XA3	F-3
U23	E-3	U26	D-3	XA4	B-1

SEE INSIDE

Figure 8-16
A4 DVM Board Ass'y
(Control Logic)

A4 DVM BOARD OPERATION

Unit and Decimal Point Logic Section.

This section converts unit and decimal point information obtained from combination of Function and Range settings to appropriate individual information. For example, when Function C and Range 1mF are selected, U25B(6) and U26 (6) go to H which means that unit is "mF" and decimal point is positioned at DP5. Same information is sent to DIGITAL OUT J5 connector.

A4 Parts Locations under Fold

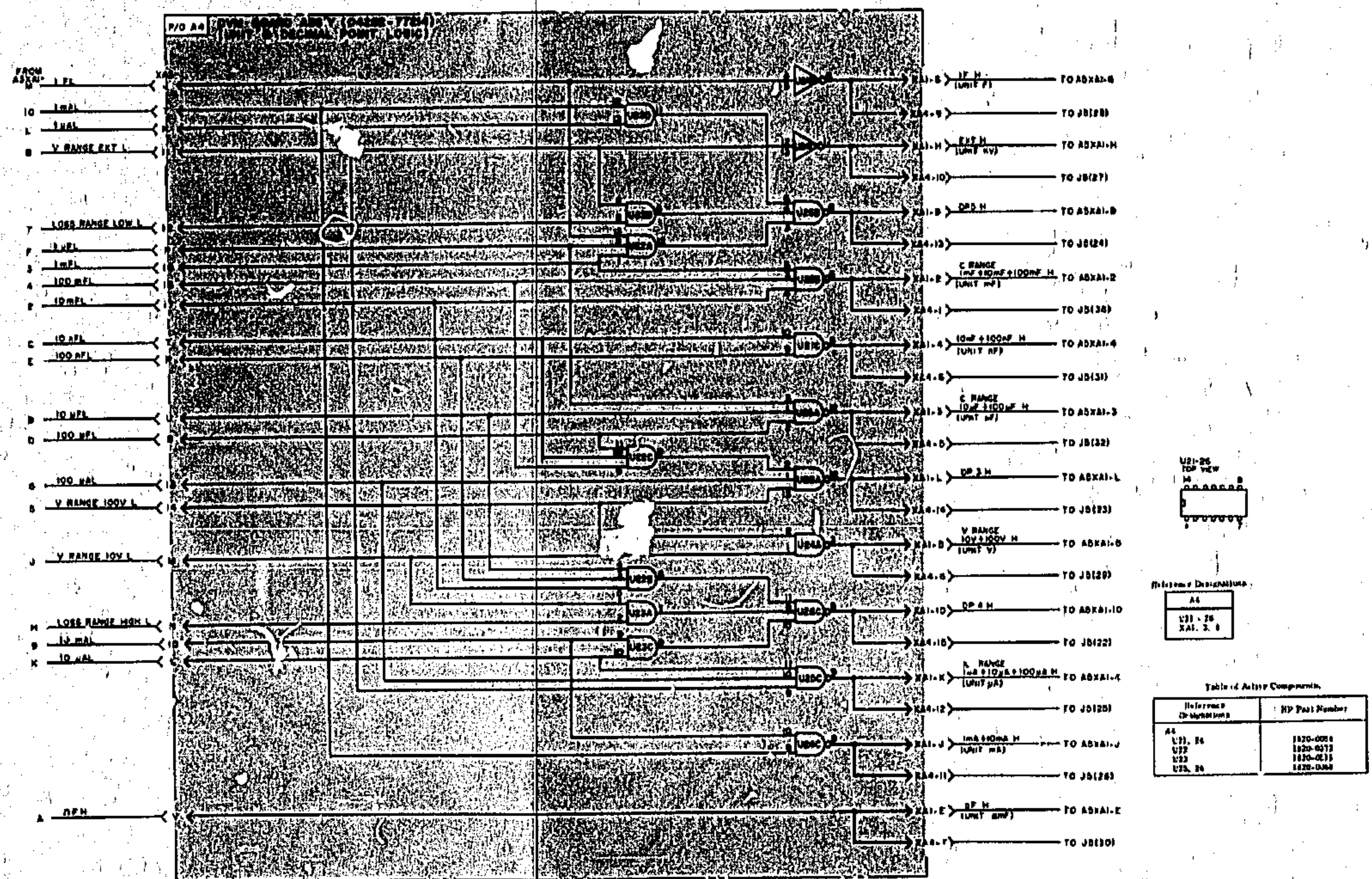
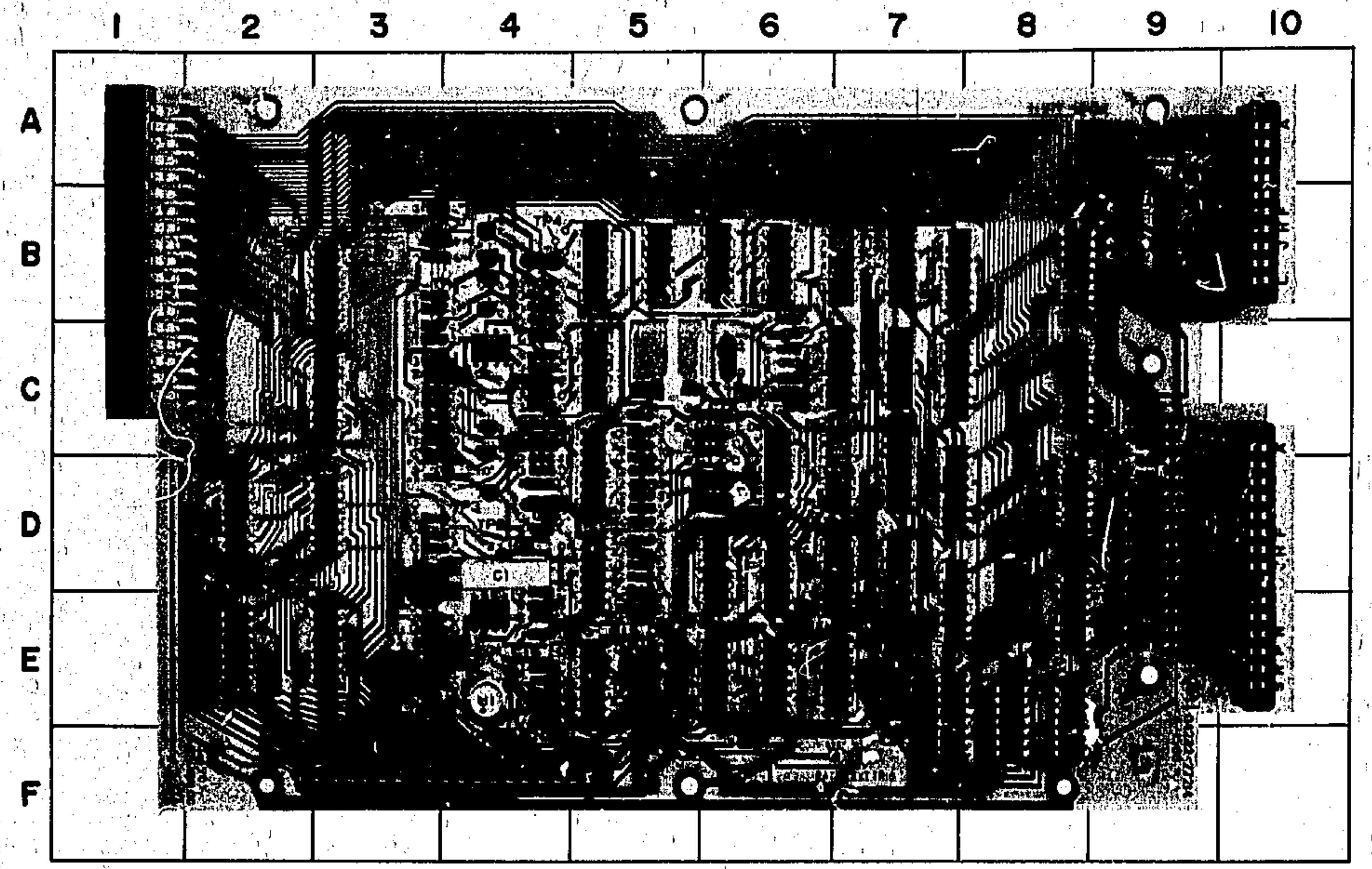
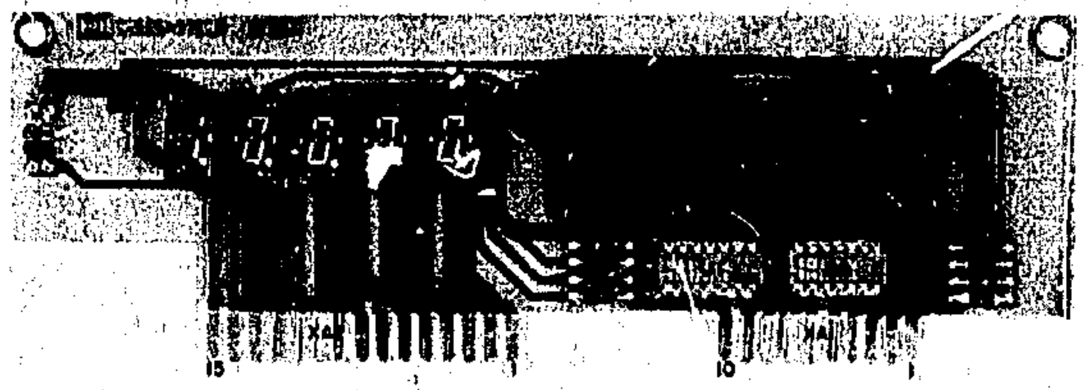


Figure 8-17. A4 DVM Board Ass'y. (Unit & Decimal Point Logic)





PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C23	C-7	R90	D-9	U27	B-7
C24	F-7	R91	D-9	U28	C-7
		R92	D-9	U29	D-7
R76	C-9	R93	D-9	U30	D-7
R77	C-9	R94	D-9	U31	E-7
R78	D-9	R95	D-9	U32	B-8
R79	C-9	R96	D-9	U33	D-8
R80	C-9	R97	E-9	U34	D-8
R81	C-9	R98	D-9	U35	E-8
R82	D-9	R99	E-9	U36	C-8
R83	D-9	R100	E-9	U37	B-8
R84	D-9	R101	D-9	U38	C-8
R85	D-9	R102	E-9	U39	D-7
R86	D-9	R103	E-9	U40	E-7
R87	D-9				
R88	D-9	U19	E-8	XA2	D-10
R89	D-9	U20	E-8	XA3	F-3

SEE INSIDE

Figure 8-17
A4 DVM Board Ass'y
(Unit & Decimal Point Logic)

A4 DVM BOARD OPERATION

Counter, Buffer Storage and Decoder Circuits.

These circuits form three stages and are connected in cascade. Counter U27 to U31 consists of three different counters. U27 to U29 are decade counters, U30 is ÷4 counter and U31 is ÷3 counter, for a total maximum counting capacity of 11,999. Counter U27 to U31 is reset to zero by Set Pulse at beginning of busy period. Then Counter continues to count 2.88MHz Clock divided by two while Clock Gate U10C opens. During this period, Counter provides overflow signal at U31(9) which goes to H at 8,000 counts and returns to L at 12,00· counts. When Clock Gate U10C is closed, Counter holds result which is BCD and which represents input voltage.

Next stage is Buffer Stor..ge U32 to U35 whose input is BCD output from Counter and whose output is previous data. The transfer between input and output is performed by Transfer Pulse issued at end of each busy period. Therefore, Buffer Storage holds data transferred for one reading period. Input for U32 to U34 is up to 9 decimal numbers and for U35 is up to 11 (to allow overranging). U19B/C and U20A/B are employed to take up this carry and enable display for overranging digit. U36, 1st Digit Enable, sends U32 output to Decoder when Function is C. In other functions, all four lines hold H to blank 1ct digit.

Buffer Storage output is connected to Decoder and DIGITAL OUT J5 connector. Decoder U37 to U40 in last stage is BCD to seven segment decoder. Decoder enables to display appropriate number according to input BCD.

A5 DISPLAY BOARD OPERATION

This Assembly contains Seven Segment Numeric Display DS1 to DS4, Polarity and Overrange Display DS5, Annunciators DS6 to DS11, Rate Annunciator DS12, Unit Display DS13 to DS21 and Inverters U1 and U2. DS1 to DS5 are LED including decimal point each segment of which illuminates when corresponding pin is L (low level). Decimal point is valid only in DS3 to DS5. DS6 to DS11 light when the line is L and indicate that displayed data is invalid. DS12 is single LED which illuminates for busy period. DS13 to DS21 display measuring unit when the line is H (high level) because inputs are inverted by Inverters U1 and U2.

A4 & A5 Parts Locations under Fold

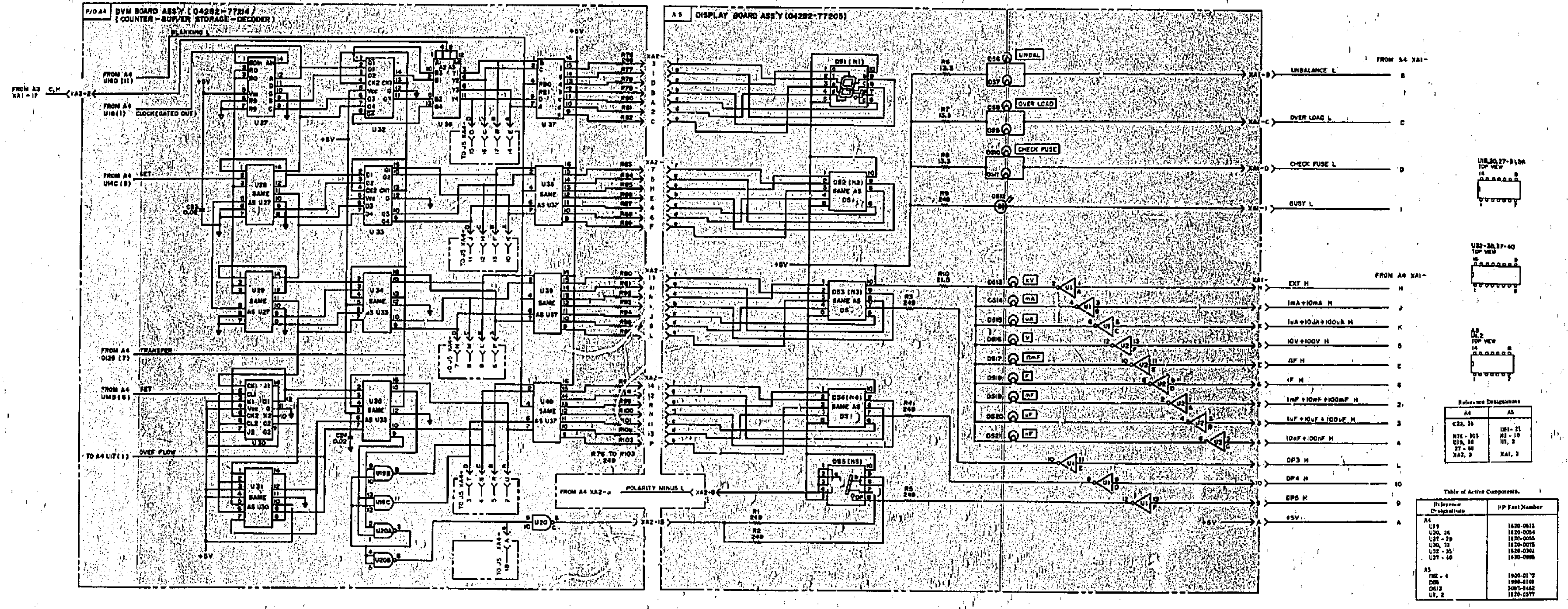
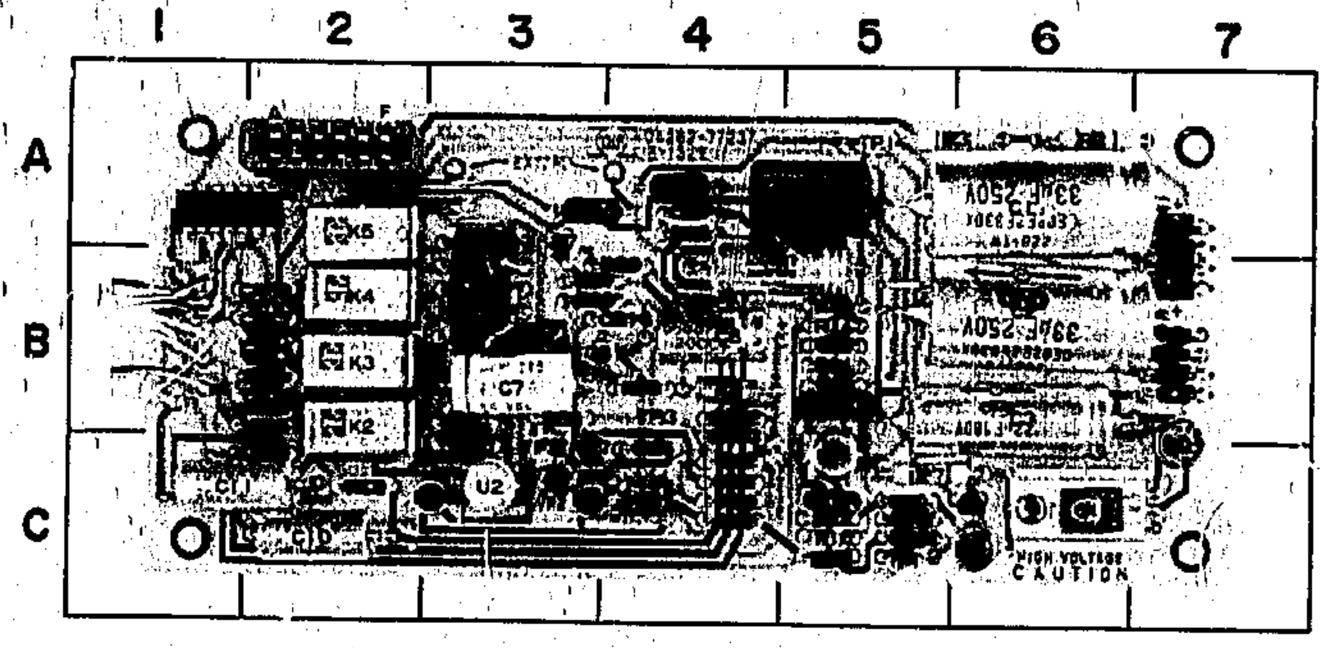


Figure 8-18. A4 DVM Board Ass'y. (Counter - Buffer Storage - Decoder)
A5 Display Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	A-6	K1	A-5	R17	B-5
C2	B-6	K2	B-2	R18	C-5
C3	B-6	K3	B-2	R19	B-3
C4	C-5	K4	B-2	R20	B-3
C5	B-5	K5	A-2	R21	B-3
C6	B-4			R22	B-3
C7	B-3	Q1	C-6	R23	A-3
C8	B-4	Q2	B-7	R24	C-3
C9	B-4	Q3	C-6	R25	C-4
C10	C-2	Q4	C-6	R26	B-3
C11	C-1	Q5	C-3	R27	C-3
		Q6	B-3	R28	C-4
		Q7	A-3	R29	C-4
CR1	A-7			R30	C-4
CR2	A-7			R31	C-3
CR3	B-7	R1	A-3	R32	C-4
CR4	B-7	R2	A-6	R33	B-4
CR5	B-7	R3	A-5	R34	B-2
CR6	B-7	R4	A-4	R35	B-2
CR7	C-5	R5	B-7	R36	B-4
CR8	C-5	R6	B-7	R37	B-3
CR9	A-4	R7	C-5	R38	B-3
CR10	C-3	R8	C-5	R39	C-2
CR11	B-3	R9	C-5	R40	C-2
CR12	B-4	R10	C-5		
CR13	B-4	R11	B-5	U1	C-5
CR14	B-4	R12	C-5	U2	C-3
CR15	B-2	R13	B-5	U3	C-4
CR16	B-2	R14	B-5	U4	A-1
CR17	B-2	R15	B-5		
CR18	B-2	R16	A-4	XA1	A-2

A7 LEAKAGE CURRENT BOARD OPERATION
(Option 001)

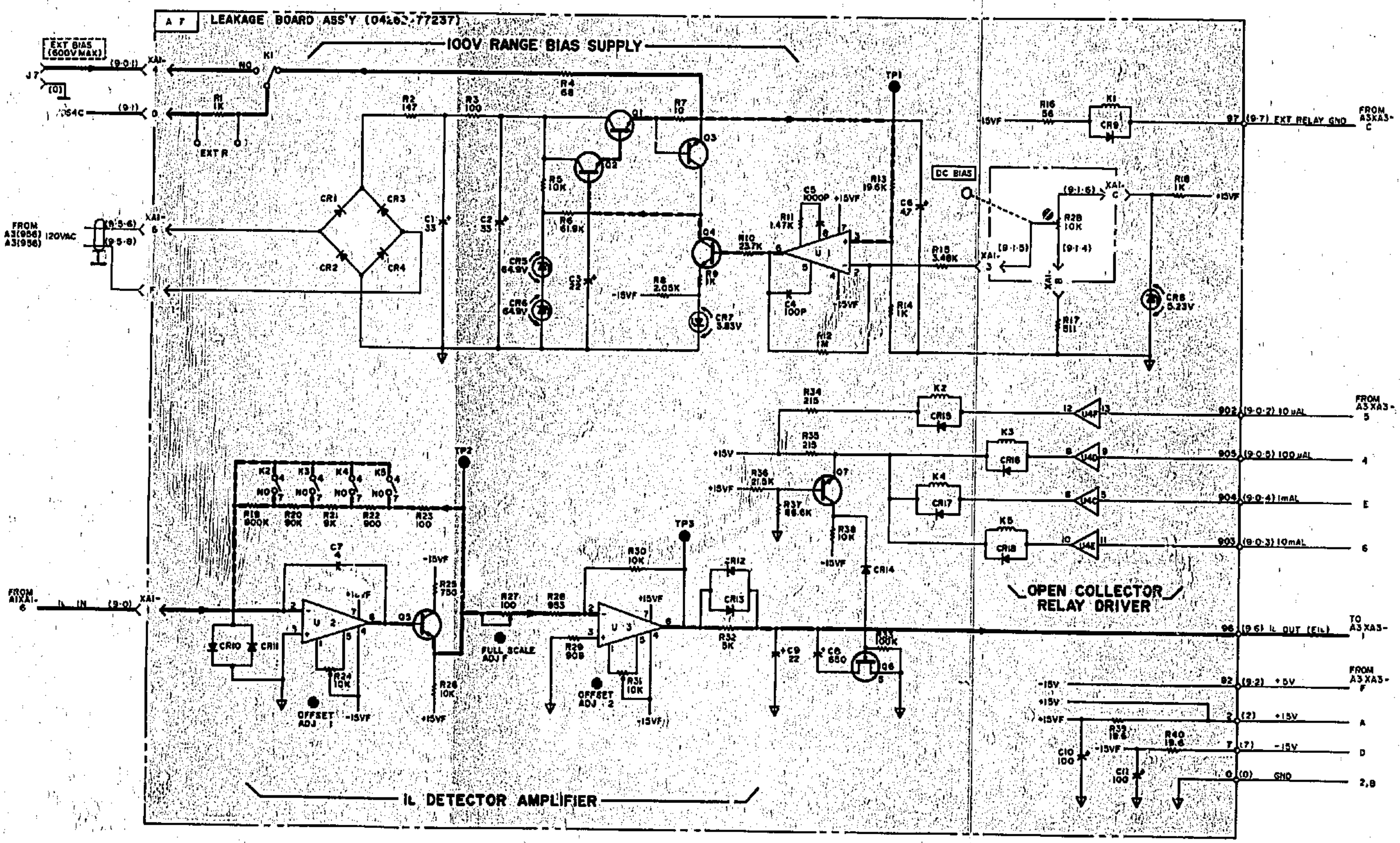
This assembly consists of two sections, 100V Range Bias Supply and I_L Detector-Amplifier. The Bias Supply has a regulated voltage range of over 100V. The output current is above 12mA. The voltage is controlled by DC BIAS control R2B connected to Differential Amplifier U1(2). When R2B is set, reference level of operation of the circuit is determined and regulation is accomplished by feeding back the output voltage to U1(3). Breakdown diodes CR5 and CR6 are employed to eliminate effects of ac line variation. Q3 the Current Limiter, acts when voltage drop across R7 exceeds approximately 0.5V to protect Series Regulator Q1. This condition may occur when building up capacitors above 10mF. Q1 can endure about one minute in this condition before being damaged. R1 is Protective Resistor and can be adjusted by connecting a resistor in parallel with R1 at EXT R position.

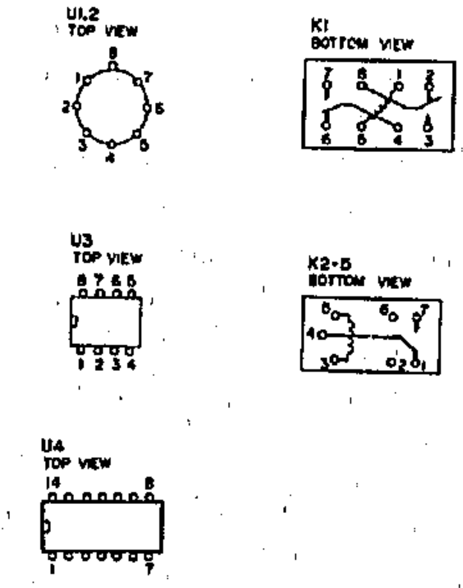
The I_L Detector-Amplifier consists of two stages, Detector U2/Q5 and Amplifier U3. The feedback loop of Detector is formed by I_L Range resistors R19 to R23. Since U2(3) is grounded, U2(2) is almost zero. This means that entire dc bias voltage is applied across unknown capacitor and leakage current flows through Range resistors. Therefore output of Detector equals product of Range resistors and leakage current, which is 1V at full scale. Amplifier U3, whose gain is about 10, provides 10V at full scale. The output, E_{IL} is sent to DVM Board A4 through Control Board A3. Open Collector Relay Driver U4 performs I_L Range selection as shown. FET switch Q6 is turned on when I_L Range is $1\mu A$ or $10\mu A$, which connects C8 to C9 in parallel to enhance smoothing effect. This, in turn, increases response time to approximately 20 seconds.

SEE INSIDE

Figure 8-18
A4 DVM Board Ass'y
(Counter - Buffer Storage - Decoder)
A5 Display Board Ass'y

A7 Parts Locations under Fold





Reference Designations

A7
C1 - 11
CR1 - 18
K1 - 5
Q1 - 7
R1 - 40
U1 - 4
XA1

Table of Active Components.

Reference Designations	HP Part Number
A7	
CR1 - 4, 10, 11	1901-0230
CR5, 6	1901-0574
CR7	1902-3069
CR8	1902-3097
CR9, 14 - 18	1902-0025
CR12, 13	1901-0063
Q1	1854-0330
Q2, 4	1854-0232
Q3, 5	1854-0071
Q6	1855-0020
Q7	1853-0036
U1	1820-0068
U2	1826-0136
U3	1820-0316
U4	1820-0668

Figure 8-19. A7 Leakage Board Ass'y.

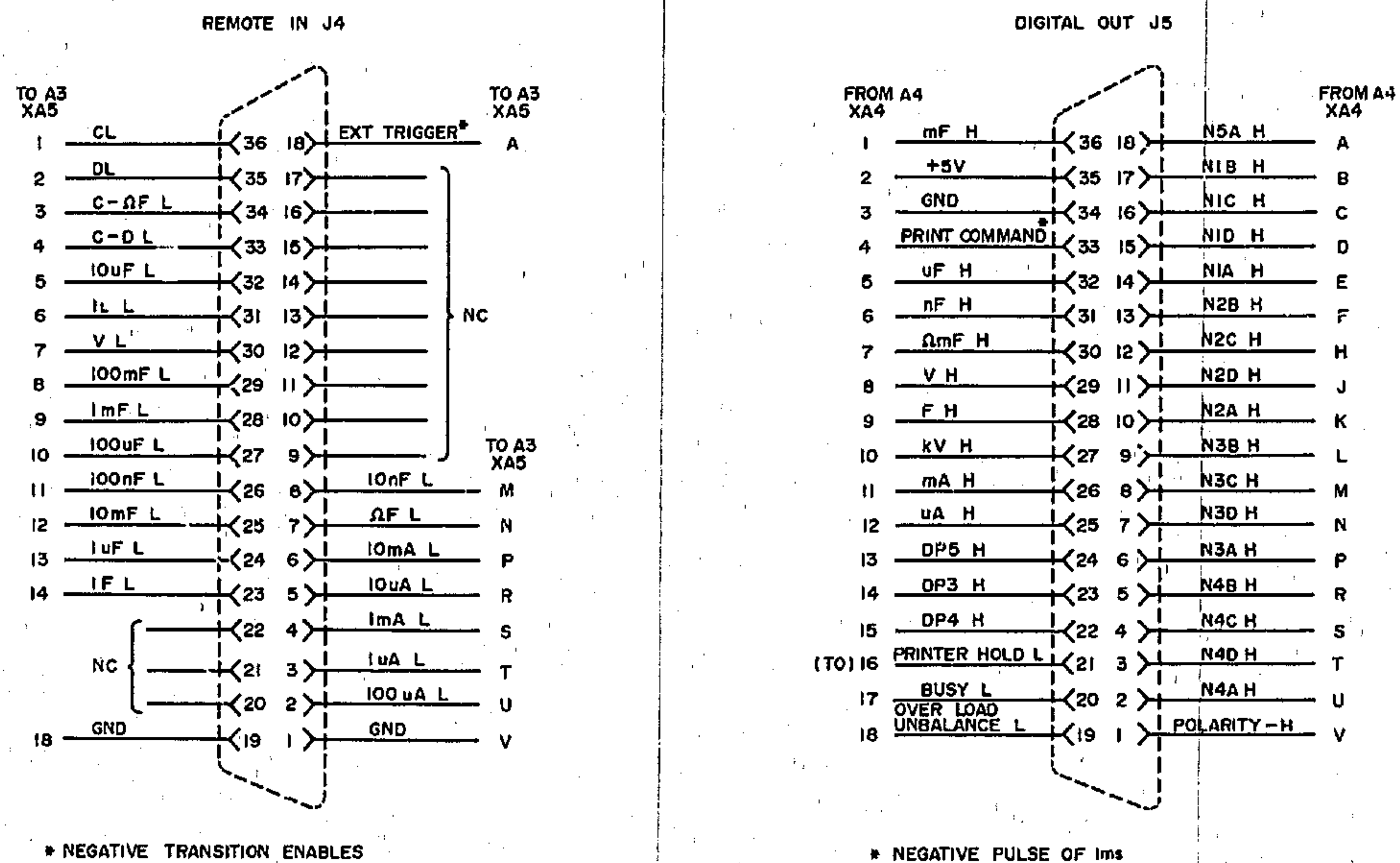


Figure 8-20. REMOTE IN Connector J4 and DIGITAL OUT Connector J5 Pin - Connection.

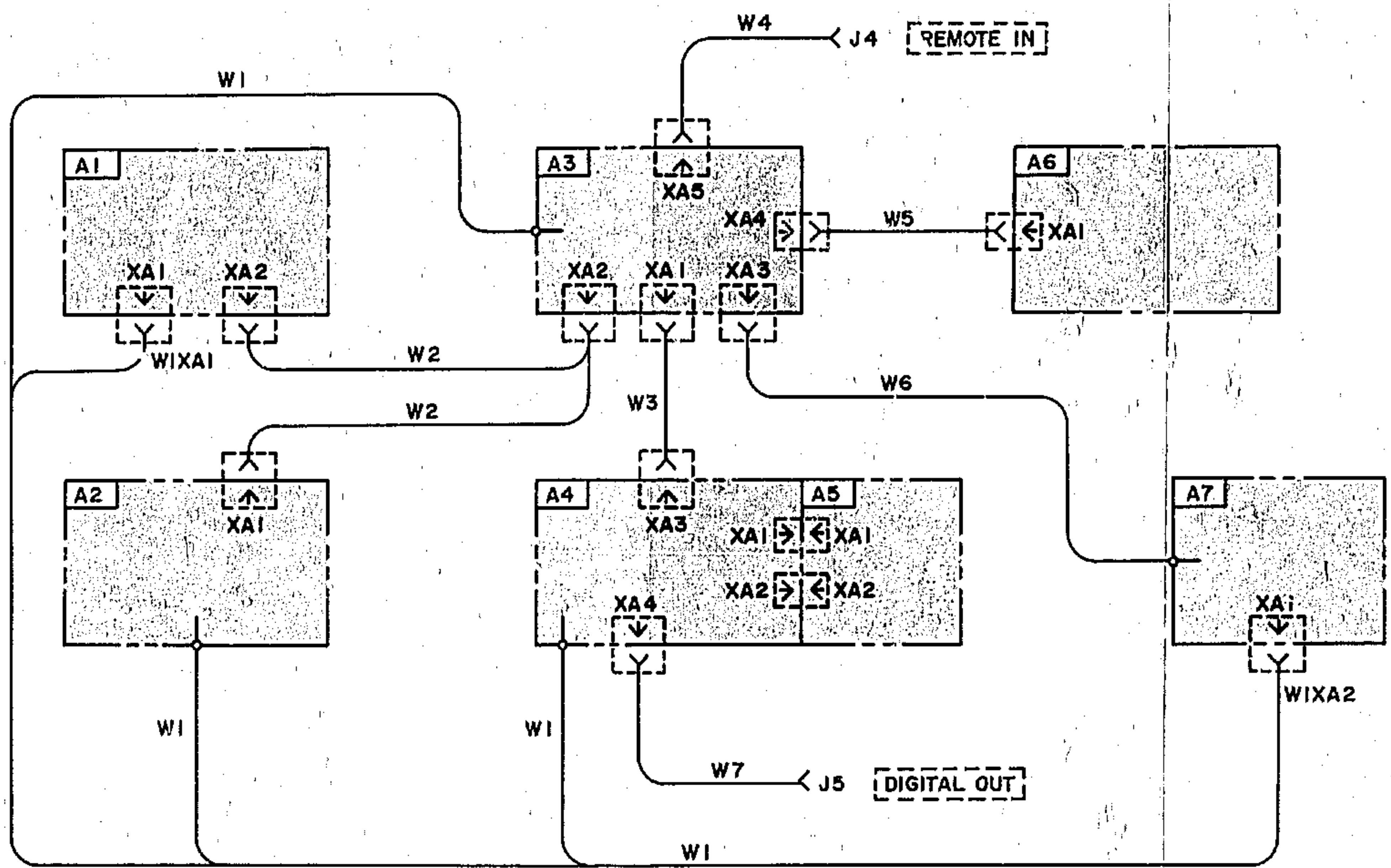
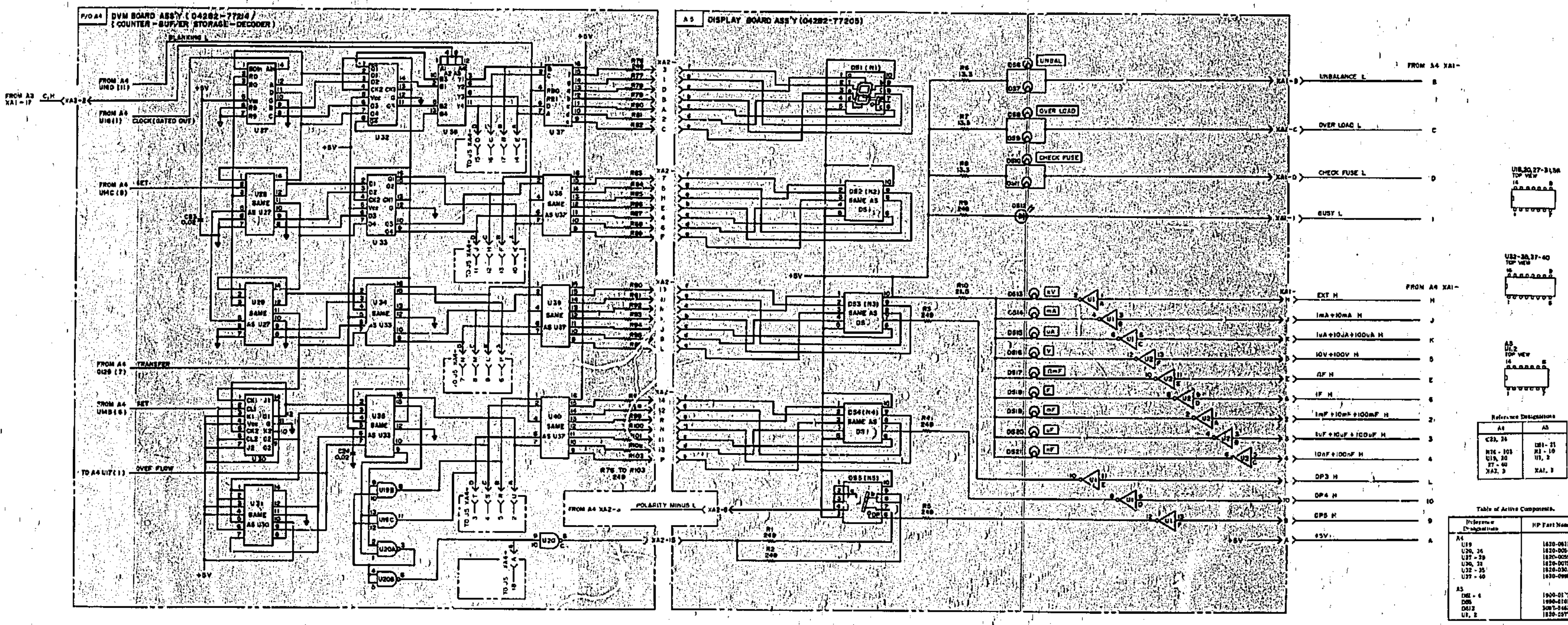


Figure 8-21. Cable Connections.



Reference Designations

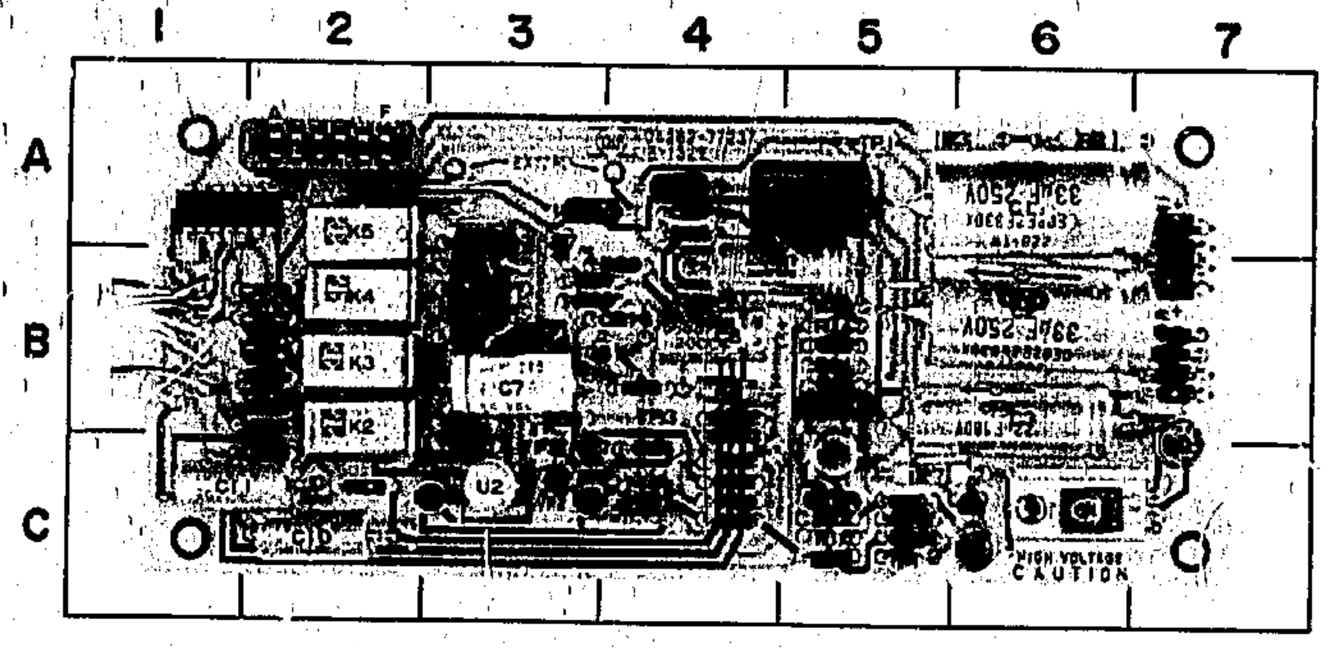
A4	A5
C23, 24 R76 - 103 U19, 20 27 - 40 XA2, 3	DS1 - 21 R1 - 10 U1, 2 XA1, 3

Table of Active Components.

Reference Designation	HP Part Number
A4	
U19	1820-0611
U20, 36	1820-0054
U27 - 29	1820-0055
U30, 31	1820-0075
U32 - 35	1820-0301
U37 - 40	1820-0096
A5	
DS1 - 4	1990-0177
DS5	1990-0101
DS12	5082-4482
U1, 2	1820-0577

Figure 8-18. A4 DVM Board Ass'y.
(Counter - Buffer Storage - Decoder)

A5 Display Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	A-6	K1	A-5	R17	B-5
C2	B-6	K2	B-2	R18	C-5
C3	B-6	K3	B-2	R19	B-3
C4	C-5	K4	B-2	R20	B-3
C5	B-5	K5	A-2	R21	B-3
C6	B-4			R22	B-3
C7	B-3	Q1	C-6	R23	A-3
C8	B-4	Q2	B-7	R24	C-3
C9	B-4	Q3	C-6	R25	C-4
C10	C-2	Q4	C-6	R26	B-3
C11	C-1	Q5	C-3	R27	C-3
		Q6	B-3	R28	C-4
		Q7	A-3	R29	C-4
CR1	A-7			R30	C-4
CR2	A-7			R31	C-3
CR3	B-7	R1	A-3	R32	C-4
CR4	B-7	R2	A-6	R33	B-4
CR5	B-7	R3	A-5	R34	B-2
CR6	B-7	R4	A-4	R35	B-2
CR7	C-5	R5	B-7	R36	B-4
CR8	C-5	R6	B-7	R37	B-3
CR9	A-4	R7	C-5	R38	B-3
CR10	C-3	R8	C-5	R39	C-2
CR11	B-3	R9	C-5	R40	C-2
CR12	B-4	R10	C-5		
CR13	B-4	R11	B-5	U1	C-5
CR14	B-4	R12	C-5	U2	C-3
CR15	B-2	R13	B-5	U3	C-4
CR16	B-2	R14	B-5	U4	A-1
CR17	B-2	R15	B-5		
CR18	B-2	R16	A-4	XA1	A-2

Figure 8-18

A4 DVM Board Ass'y
(Counter - Buffer Storage - Decoder)

A5 Display Board Ass'y

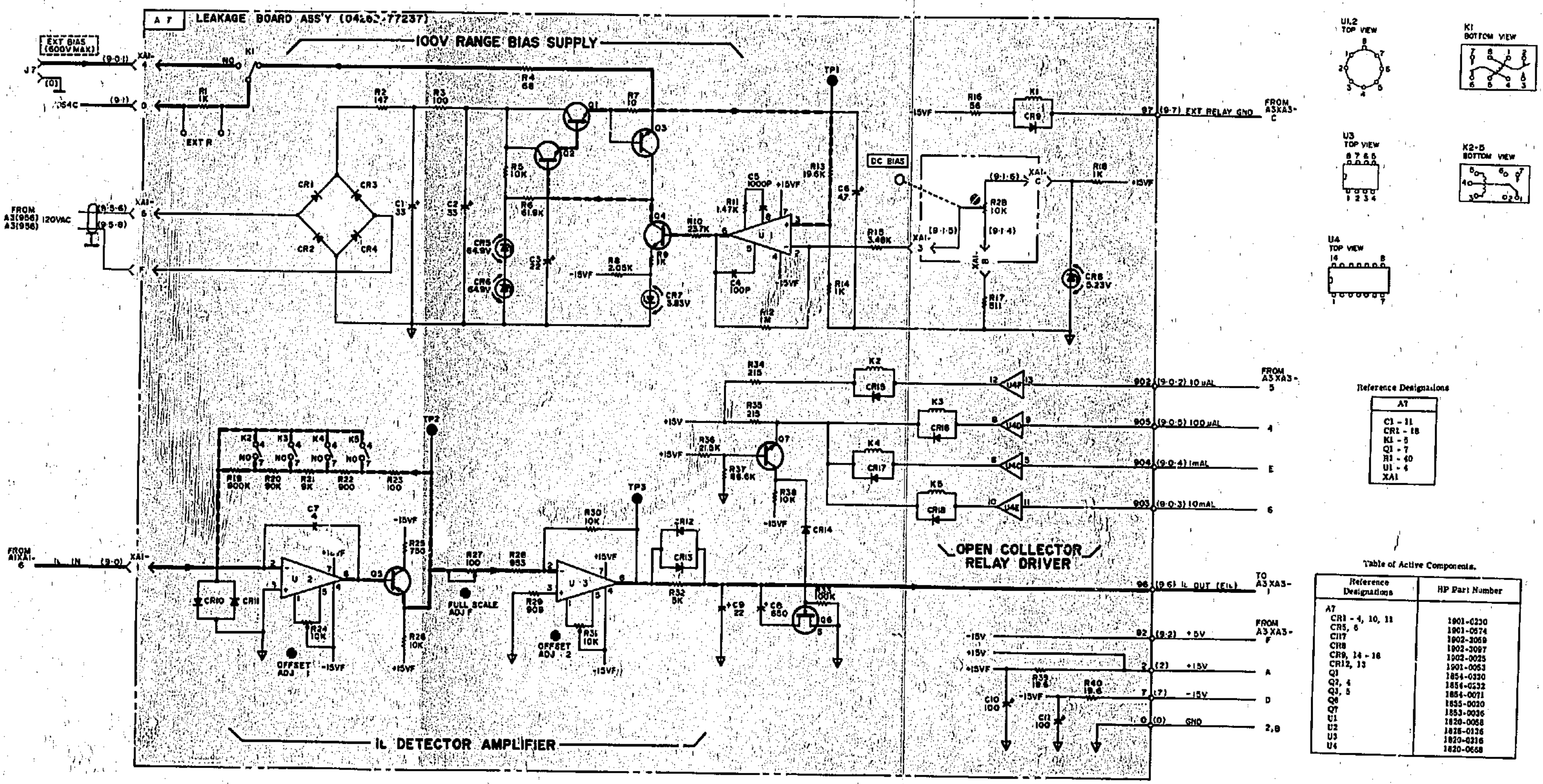
SEE INSIDE

A7 LEAKAGE CURRENT BOARD OPERATION
(Option 001)

This assembly consists of two sections, 100V Range Bias Supply and I_L Detector-Amplifier. The Bias Supply has a regulated voltage range of over 100V. The output current is above 12mA. The voltage is controlled by DC BIAS control R2B connected to Differential Amplifier U1(2). When R2B is set, reference level of operation of the circuit is determined and regulation is accomplished by feeding back the output voltage to U1(3). Breakdown diodes CR5 and CR6 are employed to eliminate effects of ac line variation. Q3 the Current Limiter, acts when voltage drop across R7 exceeds approximately 0.5V to protect Series Regulator Q1. This condition may occur when building up capacitors above 10mF. Q1 can endure about one minute in this condition before being damaged. R1 is Protective Resistor and can be adjusted by connecting a resistor in parallel with R1 at EXT R position.

The I_L Detector-Amplifier consists of two stages, Detector U2/Q5 and Amplifier U3. The feedback loop of Detector is formed by I_L Range resistors R19 to R23. Since U2(3) is grounded, U2(2) is almost zero. This means that entire dc bias voltage is applied across unknown capacitor and leakage current flows through Range resistors. Therefore output of Detector equals product of Range resistors and leakage current, which is 1V at full scale. Amplifier U3, whose gain is about 10, provides 10V at full scale. The output, E_{IL} is sent to DVM Board A4 through Control Board A3. Open Collector Relay Driver U4 performs I_L Range selection as shown. FET switch Q6 is turned on when I_L Range is 1μA or 10μA, which connects C8 to C9 in parallel to enhance smoothing effect. This, in turn, increases response time to approximately 20 seconds.

A7 Parts Locations under Fold



Reference Designations

A7
C1 - 11
CR1 - 18
K1 - 5
Q1 - 7
R1 - 40
U1 - 4
XA1

Table of Active Components.

Reference Designations	HP Part Number
A7	
CR1 - 4, 10, 11	1901-0230
CR5, 6	1901-0574
CR7	1902-3069
CR8	1902-3097
CR9, 14 - 18	1902-0025
CR12, 13	1901-0053
Q1	1854-0330
Q2, 4	1854-0232
Q3, 5	1854-0071
Q6	1855-0020
Q7	1853-0036
U1	1820-0058
U2	1826-0136
U3	1820-0316
U4	1820-0668

Figure 8-19. A7 Leakage Board Ass'y.

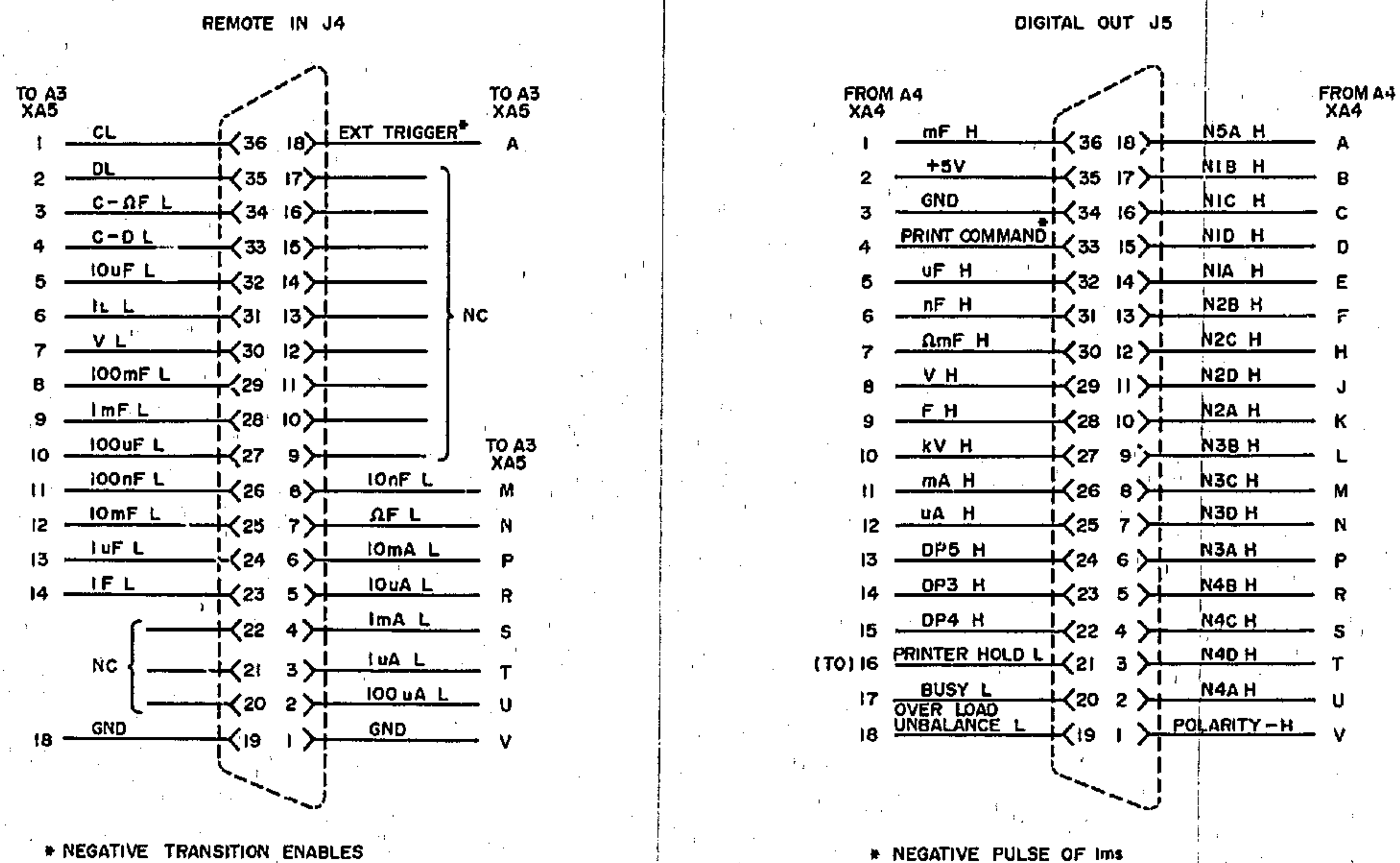


Figure 8-20. REMOTE IN Connector J4 and DIGITAL OUT Connector J5 Pin - Connection.

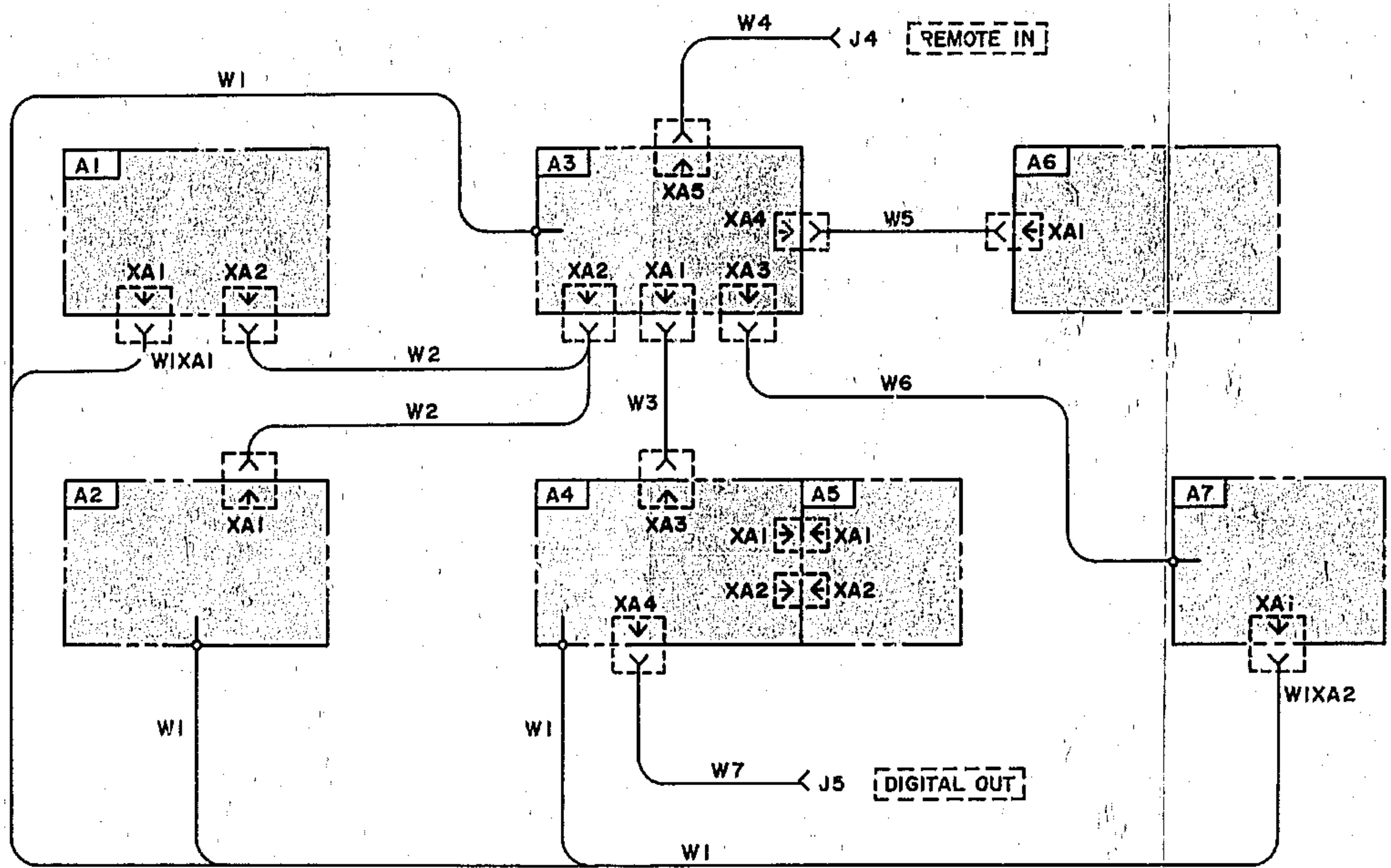


Figure 8-21. Cable Connections.

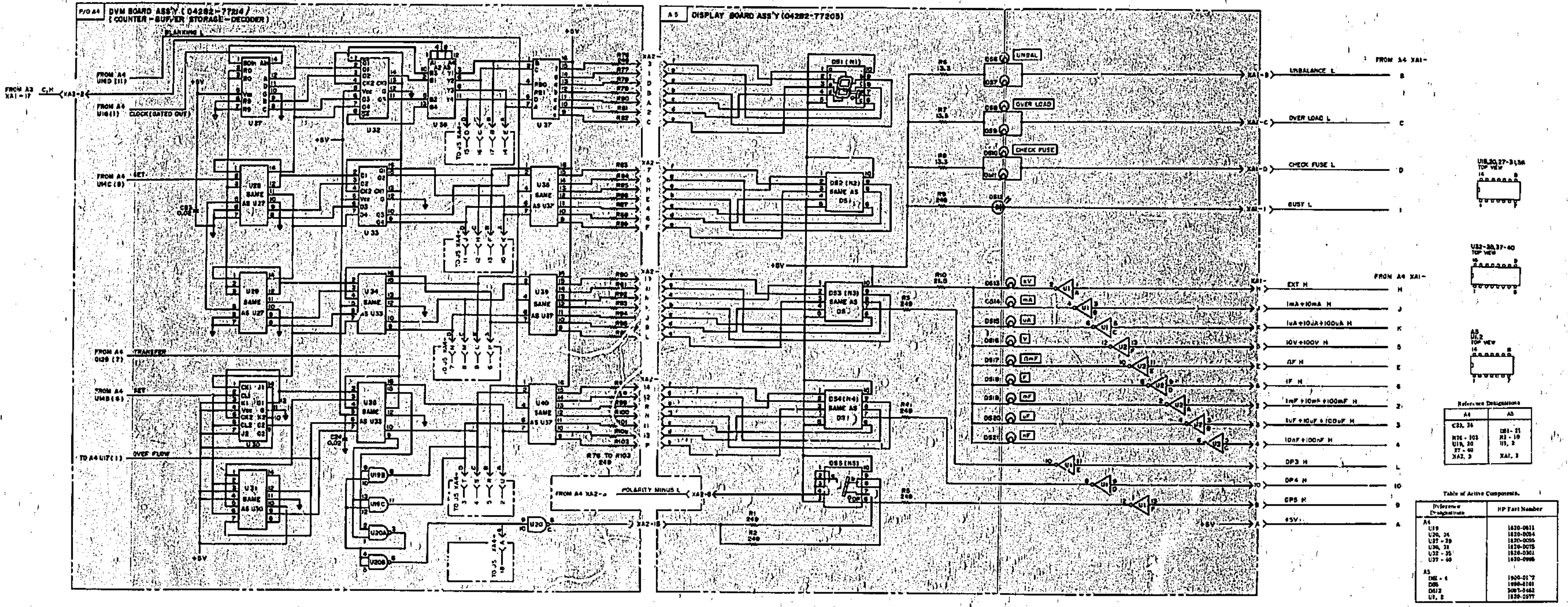
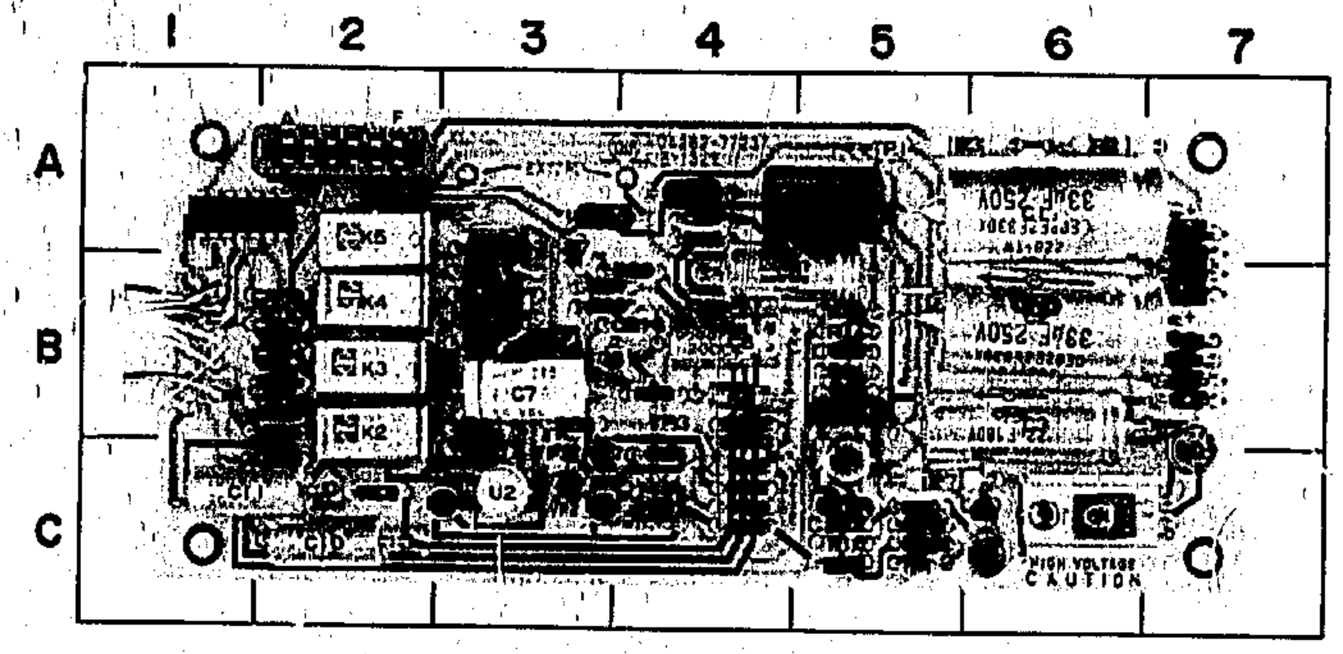


Figure 8-18. A4 DVM Board Ass'y. (Counter - Buffer Storage - Decoder)
A5 Display Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	A-6	K1	A-5	R17	B-5
C2	B-6	K2	B-2	R18	C-5
C3	B-6	K3	B-2	R19	B-3
C4	C-5	K4	B-2	R20	B-3
C5	B-5	K5	A-2	R21	B-3
C6	B-4			R22	B-3
C7	B-3	Q1	C-6	R23	A-3
C8	B-4	Q2	B-7	R24	C-3
C9	B-4	Q3	C-6	R25	C-4
C10	C-2	Q4	C-6	R26	B-3
C11	C-1	Q5	C-3	R27	C-3
		Q6	B-3	R28	C-4
		Q7	A-3	R29	C-4
CR1	A-7			R30	C-4
CR2	A-7			R31	C-3
CR3	B-7	R1	A-3	R32	C-4
CR4	B-7	R2	A-6	R33	B-4
CR5	B-7	R3	A-5	R34	B-2
CR6	B-7	R4	A-4	R35	B-2
CR7	C-5	R5	B-7	R36	B-4
CR8	C-5	R6	B-7	R37	B-3
CR9	A-4	R7	C-5	R38	B-3
CR10	C-3	R8	C-5	R39	C-2
CR11	B-3	R9	C-5	R40	C-2
CR12	B-4	R10	C-5		
CR13	B-4	R11	B-5	U1	C-5
CR14	B-4	R12	C-5	U2	C-3
CR15	B-2	R13	B-5	U3	C-4
CR16	B-2	R14	B-5	U4	A-1
CR17	B-2	R15	B-5		
CR18	B-2	R16	A-4	XA1	A-2

SEE INSIDE

Figure 8-18
A4 DVM Board Ass'y
(Counter - Buffer Storage - Decoder)
A5 Display Board Ass'y

A7 LEAKAGE CURRENT BOARD OPERATION
(Option 001)

This assembly consists of two sections, 100V Range Bias Supply and I_L Detector-Amplifier. The Bias Supply has a regulated voltage range of over 100V. The output current is above 12mA. The voltage is controlled by DC BIAS control R2B connected to Differential Amplifier U1(2). When R2B is set, reference level of operation of the circuit is determined and regulation is accomplished by feeding back the output voltage to U1(3). Breakdown diodes CR5 and CR6 are employed to eliminate effects of ac line variation. Q3 the Current Limiter, acts when voltage drop across R7 exceeds approximately 0.5V to protect Series Regulator Q1. This condition may occur when building up capacitors above 10mF. Q1 can endure about one minute in this condition before being damaged. R1 is Protective Resistor and can be adjusted by connecting a resistor in parallel with R1 at EXT R position.

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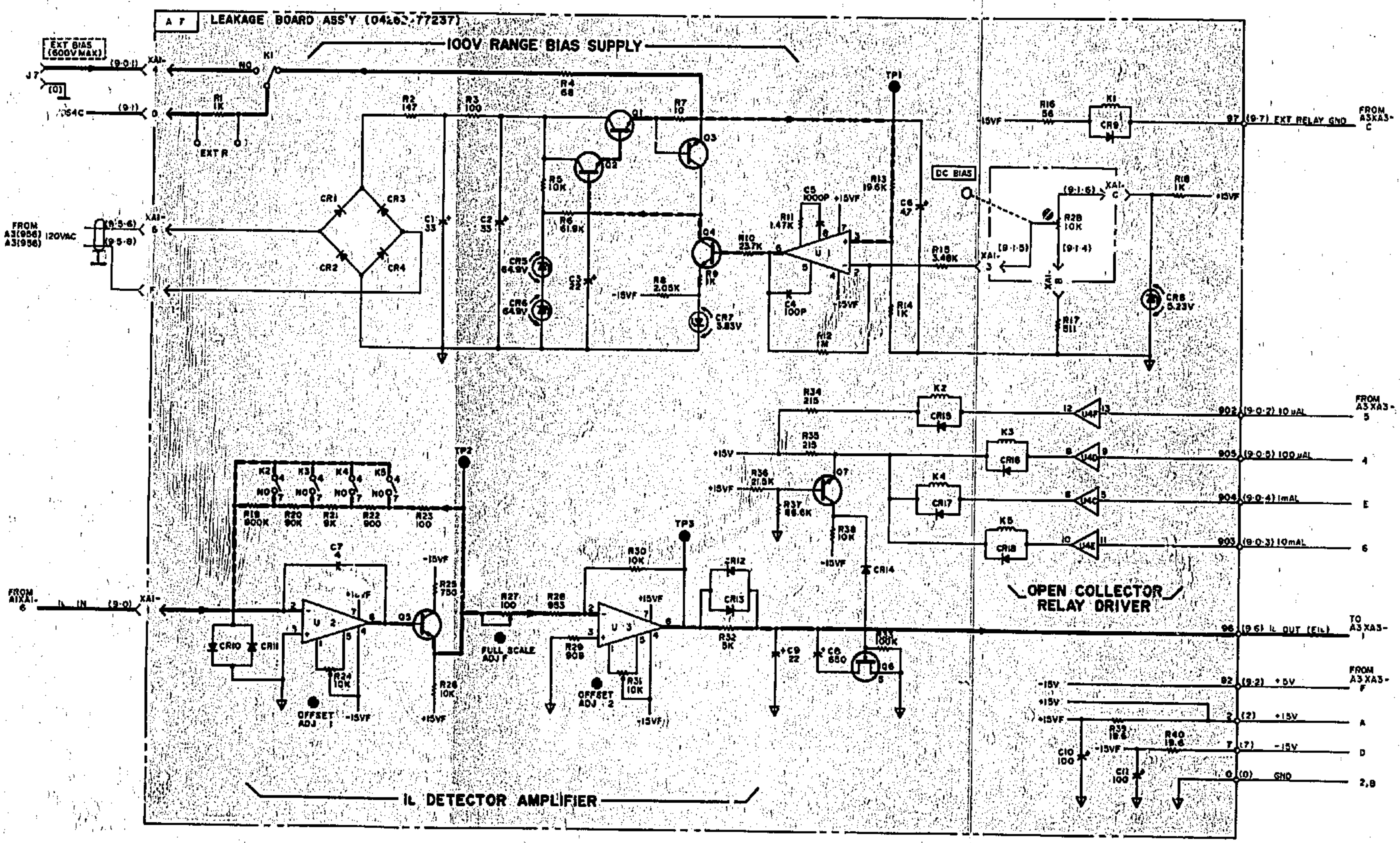
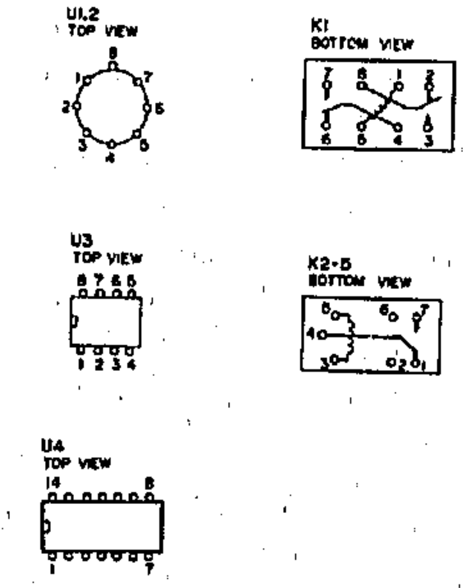
A7 Parts Locations under Fold





Reference Designations

A7
C1 - 11
CR1 - 18
K1 - 5
Q1 - 7
R1 - 40
U1 - 4
XA1

Table of Active Components.

Reference Designations	HP Part Number
A7	
CR1 - 4, 10, 11	1901-0230
CR5, 6	1901-0574
CR7	1902-3069
CR8	1902-3097
CR9, 14 - 18	1902-0025
CR12, 13	1901-0053
Q1	1854-0330
Q2, 4	1854-0232
Q3, 5	1854-0071
Q6	1855-0020
Q7	1853-0036
U1	1820-0058
U2	1826-0136
U3	1820-0316
U4	1820-0668

Figure 8-19. A7 Leakage Board Ass'y.

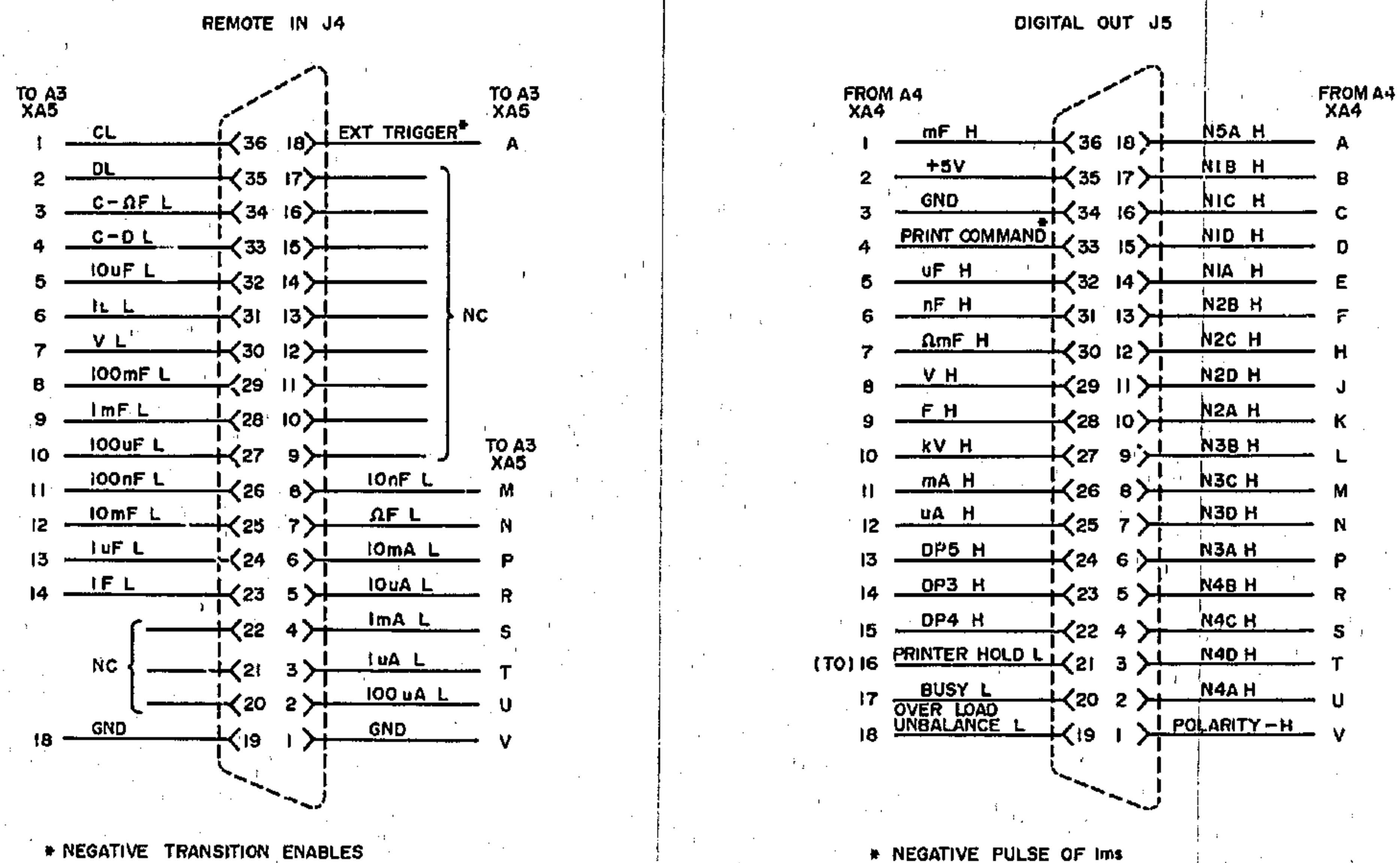


Figure 8-20. REMOTE IN Connector J4 and DIGITAL OUT Connector J5 Pin - Connection.

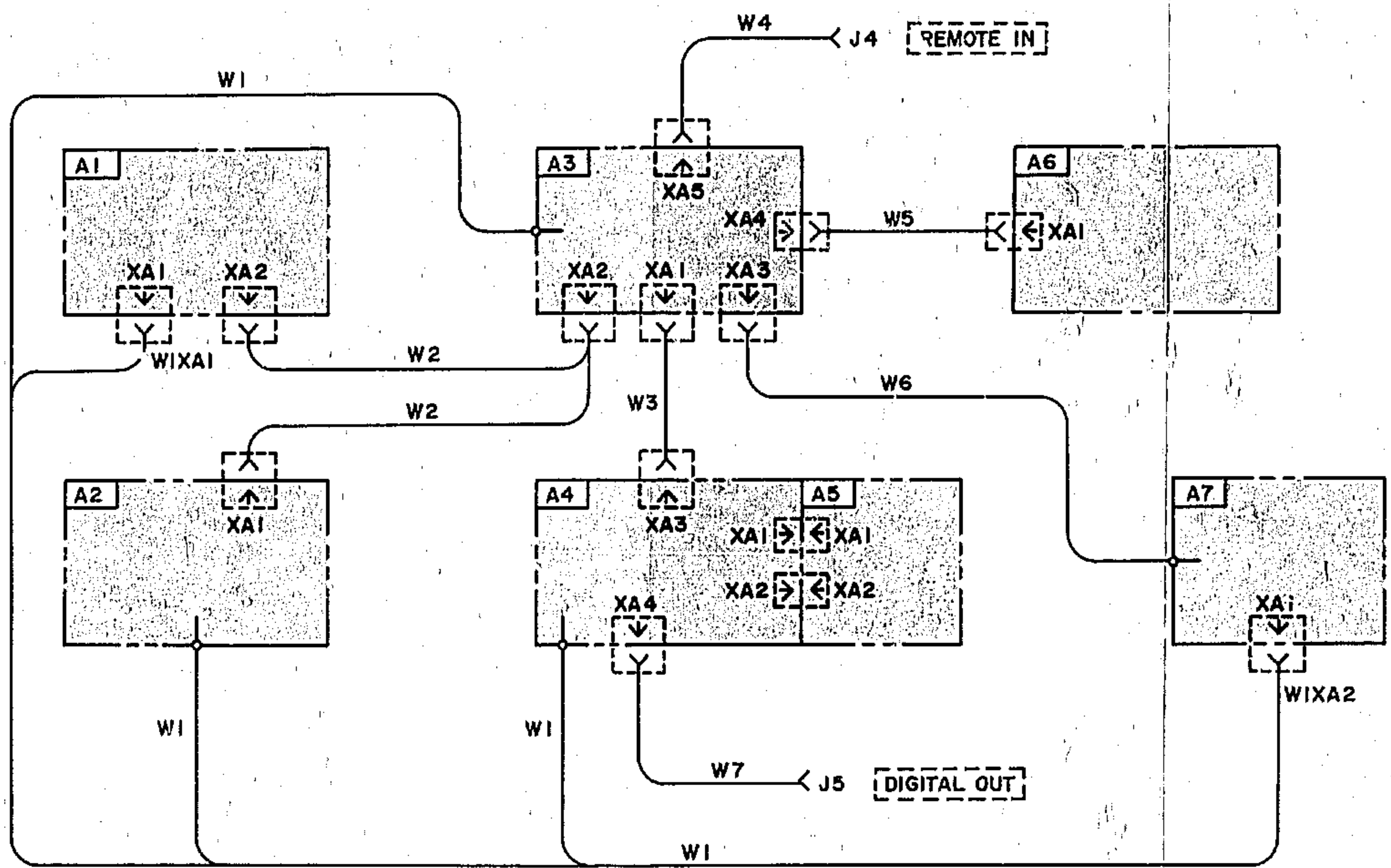


Figure 8-21. Cable Connections.

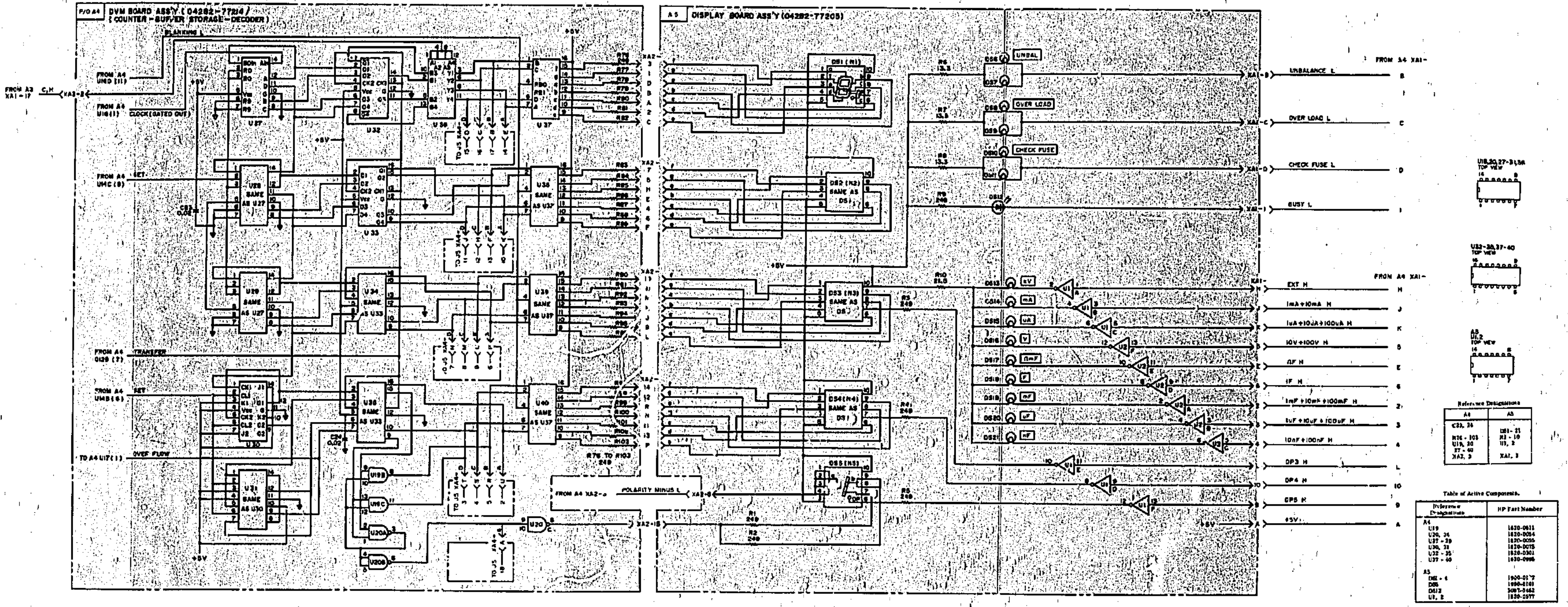
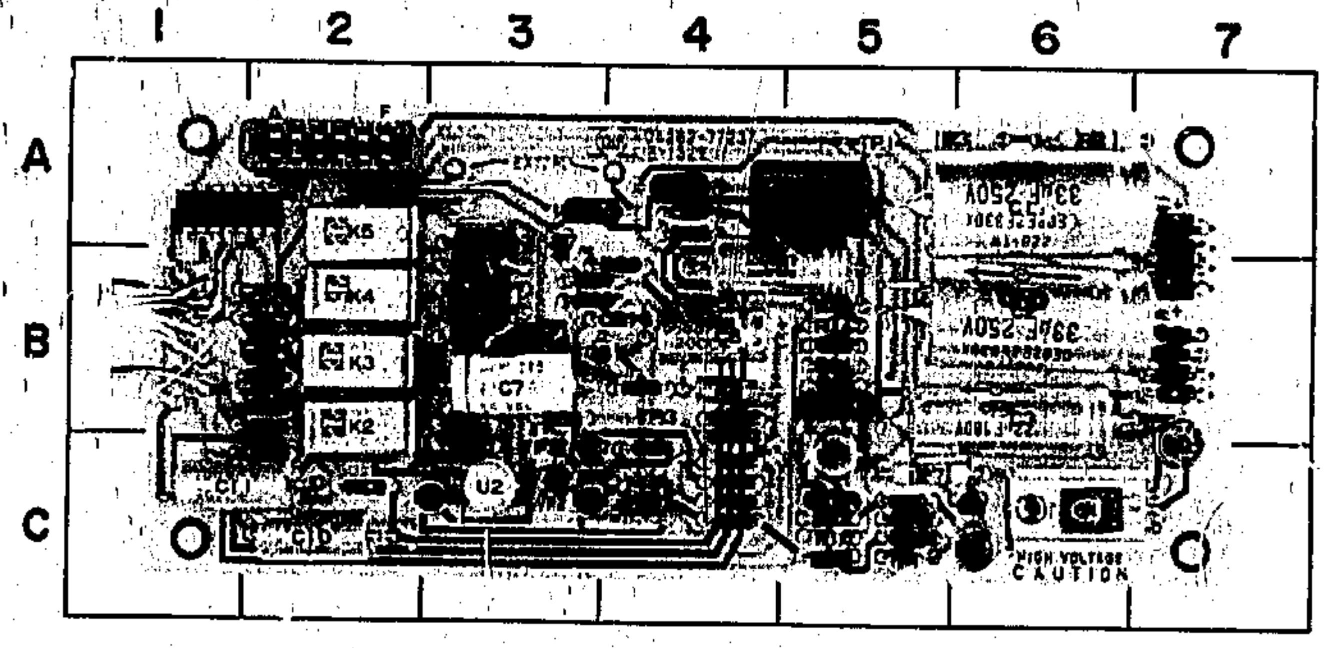


Figure 8-18. A4 DVM Board Ass'y. (Counter - Buffer Storage - Decoder)
A5 Display Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	A-6	K1	A-5	R17	B-5
C2	B-6	K2	B-2	R18	C-5
C3	B-6	K3	B-2	R19	B-3
C4	C-5	K4	B-2	R20	B-3
C5	B-5	K5	A-2	R21	B-3
C6	B-4			R22	B-3
C7	B-3	Q1	C-6	R23	A-3
C8	B-4	Q2	B-7	R24	C-3
C9	B-4	Q3	C-6	R25	C-4
C10	C-2	Q4	C-6	R26	B-3
C11	C-1	Q5	C-3	R27	C-3
		Q6	B-3	R28	C-4
		Q7	A-3	R29	C-4
CR1	A-7			R30	C-4
CR2	A-7			R31	C-3
CR3	B-7	R1	A-3	R32	C-4
CR4	B-7	R2	A-6	R33	B-4
CR5	B-7	R3	A-5	R34	B-2
CR6	B-7	R4	A-4	R35	B-2
CR7	C-5	R5	B-7	R36	B-4
CR8	C-5	R6	B-7	R37	B-3
CR9	A-4	R7	C-5	R38	B-3
CR10	C-3	R8	C-5	R39	C-2
CR11	B-3	R9	C-5	R40	C-2
CR12	B-4	R10	C-5		
CR13	B-4	R11	B-5	U1	C-5
CR14	B-4	R12	C-5	U2	C-3
CR15	B-2	R13	B-5	U3	C-4
CR16	B-2	R14	B-5	U4	A-1
CR17	B-2	R15	B-5		
CR18	B-2	R16	A-4	XA1	A-2

SEE INSIDE

Figure 8-18
A4 DVM Board Ass'y
(Counter - Buffer Storage - Decoder)
A5 Display Board Ass'y

A7 LEAKAGE CURRENT BOARD OPERATION (Option 001)

This assembly consists of two sections, 100V Range Bias Supply and I_L Detector-Amplifier. The Bias Supply has a regulated voltage range of over 100V. The output current is above 12mA. The voltage is controlled by DC BIAS control R2B connected to Differential Amplifier U1(2). When R2B is set, reference level of operation of the circuit is determined and regulation is accomplished by feeding back the output voltage to U1(3). Breakdown diodes CR5 and CR6 are employed to eliminate effects of ac line variation. Q3 the Current Limiter, acts when voltage drop across R7 exceeds approximately 0.5V to protect Series Regulator Q1. This condition may occur when building up capacitors above 10mF. Q1 can endure about one minute in this condition before being damaged. R1 is Protective Resistor and can be adjusted by connecting a resistor in parallel with R1 at EXT R position.

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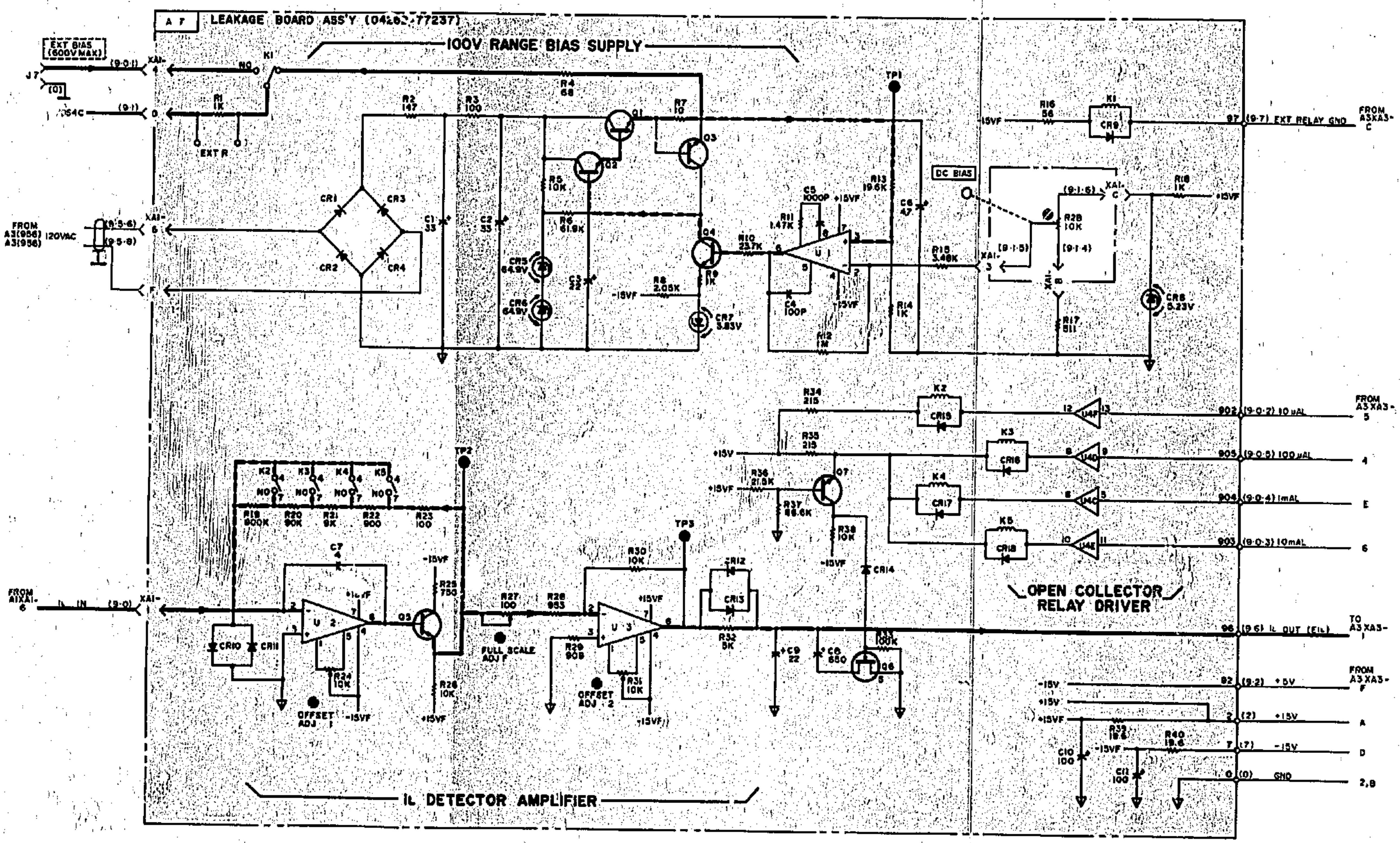
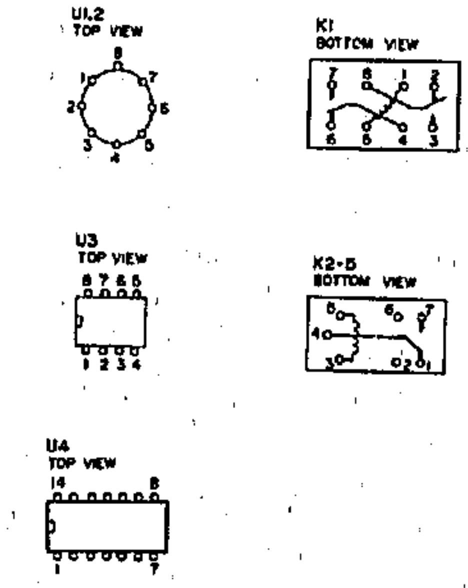
A7 Parts Locations under Fold





Reference Designations

A7
C1 - 11 CR1 - 18 K1 - 5 Q1 - 7 R1 - 40 U1 - 4 XA1

Table of Active Components.

Reference Designations	HP Part Number
A7	
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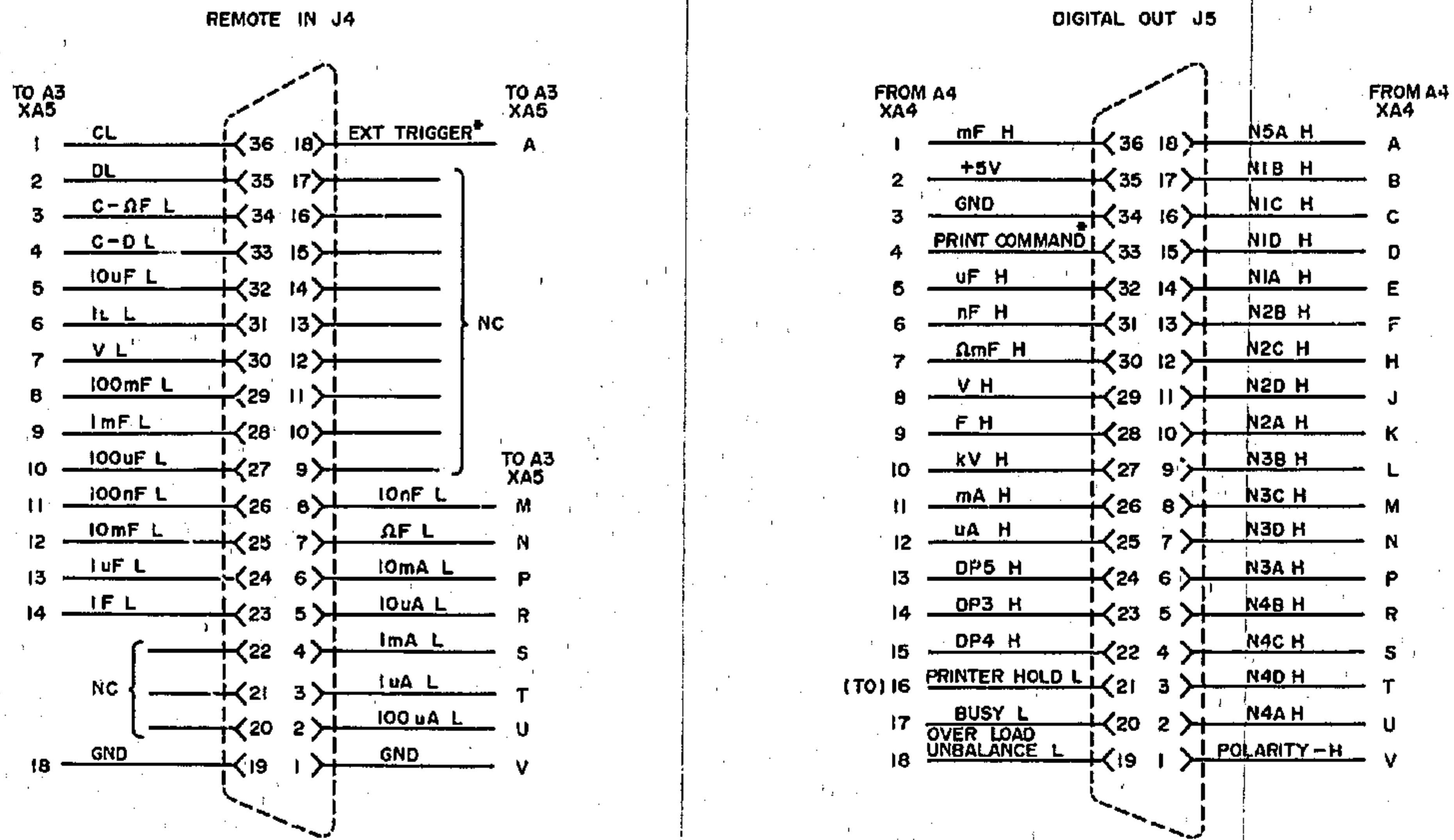
CR7	1902-3069
CR8	1902-3097
CR9, 14 - 18	1902-0025
CR12, 13	1901-0053
Q1	1854-0330
Q2, 4	1854-0232
Q3, 5	1854-0071
Q6	1855-0020
Q7	1853-0036
U1	1820-0058
U2	1826-0136
U3	1820-0316
U4	1820-0668

Figure 8-19. A7 Leakage Board Ass'y.



* NEGATIVE TRANSITION ENABLES

* NEGATIVE PULSE OF 1ms

Figure 8-20. REMOTE IN Connector J4 and DIGITAL OUT Connector J5 Pin - Connection.

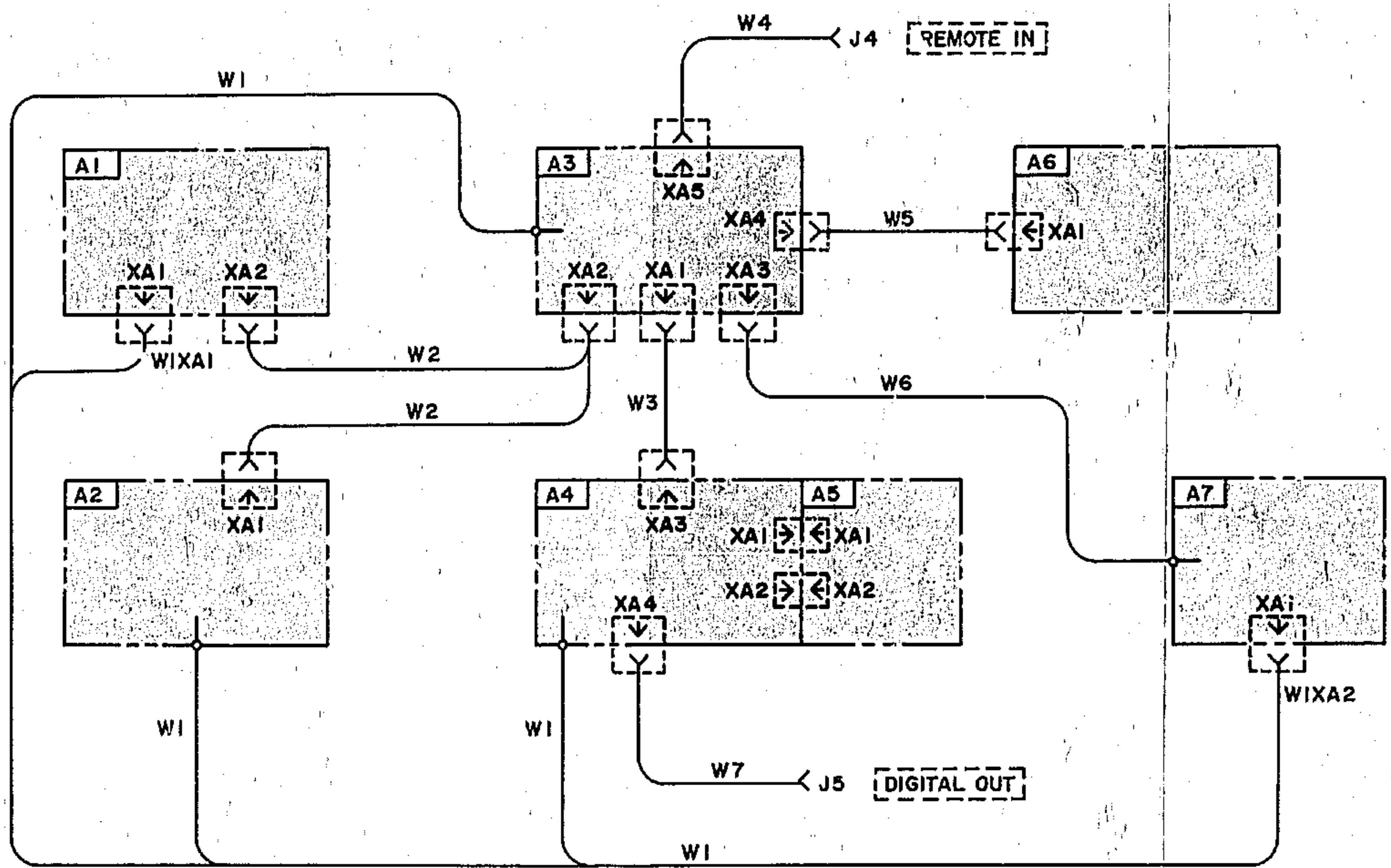


Figure 8-21. Cable Connections.

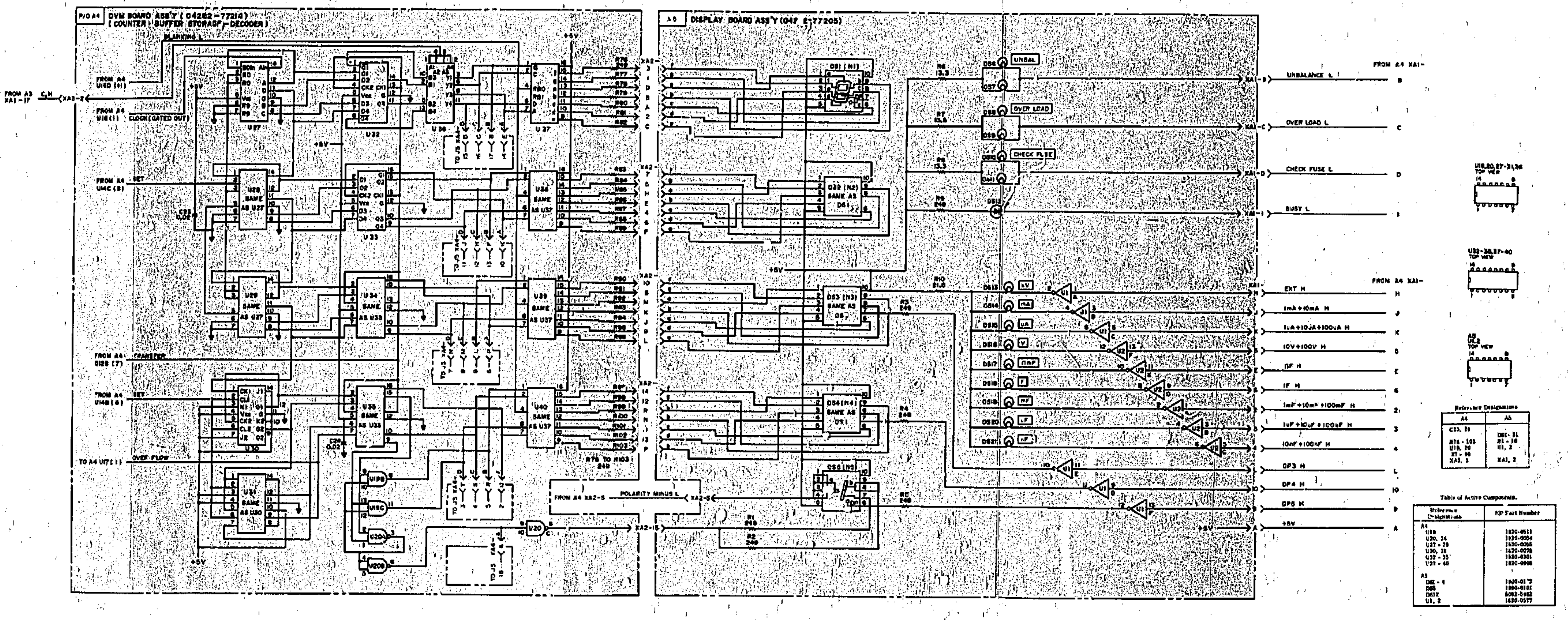
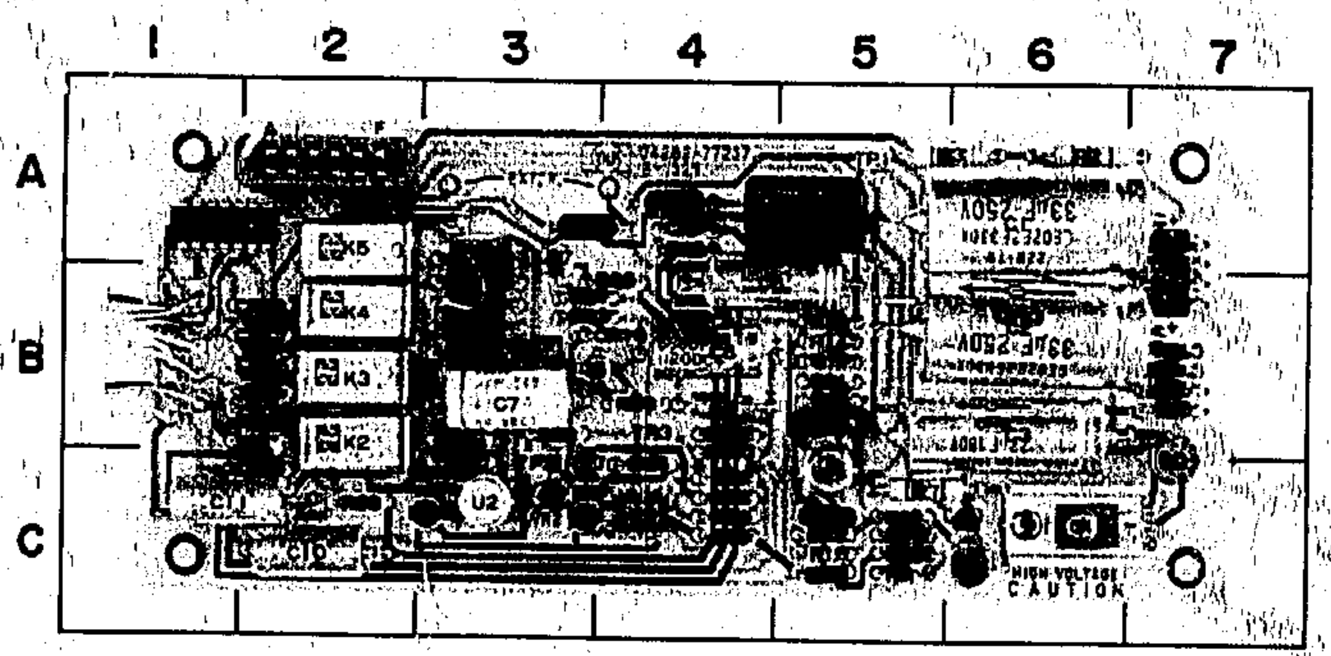


Figure 8-18. A4 DVM Board Ass'y, (Counter - Buffer Storage - Decoder)
A5 Display Board Ass'y.



PARTS LOCATOR

Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.	Ref. Desig.	Grid. Loc.
C1	A-6	K1	A-5	R17	B-5
C2	B-6	K2	B-2	R18	C-5
C3	B-6	K3	B-2	R19	B-3
C4	C-5	K4	B-2	R20	B-3
C5	B-5	K5	A-2	R31	B-3
C6	B-4			R22	B-3
C7	B-3	Q1	C-6	R23	A-3
C8	B-4	Q2	B-7	R24	C-3
C9	B-4	Q3	C-6	R25	C-4
C10	C-2	Q4	C-6	R26	B-3
C11	C-1	Q5	C-3	R27	C-3
		Q6	B-3	R28	C-4
		Q7	A-3	R29	C-4
CR1	A-7			R30	C-4
CR2	A-7			R31	C-3
CR3	B-7	R1	A-3	R32	C-4
CR4	B-7	R2	A-6	R33	B-4
CR5	B-7	R3	A-5	R34	B-2
CR6	B-7	R4	A-4	R35	B-2
CR7	C-5	R5	B-7	R36	B-4
CR8	C-5	R6	B-7	R37	B-3
CR9	A-4	R7	C-5	R38	B-3
CR10	C-3	R8	C-5	R39	C-2
CR11	B-3	R9	C-5	R40	C-2
CR12	B-4	R10	C-5		
CR13	B-4	R11	B-5	U1	C-5
CR14	B-4	R12	C-5	U2	C-3
CR15	B-2	R13	B-5	U3	C-4
CR16	B-2	R14	B-5	U4	A-1
CR17	B-2	R15	B-5		
CR18	B-2	R16	A-4	XA1	A-2

SEE INSIDE

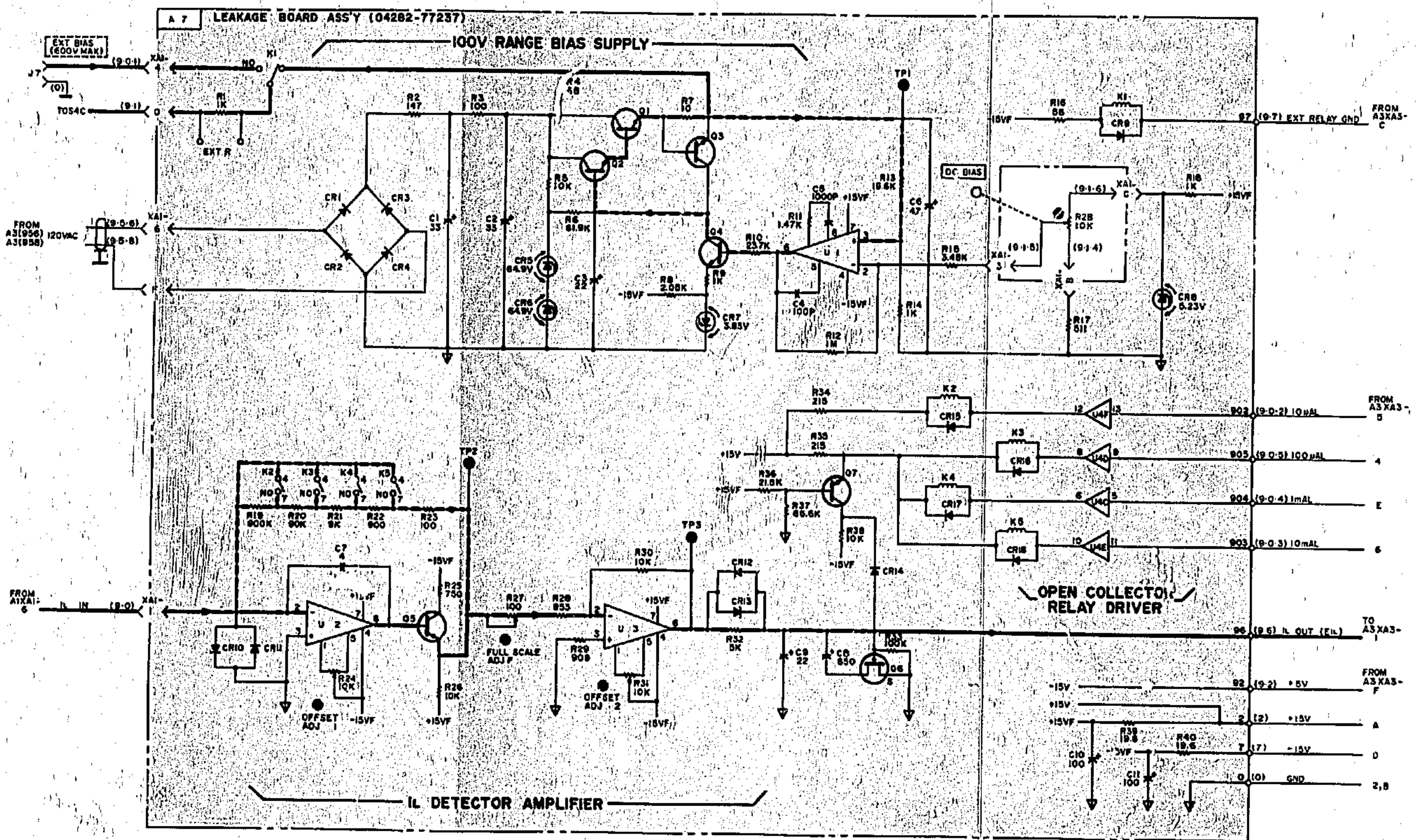
Figure 8-18
A4 DVM Board Ass'y
(Counter - Buffer Storage - Decoder)
A5 Display Board Ass'y

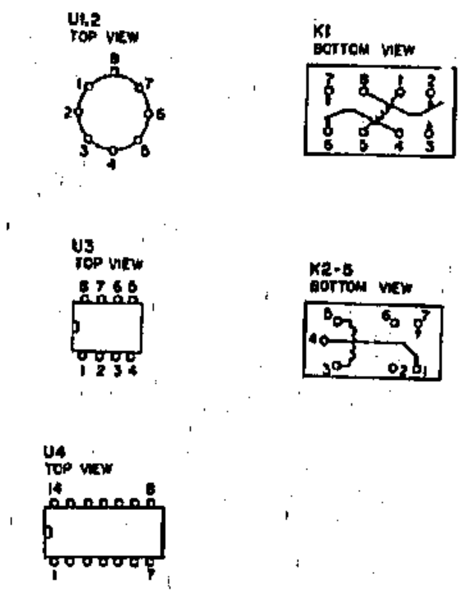
A7 LEAKAGE CURRENT BOARD OPERATION
(Option 001)

This assembly consists of two sections, 100V Range Bias Supply and I_L Detector-Amplifier. The Bias Supply has a regulated voltage range of over 100V. The output current is above 12mA. The voltage is controlled by DC BIAS control R2B connected to Differential Amplifier U1(2). When R2B is set, reference level of operation of the circuit is determined and regulation is accomplished by feeding back the output voltage to U1(3). Breakdown diodes CR5 and CR6 are employed to eliminate effects of ac line variation. Q3 the Current Limiter, acts when voltage drop across R7 exceeds approximately 0.5V to protect Series Regulator Q1. This condition may occur when building up capacitors above 10mF. Q1 can endure about one minute in this condition before being damaged. R1 is Protective Resistor and can be adjusted by connecting a resistor in parallel with R1 at EXT R position.

The I_L Detector-Amplifier consists of two stages, Detector U2/Q5 and Amplifier U3. The feedback loop of Detector is formed by I_L Range resistors R19 to R23. Since U2(3) is grounded, U2(2) is almost zero. This means that entire dc bias voltage is applied across unknown capacitor and leakage current flows through Range resistors. Therefore output of Detector equals product of Range resistors and leakage current, which is 1V at full scale. Amplifier U3, whose gain is about 10, provides 10V at full scale. The output, E_{IL} is sent to DVM Board A4 through Control Board A3. Open Collector Relay Driver U4 performs I_L Range selection as shown. FET switch Q6 is turned on when I_L Range is 1μA or 10μA, which connects C8 to C9 in parallel to enhance smoothing effect. This, in turn, increases response time to approximately 20 seconds.

A7 Parts Locations under Fold





Reference Designations

A7
C1 - 11
CR1 - 18
K1 - 5
Q1 - 7
R1 - 40
U1 - 4
XA1

Table of Active Components.

Reference Designations	HP Part Number
A7	
CR1 - 4, 10, 11	1901-0230
CR5, 6	1901-0574
CR7	1902-3059
CR8	1902-3097
CR9, 14 - 18	1902-0025
CR12, 13	1901-0053
Q1	1854-0330
Q2, 4	1854-0232
Q3, 5	1854-0071
Q6	1855-0020
Q7	1853-0036
U1	1820-0058
U2	1826-0136
U3	1820-0216
U4	1820-0668

Figure 8-19. A7 Leakage Board Ass'y.

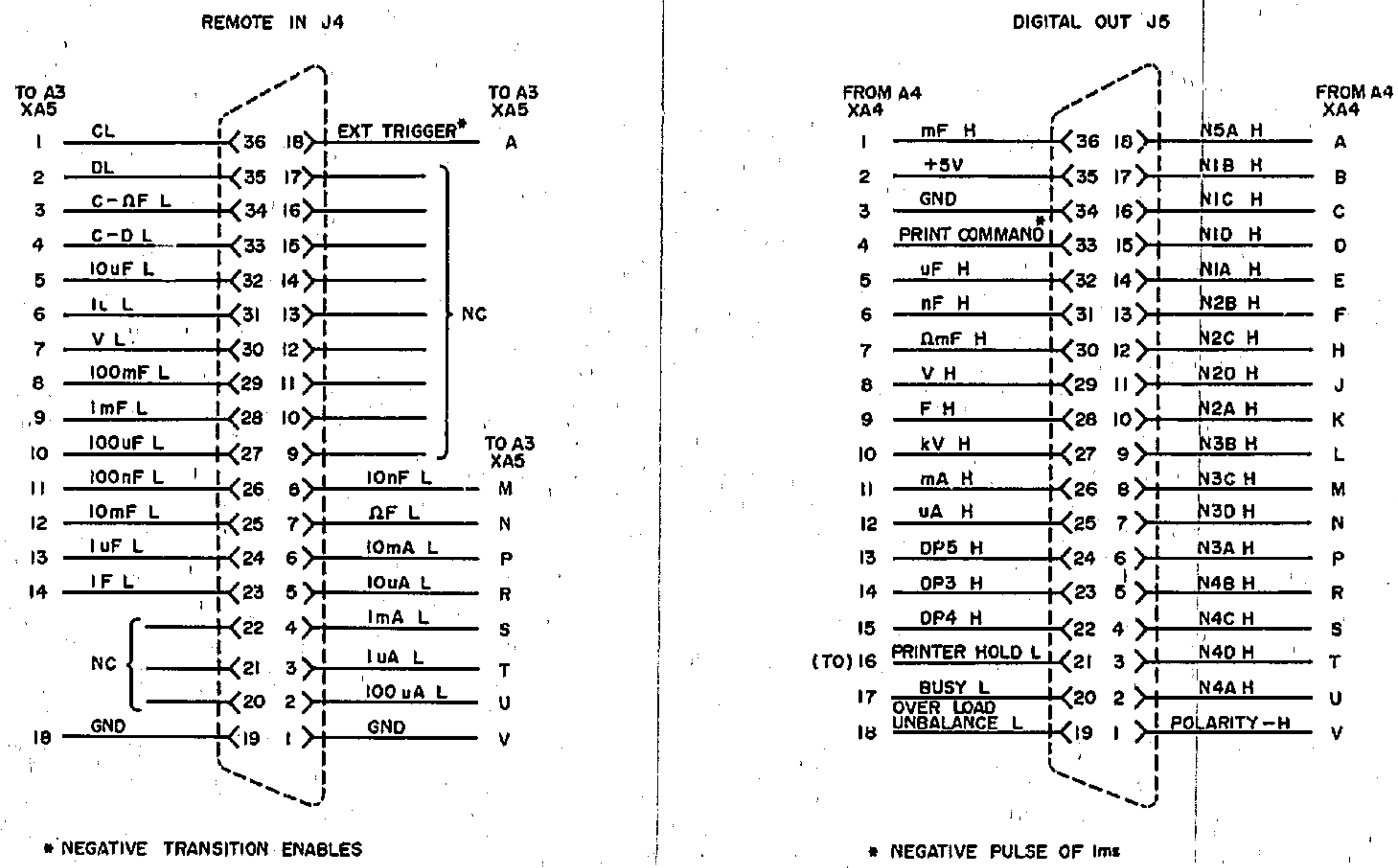


Figure 8-20. REMOTE IN Connector J4 and DIGITAL OUT Connector J5 Pin - Connection.

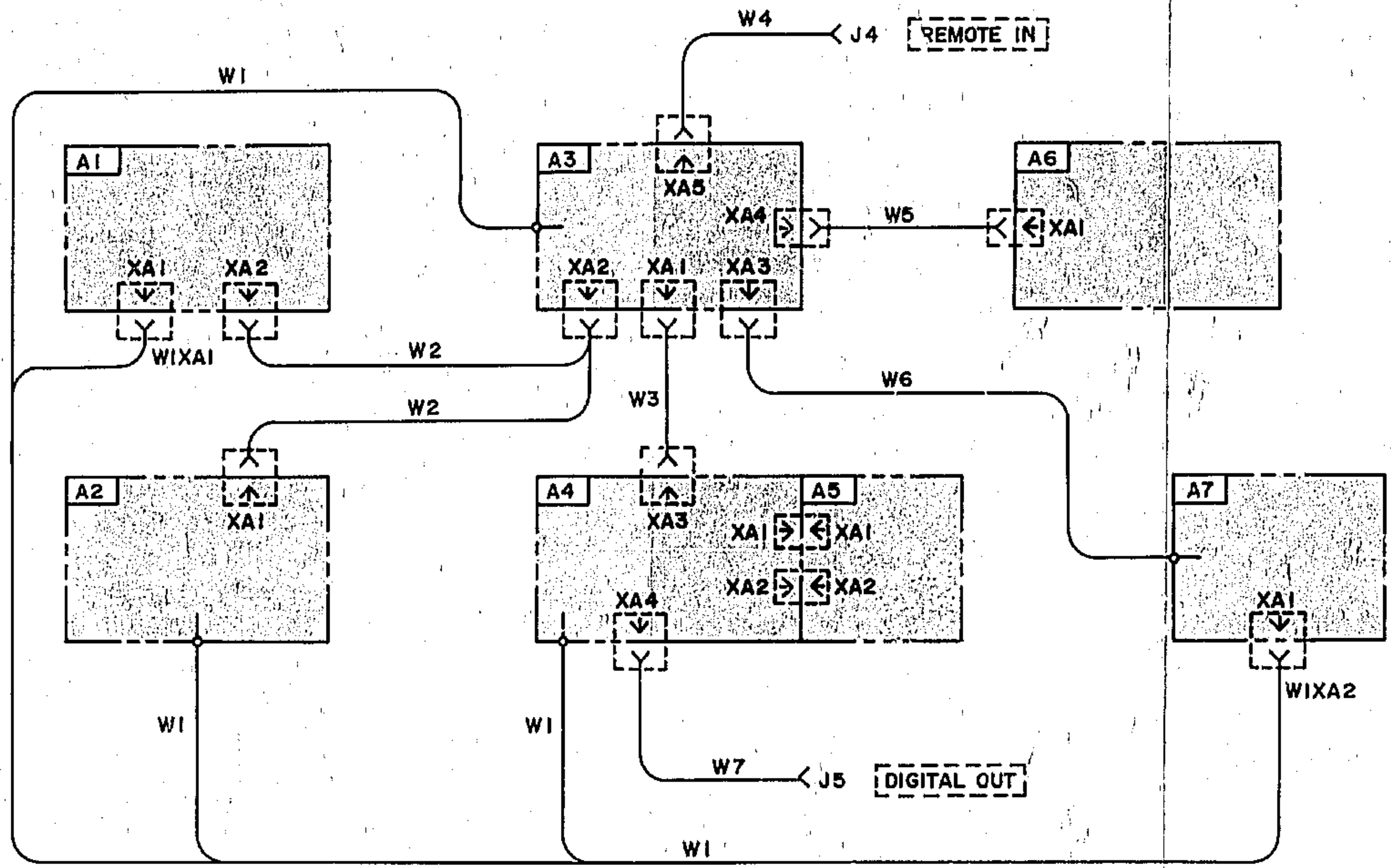


Figure 8-21. Cable Connections.